The 2008 KDI-KAEA Conference on Enhancing Productivity and Sustaining Growth

Foreword

This collection of conference papers is an accumulation of materials from "The 2008 KDI-KAEA Conference on Enhancing Productivity and Sustaining Growth" held on July 8, 2008 at the Korea Development Institute (KDI) in Seoul, Korea.

The purpose of this conference was to gather papers that are in-line with the KDI's 2008 major research agenda such as Productivity Growth, Economic Integration and FTA, Foreign Ownership and Firm Size and Corporate Performance, Macroeconomic Issues, Tax Reform, and Financial Market Issues. This year's 6th KDI-KAEA Conference holds a great meaning, in particular, because as of the end of 2007 Korea Development Review was listed at the Korea Research Foundation, a national organization dedicated to social and scientific development through the promotion of scientific research. As of the end of 2007 the Editorial Board of the Review has filed the application to have the publication enlisted on the Social Science Citation Index. It is our hope that the conference provided a venue to exchange ideas on the future policy direction for Korea to leap into the league of advanced economies in the near future. Currently, most of the papers presented during the conference are in review process for publication in the KDI Journal of Economic Policy.

The conference had 6 sessions: Session I-Issues of Productivity Growth; Session II-Economic Integration and FTA; Session III-Foreign Ownership and Firm Size and Corporate Performance; Session IV-Macroeconomic Issues Session; V-Tax Reform; Session VI-Financial Market Issues. This volume comprises of papers that have already been revised by the authors by reflecting the pertinent discussion notes, which are also included in the proceedings. Furthermore, the discussion notes have contributed substantial amount of input into the original papers.

My acknowledgement goes out to all participants and particularly to those who were on the Screening Board with me including Professor Sunghyun Kim, Vice President of KAEA for assisting in the preliminary paper selection. Moreover, I would like to extend my gratitude to Mr. Jungho Park, and Ms. Nanhee Kim for their hard work and overall coordination of the conference. Also, I thank Ms. Jinwook Jung for her excellent administrative support and hard work to format the manuscript.

Sangdal Shim
Chief Editor
KDI Journal of Economic Policy

Contents

CHAPTER VI-2

Table of Contents

CHAPTER I-3

CHAPTER II-1

CHAPTER II-2

CHAPTER V-2

CHAPTER VI-1

Figure of Contents

CHAPTER III-2

CHAPTER IV-1

CHAPTER IV-2

CHAPTER IV-3

CHAPTER V-1

CHAPTER V-2

CHAPTER VI-1

CHAPTER I-1

Linkages Between Exchange Rate Policy and Macroeconomic Performance

by

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Abstract

From a panel of 137 countries over the years 1971 to 2002, we find evidence that an exchange rate policy of 'fear of floating' is associated with superior macroeconomic performance in non-industrialized countries. We examine four different measures of performance-per capita GDP growth, ii) the CPT inflation rate, iii) GDP growth volatility, and iv) inflation volatility and how they respond to a 'words versus deeds' measure of exchange-rate policy obtained by interacting a country's de jure exchange rate policy with its de facto policy as codified by Rogoff and Reinhart (2004). For non-industrialized countries, the highest GDP growth rates are associated with those who pursue fear of floating (de jure float and de facto fix) whereas the lowest inflation rates are achieved by countries that pursue a matched fix (de jure and de facto fixing). Countries that pursued fear of floating also experienced the lowest GDP and inflation volatility while those that pursued a matched de jure and de facto float experienced the greatest macroeconomic instability.

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I. Introduction

This paper is an empirical investigation of the linkage between exchange rate policy and macroeconomic performance. We study a panel data set consisting of annual observations from 1971 to 2002 across 137 countries. Our measure of exchange rate policy is a four-category interaction between the official IMF (*de jure*) and the de facto classification of Reinhart and Rogoff (2004) that indicates whether the central bank actually implements its publicly announced policy. We refer to exchange rate policy measured in this way as '*words versus deeds*' policy.

The literature has offered many reasons to think that exchange rate policy may impact economic performance but has been less clear-cut in the direction of its predictions. On the one hand, flexible exchange rates may lead to better performance because they provide better insulation and adjustment to external shocks. On the other hand, exchange rate uncertainty may have a negative impact on investment, and therefore growth, when investment is irreversible [Dixit and Pyndick (1994), Aizenman and Marion (1993)]. In this case, exchange rate stability may lead to better outcomes. Thus, it is perhaps not surprising that the empirical significance of exchange rate policy in macroeconomic performance remains an open question.

The modern genesis of this line of empirical work begins with Baxter and Stockman (1995), who found no difference in either the growth or volatility of GDP growth in OECD countries before and after the collapse of the Bretton Woods exchange rate system. Frankel and Rose (2000), on the other hand, estimate that joining a currency union can potentially raise GDP by as much as 38 percent. Ghosh et al. (2002), who use a consensus classification, and Reinhart and Rogoff (2004) (hereafter RR), who use their own natural de facto classification, find that high GDP growth is associated with more stable exchange rates.[1] However, Levy-Yeyati and Sturtznegger (2003) (LYS), who classify exchange rate regimes using cluster analysis, find that higher growth is associated with exchange rate flexibility.[2]

A clearer picture of exchange rate policy and performance seems to be forming for non-industrialized countires. Husain et al. (2005) use the RR classification and

1) In Ghosh et al. (2002) the regimes are classified as fixed, intermediate and flexible. The highest growth rates are found to be associated with the intermediate regimes. Reinhart and Rogoff find the highest growth rates to be associated with regimes of "limited flexibility," which is the second most stable category in their five-way classification.

2) Frankel (2003) shows that these alternative de facto classifications are largely uncorrelated with each other. Harms and Kretschmann (2007) attribute such contradictory results to the fundamental differences of the exchange rate policies that the de facto classifications of LYS and RR capture.

find that the *de facto* fixing has a significant impact on the macroeconomic performance for developing countries by delivering low inflation without sacrificing economic growth. Using a set of 42 counties, Fatas et al. (2007) study how setting and achieving quantitative targets for monetary policy affects inflation. They examine several alternative monetary policy frameworks (including *de facto* currency pegging) and find that the economy enjoys the lowest rate of inflation when the central bank's deeds go along with its words. Our study contributes to the literature by considering the complete set of *'words vs. deeds'* exchange rate policies which provides a more nuanced account of the exchange rate channel for domestic macroeconomic performance. The empirical part of our paper proceeds in two stages.

In the first stage, we examine the relationship among output growth, inflation, and exchange rate policy. Here we find that *de jure* floats and *de facto* fixes (Calvo and Reinhart (2002) fear of floating) are associated with the highest GDP growth rates, while the *de jure* and *de facto* fix (matched fix category) is associated with the lowest inflation. By identifying sub-categories of *de facto* fixers that produce different macroeconomic performance, our results extend the findings of RR and Husain et al. (2005), who find that de facto currency fixing is positively associated with the real GDP growth and negatively associated with inflation. Our first result supports the hypothesis that the fear of floating policy has a growth promoting effect, while the second result is consistent with the Barro-Gordon inspired notion on inflationary bias reduction by means of nominal anchors. The matched fix policy, which is the outcome of *de facto* fixing and *de jure* fixing, represents a disciplined monetary policy that is easily verifiable by the private sector and capable of successfully anchoring its inflationary expectations

In the second stage of empirical analysis, we examine the impact of exchange rate policy on the volatility of GDP growth and inflation volatility. Ever since Lucas (1987) argued that welfare gains associated with higher growth exceed those to reduction of business cycle volatility, little attention has been paid to empirical modeling of macro-economic volatility. In comparison to the huge literature devoted to finding statistically robust factors in the growth regression framework (see Levine and Renelt (1992), Romer (1986) for an overview), the literature on the determinants of macroeconomic volatility is very thin (see Ramey and Ramey (1995)). However, the possible returns from bringing growth and business cycle research together have considerably increased over the last two decades as most central banks adopted macroeconomic stabilization as one of the principal objectives of monetary policy. Here, we find that non-industrialized countries that pursue fear of floating face a trade-off between GDP growth and inflation but are able to achieve lower volatility of GDP growth without higher inflation volatility.

The remainder of the paper is as follows. The next section describes the words versus deeds exchange rate policy classification that we employ and their evolution over our sample. The main empirical results are reported in Section 3 and Section 4 concludes.

II. Classifying exchange rate policy by words and deeds

Economists have long been dissatisfied with the *de jure* exchange rate classification due to the large discrepancies in the actual exchange rate behavior under publicly stated policies. For example, RR argue that exchange rates may have been much more flexible during the Bretton Woods era, which is associated with fixing, and much more stable during the post Bretton Wood era, which is associated with floating. This thinking has yielded a number of *de facto* schemes, which use the observed behavior of the nominal exchange rates and monetary policy indicators in order to define the exchange rate regimes actually pursued by the central bank.

We obtain our '*words vs. deeds*' factors from an interaction between the de facto classification of RR and the de jure classification from *the IMF's Annual Report* on *Exchange Rate Arrangements and Exchange Restrictions.*

The first two columns of Table 1 demonstrate how we reduce the 6-way IMF *de jure* classification to a 2-way coarse classification of "fixed" or "flexible".[3] If the announced regime for a given country in a certain year falls into any of the categories in column (1) of the table, we allocate it according to the categories in column (2). Columns (3) and (4) demonstrate how we reduce the RR de facto 5-way classification into a 3-way coarse classification of "free falling", "fixed" or "flexible" exchange rates regimes. RR pay particular attention to countries in situations of currency crisis and hyperinflation, which they classify as having a "free falling" exchange rate regime. In our classification we retain this regime as a separate category. The same country-year observations classified by RR according to column (3) are thus allocated according to column (4) of the table. In table 2 we create the '*words vs. deeds*' classification that records the nature of agreement or disagreement between the coarse *de jure 2- way* and *de facto 3-way* classifications described in Table 1. The '*words vs. deeds*' classification has five regimes, where four regimes capture the discrepancy between announced and de facto currency

3) Unlike studies of Husain et al. (2005) and Ghosh et al. (2002), we do not identify the intermediate regime in the original exchange rate classification.

regimes in countries under normal conditions. The country-year observations identified by RR as crisis situations are allocated into a fifth free falling category regardless of the officially announced regime.

Table 1. Sorting the classifications

<table>
<tr><th>6-way de jure (IMF)</th><th>Coarsede jure</th><th>5-way de facto(RR)</th><th>Coarse
de facto</th></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td></tr>
<tr><td rowspan="2">1) Independently Floating
2) Managed Floating
3) Adjusted According to Indicators</td><td rowspan="2">Flexible</td><td>1) Freely falling</td><td>Freely falling</td></tr>
<tr><td>2) Freely floating
- Managed floating
- Noncrawling band
3) - De facto wide crawling band
- Preannounced wide crawling band</td><td>Flexible</td></tr>
<tr><td>4) Cooperative Arrangements
5) Limited Flexibility
6) Currency Peg</td><td>Fixed</td><td>4) - De facto narrow crawling band
- De facto crawling peg
- Preannounced crawling band
- Preannounced crawling peg
5) - De facto peg
- Preannounced horizontal band
- Preannounced peg or currency board
- No separate legal tender</td><td>Fixed</td></tr>
</table>

Table 2. Characteristics of the fear factor exchange rate regime classification

Fear factor classification (1)	De jure and de facto classifications (2)	Characteristics (3)
1. Matched float	de jure floaters ∩ de facto floaters	- Announce the currency float and allow the currency to fluctuate - Monetary policy is discretionary
2. Matched fix	de jure fixers ∩ de facto fixers	- Announce the currency peg and maintain fixing - Monetary policy is anchored to the foreign policy
3. Fear of floating	de jure floaters ∩ de facto fixers	- Announce floating but exhibit the characteristics of fixers - Monetary policy may have domestic anchors
4. Broken commitments	de jure fixers ∩ de facto floaters	- Announce the currency peg but not able to maintain it - Monetary policy is officially anchored but is not credible
5. Free falling	de facto free falling	- The announced regime can belong to any category but de de facto country is in crisis

Countries in categories (1) and (2) do what they say, while those in categories (3) and (4) do not. Calvo and Reinhart (2002) present a systematic study of countries in category (3) countries, which they say have a 'fear of floating.'

1. Evolution of exchange rate policies

One of the reasons for choosing the RR classification is that it well distinguishes the 'fear of floating' policy. Figure 1 provides an overview of the evolution of the exchange rate policies according to constructed '*words vs. deeds*' classification. The vertical axis tracks the share of countries that pursued certain exchange rate policy, plotted on the graph, in a given year with respect to the total sample in that year. We observe a downward trend in the relative number of countries that adhered to fixed exchange rate arrangements. An important observation is that the proportion of countries that *de facto* delivered their de jure commitment to fixing (Match Peg category) was gradually decreasing until the currency crises of 1997-1998, while the proportion of countries that *de jure* pegged but *de facto* floated (Broken Commitment) was stable until the 1990s (when it started decreasing).

An opposite picture is observed for the *de jure* floaters. The percentage of *de jure* floaters that let their currencies to float freely (Match Float category) was fairly stable in the 1970-80s time, and gradually increased in the 1990s. Most interestingly, the proportion of Fear Floaters whose actual behavior diverged from the stated exchange rate policy of *de jure* floating steadily increased until the late 1990s.

Figure 2 plots a similar graph for the sample of non-industrialized countries, which is central to our study. We observe the same trends as for the all countries sample with the exception of a less pronounced drop in the proportion of fear of floating countries after the Asian crises in 1997, which means that fear of floating remains a popular exchange rate policy in the non-industrialized countries.

An overall observation is that until the 1990s, trends in exchange rate policies were fairly stable across countries, with a growing number of central banks allowing their currencies to float de jure. However, as of the last decade of the previous century, the situation started changing and the variability in exchange rate policies across countries significantly increased. Several noticeable jumps in that time period deserve attention.

The first shift occurred in 1991, when the share of Free Falling countries increased by nearly 10% in the whole sample, and the share of Broken Commitments category fell by 10%. This has two explanations. First, in 1991, a number of newly independent countries from the former Soviet Union and the Eastern Block entered the sample for the first time. Among them are: Albania, Belarus, Bulgaria, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Poland, Romania, Russia, Slovenia, Tajikistan, and Ukraine. Since these countries were in financial turmoil, RR classify them as free falling. This boosts the free falling share in the sample. Secondly, in Table A1 in Appendix A, we can see that a number of countries that were classified as Broken Commitment up to the early 1990s switched to de jure floating exchange rate policies in that time period. Among them are China, Egypt, Haiti, Iran, Jordan, Kenya, Malawi, Mauritania, Mauritius, Mongolia, Suriname, and Zimbabwe.

Another interesting phenomenon is a rapid increase in the proportion of fear of floating countries in 1994-1997 and a simultaneous decrease in the share of free falling countries. This development corresponds to a global trend of inflation stabilization, as the number of countries that were experiencing annual inflation rates over 40% managed to decrease the percentage rates to more normal levels. It is tempting to think that the surge in the number of fear of floaters and the *de facto* stabilization of exchange rates pursued by those countries is the cause of the inflation moderation and the drop of the proportion of free falling countries. However, it is also

Figure 1. Evolution of words vs. deeds exchange rate policies constructed from RR classification (All countries sample)

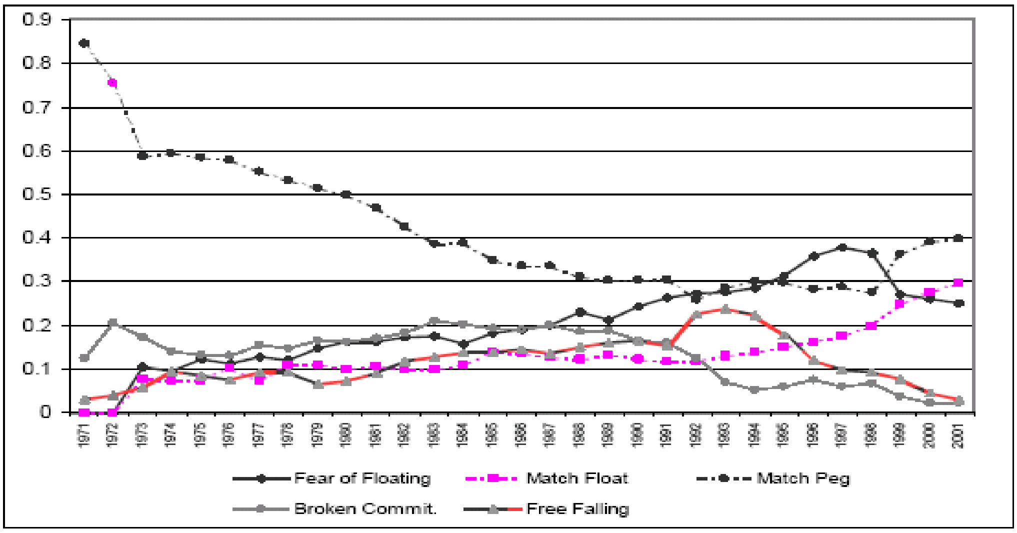
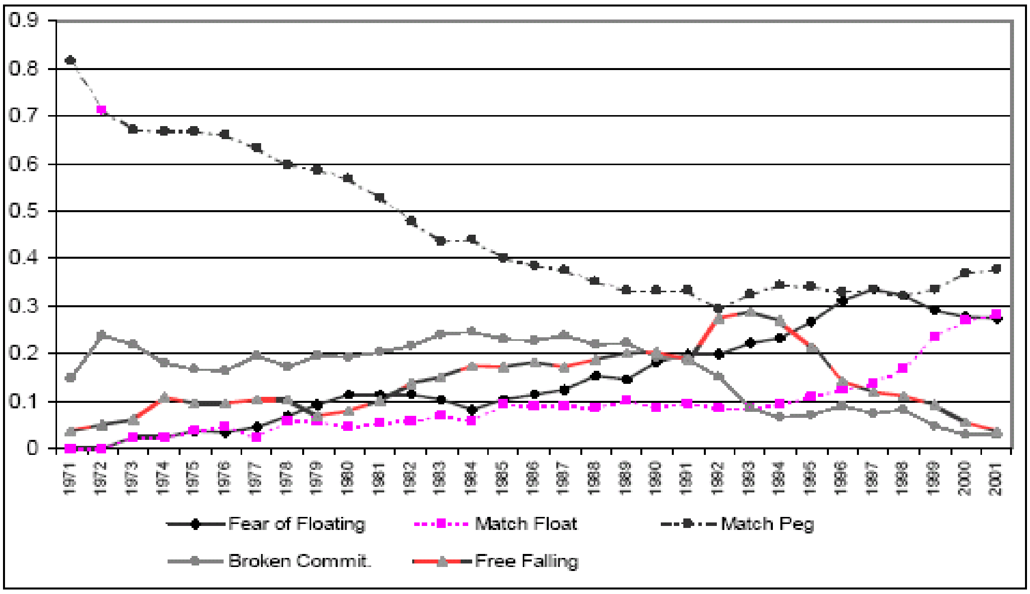


Figure 2. Evolution of words vs. deeds exchange rate policies constructed from RR classification (Non-Industrialized countries)



possible that the inflation stabilization was a result of monetary polices targeting domestic inflation, which also resulted in stable exchange rates. While explicit inflation targeting is not possible for most countries with weak monetary institutions, Carare and Stone (2006) identify alternative, the so-called inflation targeting lite (ITL) policies. These policies include informal inflation targets and a package of measures directed at reducing inflation, such as controlling money supply growth or smoothing out exchange rate fluctuations by adjusting domestic interest rates. When countries pursuing ITL policies succeeded in reducing inflation rates and left the Free Falling category, most of them relocated to the Fear of Floating group as their exchange rate policies were *de jure* floating but *de facto* fixed. Countries that switched to the fear of floating type of exchange rate policy in the mid-nineties are: Algeria, Armenia, Azerbaijan, China, Dominican Republic, Egypt, Gambia, Guyana, Hungary, Jamaica, Kazakhstan, Malawi, Malaysia, Mauritania, Mauritius, Nicaragua, Peru, Philippines, Slovenia, Uruguay, Venezuela, and Zimbabwe[4)].

The last significant change in the conduct of exchange rate policies occurred in 1998, when we observe a sharp decline in the number of fear of floaters and an increase in the proportion of countries whose de facto and de jure policies match. This can be described as a so called "vanishing middle ground phenomenon" [Eichengreen (1994), Frankel et al. (2001)] meaning that a large number of countries opted for the "corner solutions". Among them are: Brazil, China, Guinea, Hungary, Indonesia, Korea, Lebanon, Malawi, Malaysia, Paraguay, Philippines, Saudi Arabia, Singapore, and Sri Lanka. The timing of the trend and the countries involved confirm that the "corner solution" was an aftermath of the Asian, Russian and Latin American currency crises. However, as can be seen from Figure 2 and Appendix A, a fair number of countries (especially in Latin America) continues to pursue the fear floating policies until the end of our sample period. Unfortunately, the RR data ends in 2001, as a result of which we can not extend our words vs. deed analysis beyond that year.

4) Appendix B lists countries that are classified by Carare and Stone (2006) as ITL together with the list of countries that pursued fear of floating exchange rate policies in the 19990s. As can be seen from the table, the lists largely overlap.

III. Exchange Rate Policies and Macroeconomic Performance

1. Empirical Methodology

Let Y_{it} be the measure of economic performance of country i in year t, X_{it} be a vector of control variables and $P_{i,j,t}$ be the exchange rate policy dummy variable pursued by country i in year t. With the Match Peg exchange rate policy being the reference category, the subscript j refers to one of the four *words vs. deed* exchange rate policies defined in Table 2. The panel data regressions take the form:

$$Y_{it} = \sum_{j=1}^{4} \delta_j P_{i,j,t} + \boldsymbol{\beta}' \mathbf{X}_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where the error term $\alpha_i + \gamma_t + \varepsilon_{it}$ has an error-components decomposition. γ_t is a year fixed time effect, α_i is a random (country specific) effect[5] and ε_{it} are i.i.d. random variables with finite second moments. The key parameters of interest are the δ_j which links exchange rate policy to growth.

For the growth regression specification, the independent variables X_{it} represent the Levine-Renelt standard growth controls. They are the investment share to GDP, the annual rate of population growth, and the annual rate of terms of trade growth. They are shown to be robust proxies for the domestic policy outcomes in many empirical studies and are also used in the open economy context by Husain et al. (2005).

For the CPI inflation regression, we choose independent variables based on the studies of Ghosh et al. (2002) and Fatas et al. (2007). They are openness, terms of trade volatility and GDP per capita in US dollars.

2. Growth and inflation regressions

This section summarizes growth regression results with respect to exchange rate policies for non-industrialized and industrialized countries. We extend the previous study of Husain et al. (2004), who focus only on *de facto* exchange rate regimes, by examining how announcing and delivering exchange rate policies affects the

5) The method of including country specific effects has the advantage of controlling for the incidence of time-invariant omitted variables that may be correlated with the set of controls.

macroeconomic performance. In our *words vs. deeds* classification the exchange rate policies correspond to the following types of monetary policies: i) Match Peg - successful exchange rate quantitative target ii) Broken Commitment - unsuccessful exchange rate quantitative target iii) Fear of Floating - implicitly pursued quantitative monetary target (inflation targeting lite) with emphasis on exchange rate smoothing iv) Free Floating - any other quantitative monetary targets without exchange rate smoothing.

The results reported in column (5) of Table 3 suggest that, in the case of industrialized economies, exchange rate policies are largely neutral with respect to growth as the estimates are statistically insignificant[6]. Hence, the following discussion focuses only on the economically and statistically significant results for non-industrialized countries.

The benchmark estimates for the non-industrialized sample, which includes 90 countries[7], are reported in column (2) of the table. We see that relative to the reference Match Peg category, only the Fear of Floating dummy is statistically significant. The sign of the estimated coefficient suggests that fear of floating exchange rate policy is positively associated with real economic growth.

It is tempting to interpret the results as causal, but reverse causality or "endogeneity" remains a concern. As pointed out by Husain et al. (2004), the problem can not be fully resolved in the single equation framework but could be partially mitigated by using the regime prevailing in the previous 2 years as the explanatory variable. This controls for the situation when a temporary change in macroeconomic performance influences a change in the choice of exchange rate regime. The estimates of the specification with all exchange rate regime lagged by 2 years and applied to the full non-industrialized countries sample is reported in column (3) of the table. The signs and significance of the estimates are unchanged.

In order to check the robustness of our findings, we reduce the benchmark non-industrialized countries sample and focus on the 1986-2002 time period. As can be seen in Figures 1 and 2, there is a much higher variation of exchange rate regimes in the in the post-1985 sample compared to the pre-1985 sample, when the Match Peg category

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6) However, the relative sizes of the coefficients indicate that the Match Float category is associated with the highest economic growth. This is consistent with Husain et al. (2004), who find that the de facto floating exchange rate policy is the most advantageous policy for developed countries.

7) See Appendix A for the complete list of non-industrialized countries. We reduced our benchmark non-industrialized sample by dropping countries that excessively switched their exchange rate pol- icy. The list of dropped countries includes: Albania, Belarus, Bosnia, Burkina Faso, Congo, Equador, Georgia, Ghana, Kyrgys Republic, Liberia, Mongolia, Myanmar, Romania, Suriname, Tajikistan, Turk- menistan, Uganda, Ukraine, Zambia, and Zimbabwe.

prevailed. We drop earlier observations in order to check the robustness of our full sample results. The estimates are reported in column (4) of Table 3 and, compared to the full sample estimates, all exchange rate dummy estimates are statistically significant.

Our results provide a partial reconciliation to the contradictory RR and Levy-Yeyati and Sturtznegger (2003) results on exchange rate regimes and growth. We find that countries that pursued *de jure/de facto* floating (Match Float) grew faster relative to those that pursued *de jure/de facto* fixing (Match Peg). However, the Fear of Floating exchange rate policy is associated with the highest real GDP growth.

Table 3. Growth performance and *word vs. deeds* factors Dependent variable: real per capita GDP growth, Annual Panel for 1971-2002

Independent Variable	Non-Indust. Full Sample[b]	Non-Indust. 2-year lagged regime variables	Non-Indust. 1986-2002 Sample	Indust.	All
(1)	(2)	(3)	(4)	(5)	(6)
Fear of floating	0.913*** (0.346)[a]	0.669*** (0.276)	0.855*** (0.316)	0.021 (0.277)	0.206 (0.237)
Broken commitment	-0.413 (0.379)	-0.156 (0.355)	-0.960** (0.474)	0.051 (0.574)	-0.561 (0.351)
Matched float	0.161 (0.439)	0.151 (0.352)	0.110*** (0.370)	0.145 (0.272)	0.006 (0.249)
Free falling	-3.222*** (0.428)	-0.462 (0.433)	-3.773*** (0.784)		-3.262*** (0.438)
Terms of trade growth	0.068*** (0.005)	0.060*** (0.017)	0.054*** (0.023)	0.065*** (0.016)	0.072*** (0.017)
Population growth	-0.672*** (0.107)	-0.811*** (0.113)	-0.444*** (0.171)	-0.607*** (0.251)	-0.480*** (0.115)
Investment to GDP per capita	0.158*** (0.014)	0.159*** (0.021)	0.141*** (0.026)	0.196*** (0.026)	0.156*** (0.021)
Constant	0.173 (0.827)	0.240 (1.071)	0.277*** (0.935)	-0.719 (0.932)	-0.177 (0.881)
Num. Obs.	2173	2170	1275	660	3130
Num. Countr.	90	90	89	22	131

Notes : a Heteroskedastisity robust standard errors are in parenthesis.
b Sample without countries with unstable exchange rate policy.
** Denotes significance at 5% level. ***Denotes significance at 1% level.

The next table reports regression results for CPI inflation. Given the negative link between high inflation and exchange rate stability established in previous studies [Ghosh et al. (2002), Fatas et al. (2007)], we attempt to assess if lower CPI inflation under currency peg is due to the reduction of the exchange rate pass-through effect or if it is a result of disciplined and transparent monetary policies of central banks.

Our estimates reported in columns (2) and (3) of Table 4 indicate that, relative to the reference Match Peg category, Match Float and Fear of Floating policies are associated with a significantly higher CPI inflation. These results provide evidence, that in the case of non-industrialized countries, publicly announced de jure peg that is de facto maintained delivers lower CPI inflation than policies that de jure float. Interestingly, fear of floating policies that de facto stabilize the exchange rate are not associated with a significant inflation reduction.

As the Match Peg category represents the successful quantitative monetary policy target, our findings support the argument made by the Barro-Gordon inspired literature that explicit exchange rate pegging is the policy that is most transparent and easily understood by the public[8]. Our results suggest that this policy provides a good nominal anchor for stabilizing inflationary expectations and reducing inflationary bia s[9].

Mishkin and Savastano (2001) point out that the de jure free floating exchange rate policies mean nothing but a lack of a pronounced commitment to maintaining the domestic currency within a certain range and could be combined with any other type of monetary policies. Since non-industrialized countries typically have weak institutions, it is highly unlikely that they pursue explicit quantitative targets such as full-fledged inflation targeting (IT). This suggests that the Match Float category for this group of countries captures those countries that either do not pursue domestic inflation stabilization policies or do so unsuccessfully. It is not surprising that inflation is significantly higher for this group relative to the Match Peg category[10].

The most interesting result is obtained with respect to the Fear of Floating category

8) Frankel at al. (2001) emphasize the issue of verifiability of exchange rate regimes by the private sector. High verifiability of de facto/de jure pegged exchange rate policy may explain its superior inflation performance relative to other policies.

9) Giavazzi and Pagano (1988) argue that some European countries successfully pursued such a strategy in the 1980s by joining the Exchange Rare Mechanism(ERM).

10) There is a body of empirical literature relevant to industrialized countries that establish evidence of weak exchange rate pass-through to consumer prices. [Engel (1993), Parsley and Wei (2001)] Our results do not contradict this evidence as we capture the impact of monetary policy conduct by central banks on inflation rather than the correlation between exchange rate movements and domestic prices. The fact that the Match Float exchange rate policy is associated with higher inflation in non-industrialized countries demonstrates inability of central banks with weak institutions to credibly follow anti-inflationary domestic policies.

of countries, whose central banks pursue *de jure* floating combined with domestic policies that smooth out exchange rate fluctuations and reduce exchange rate pass-through. It is argued that the *de facto* pegging may isolate countries from nominal shocks and lower domestic inflation by reducing the pass-through effects from the exchange rate variability. Our results demonstrate that de facto fixing alone, without a publicly announced commitment, does not deliver low inflation relative to the successful exchange rate peg. This is consistent with the literature on local currency pricing (LCP), which argues that the link between movements in exchange rates and national consumer prices is weak [Devereux and Engel (2003, 2006)]. If producers set prices in local currency the variability of the exchange rate has a less pronounced impact on inflation. However, the absence of a credible and easily verifiable nominal anchor leads to inferior inflation performance in comparison with the Match Peg policy under which it is present.

The results from the first stage of our analysis reported in Tables 3 and 4 suggest that, in the case of non-industrializd countries, Fear of Floating and Match Float policies are associated with higher real economic growth and higher CPI inflation relative to the Match Peg policies. This means that there is a clear trade-off between growth promoting and inflation reducing monetary policies associated with the exchange rate channel. The next step is to evaluate this policy trade-off in terms of macroeconomic volatility performance.

Table 4. Inflation performance and word vs. deeds factors Dependent variable: CPI inflation, Annual Panel for 1971-2002

Independent Variable	Non-Indust. Full Sample[b]	Non-Indust. 2-year lagged regime variables	Non-Indust. 1986-2002 Sample	Indust.	All
(1)	(2)	(3)	(4)	(5)	(6)
Fear of floating	12.576*** (3.347)[a]	8.939*** (1.770)	6.961*** (2.220)	-0.668 (0.736)	5.590** (2.460)
Broken commitment	3.254* (1.773)	2.576* (1.494)	6.765*** (2.536)	-1.410 (1.148)	1.310 (1.892)
Matched float	10.678*** (2.098)	10.724*** (1.720)	15.348*** (2.500)	-0.603 (0.896)	4.173** (1.808)
Free falling	98.304*** (12.216)	83.758*** (10.586)	106.032*** (17.269)		82.152*** (9.262)
Terms of trade volatility	10.503*** (2.527)	8.313*** (2.101)	13.441*** (3.538)	2.319*** (0.556)	11.482*** (2.512)
Openness	-0.104*** (0.038)	-0.125*** (0.029)	-0.119*** (0.048)	0.075*** (0.020)	-0.073** (.032)
GDP per capita in dollars	5.155*** (1.897)	4.916*** (1.303)	6.622*** (2.258)	-3.024 (2.281)	2.147** (1.085)
Constant	-38.423** (16.624)	-30.549*** (11.638)	-60.229*** (20.925)	30.808 (21.886)	-29.11** (12.253)
Num. Obs.	1752	1778	1098	614	2568
Num. Countr.	85	85	83	22	121

Notes : a Heteroskedastisity robust standard errors are in parenthesis.
b Sample without countries with unstable exchange rate policy.
** Denotes significance at 5% level. ***Denotes significance at 1% level.

3. Volatility regressions

A number of empirical studies document a negative link between growth and macro-economic volatility [Ramey and Ramey (1995), Acemoglu et al. (2003), Hnatkovska and Loyaza (2005)]. The work of Loyaza et al. (2007) summarizes these findings and demonstrates that the welfare costs of macroeconomic volatility are particularly large in the developing countries. For example, Hnatkovska and Loyaza (2005) estimate that a one-standard deviation increase in macroeconomic volatility results in an average loss of 1.28 percentage points in annual par capita GDP growth. The literature on macroeconomic volatility identifies three main reasons why developing countries experience higher volatility than industrialized countries: larger exogenous shocks, self-inflicted policy mistakes and weaker "shock absorbing" institutional development.

In this section, we proceed with our investigation of macroeconomic volatility performance across alternative exchange rate policies. There is no consensus on volatility measurement in economics, as different authors use different techniques and time horizons. However, it is acknowledged that different volatility measures produce similar qualitative results in empirical studies. For example, Eichengreen (1994) points out that the cycle component extracted by the Hodrick-Prescott filter measures long-term swings in the business cycle, while the centered moving standard deviation measures short-term variability. Applying these two techniques to pre- and post-Bretton Woods samples, he does not find any strong qualitative difference between the two measures of business cycle variability.

We construct our volatility series by applying the centered moving standard deviation formula to the original data for each country in our sample[11].

$$Vol(Y_t) = \left\{ \frac{1}{2m} \sum_{k=(t-m)}^{t+m} \left[Y_{t-k} - \frac{1}{2m+1} \left[\sum_{k=(t-m)}^{t+m} Y_{t-k} \right] \right]^2 \right\}^{1/2} \tag{2}$$

By setting m = 2 in our calculations, we have a 5-year moving window of "realized volatility."

11) The moving average of the standard deviation has been widely used as a measure of exchange rate volatility in the international trade literature (for example Koray and Lastrapes (1989) and the references therein) and recently in studies by Bekaert et al. (2004) and Di Giovanni and Levchenko (2005).

We run a regression of the following form:

$$\ln(Vol(Y_{it})) = \sum_j \delta_j P_{i,j,t} + \boldsymbol{\beta}'\mathbf{X}_{it} + \alpha_i + \gamma_t + \varepsilon_{it} \tag{3}$$

where $Vol(Y_{it})$ are volatility measures of real GDP growth and CPT inflation. The log transformation effectively handles the non-normality of the original series. The set of variables X_{it} includes variables that control for domestic government policy and exogenous real shocks.

Because macroeconomic volatility may be induced by erratic fiscal and monetary policies, we include volatility of government consumption growth and volatility of short- term deposit rates in the set of control variables X_{it}. The first variable controls for fiscal policy stability, while the second controls for domestic monetary policy stability12). Inclusion of these variables on the right hand side of our specification nets out their effects on the partial correlation between macroeconomic volatility and exchange rate policy.

Previous studies [Loyaza et al. (2007)] have found that external real shocks, such as abrupt changes in international terms of trade, are one of the primary sources of instability in non-industrialized countries. Di Giovanni and Levchenko (2005) and Loayza and Raddtz (2007) also show that countries that are more open to trade tend to be more volatile. They attribute this effect to the increase in specialization and industry concentration. In order to control for external shocks, we include terms of trade volatility and openness into the set of control variables in our regression.

As seen from the Table 5, the estimated coefficients on all control variables in all columns are positive and highly significant. The signs are expected and are consistent with previous studies on macroeconomic volatility.

Regressing growth volatility on *words vs. deeds* exchange rate policy on the non industrialized countries sample yields the Fear of Floating dummy as the only statistically significant coefficient. The negative sign of the estimate suggests that the Fear of Floating countries experience lower GDP growth volatility relative to the Match Peg and all other exchange rate policies. The coefficient estimates for the industrialized countries reported in column (5) of Table 5 are insignificant which goes along with the Baxter and Stockman (1985) neutrality results for the OECD countries. Our results compare favorably with recent work on exchange rate regimes and growth volatility. For example Ghosh et al. (2002), who use their own consensus *de facto* classification,

12) Due to the skewness of the distributions all volatility measures were subject to a natural log transformation. Since we have a log-log panel regression the coefficients have an interpretation of elasticity.

find that pegged and intermediate regimes are associated with significantly lower volatility of output in the case of low and lower-middle income countries. Our *words vs. deeds* classification draws a distinction between de facto fixers according to their *de jure* policies. The results in columns (2)-(4) of Table 5 demonstrate that, relative to the reference Match Peg category, de facto fixing combined with de jure floating has a stabilizing impact on GDP volatility[13].

The next step is to look at inflation volatility performance across alternative exchange rate arrangements. From Table 4, we know that Fear of Floating and Match Float policies result in a significantly higher level of CPI inflation that Match Peg policies. For the second moment of CPI inflation, results are different. In Table 6, we see that CPI volatility is significantly higher only under the Match Float category, which confirms our claim that this category identifies countries that either do not pursue nominal anchors or are not successful in maintaining them. For the Fear of Floating policy category, inflation volatility performance is not significantly different from the Match Peg. If we accept the argument made by Eichengreen (2002) and Detken and Gaspar (2003), who show that Fear of Floating policy is observationally equivalent to policies that pursue domestic price stability (Inflation Targeting Lite under Carare and Stone (2006) classification), the results reported in columns (2)-(4) suggest that *de facto* currency smoothing is associated with inflation volatility performance that is not statistically different from the performance under the explicit currency peg.

This means that non-industrialized countries pursuing Fear of Floating policy face a trade-off between high levels of GDP growth and CPI inflation, but on average they are able to achieve lower volatility of GDP growth without experiencing higher volatility of CPI inflation relative to other exchange rate policies.

13) This result is also consistent with the more general "stylized fact" on a negative link between GDP growth and volatility of GDP growth reported in Ramey and Ramey (1995).

Table 5. GDP volatility regressions with fear factors and domestic economy policies
Dependent variable: Volatility of real per capita GDP growth, Annual Panel for 1971-2002

	Non-Indust.			Indust.	All
Independent Variable	Full Sample	2-year lagged regime variables	1986-2002 Sample		
(1)	(2)	(3)	(4)	(5)	(6)
Fear of floating	-0.166*** (0.074)[a]	-0.111* (0.070)	-0.163* (0.091)	-0.022 (0.062)	-0.093* (0.053)
Broken commitment	-0.004 (0.072)	-0.048 (0.067)	0.123 (0.096)	0.237* (0.144)	0.035 (0.058)
Match float	0.007 (0.084)	-0.103 (0.079)	0.052 (0.101)	0.044 (0.067)	-0.007 (0.057)
Free falling	0.036 (0.099)	0.013 (0.093)	0.043 (0.120)		0.010 (0.074)
Volatility of govt. consumption growth	0.158*** (0.028)	0.159*** (0.027)	0.173*** (0.032)	0.206*** (0.041)	0.169** (0.021)
Volatility of deposit rate	0.049*** (0.017)	0.047*** (0.016)	0.058*** (0.019)	0.106*** (0.027)	0.065*** (0.014)
Terms of trade volatility	0.349** (0.036)	0.339*** (0.037)	0.385*** (0.043)	0.079* (0.043)	0.277** (0.027)
Openness	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002** (0.001)	0.002*** (0.000)
Constant	-0.232*** (0.213)	-0.202 (0.212)	-0.392*** (0.165)	0.559** (0.148)	0.014 (0.142)
Num. Obs.	1170	1159	821	501	1842
Num. Countries	79	79	78	21	114

Notes : a Heteroskedastisity robust standard errors are in parenthesis.
** Denotes significance at 5% level. ***Denotes significance at 1% level.

Table 6. Inflation volatility performance and *word vs. deeds* factors Dependent variable: Volatility of CPI inflation, Annual Panel for 1971-2002

	Non-Indust.			Indust.	All
Independent Variable	Full Sample	2-year lagged regime variables	1986-2002 Sample		
(1)	(2)	(3)	(4)	(5)	(6)
Fear of floating	-0.010 (0.104)[a]	0.031 (0.083)	-0.071 (0.161)	0.032 (.072)	-0.005 (0.074)
Broken commitment	-0.002 (0.087)	0.261*** (0.077)	0.103 (0.147)	0.448*** (0.141)	-0.024 (0.075)
Matched float	0.434*** (0.106)	0.421*** (0.087)	0.579*** (0.165)	0.126 (0.081)	0.244*** (0.073)
Free falling	1.588*** (0.162)	2.129*** (0.144)	1.596*** (0.242)		1.434*** (0.122)
Terms of trade volatility	0.350*** (0.043)	0.325*** (0.039)	0.472*** (0.056)	0.027 (0.046)	0.280*** (0.035)
Openness	-0.005*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	0.002 (0.002)	-0.004*** (0 .001)
GDP per capita in dollars	-0.148*** (0.049)	-0.142*** (0.045)	-0.013 (0.062)	-0.627*** (0.164)	-0.321*** (0.031)
Constant	2.476*** (0.359)	2.283*** (0.344)	0.906** (0.461)	-7.099*** (1.574)	3.811*** (0.293)
Num. Obs.	1708	1740	1076	612	2506
Num. Countr.	85	85	83	22	121

Notes : a Heteroskedastisity robust standard errors are in parenthesis.
** Denotes significance at 5% level. ***Denotes significance at 1% level.

4. Conclusion

This paper investigates the empirical linkages between a country's exchange rate policy, per capita GDP growth and CPI inflation in an attempt to improve understanding of the how the choice of exchange rate regime impacts economic performance.

Our work can be viewed as *indirectly* addressing the exchange-rate disconnect puzzle, posed by Obstfeld and Rogoff (2000) as "the remarkably weak short-term feedback link between the exchange rate and the rest of the economy." Using a so-called *words vs. deeds* classification of exchange rate policies, which is based on the Rogoff and Reinhart (2002) *de facto* and the IMF *de jure* schemes, we identify clear patterns in macroeconomic performance across alternative exchange rate arrangements in non-industrialized countries. Our work, further, extends the results of Husain et al. (2005), who found that *de facto* fixing has a significant impact on growth and inflation in the developing countries.

A number of recent theoretical models [Gali and Monacelli (2005), Clarida et al. (2001), Devereux and Engel (2003)] have the objective to represent monetary policy in an open economy context. Our study of *words vs. deeds* policies could also be considered as providing a set of "stylized facts" for the exchange rate channel in these theoretical models. Moreover, the results reported in our paper provide a partial reconciliation to the contradictory results on exchange rate regimes and growth found in RR and Levy Yeyati and Sturtznegger (2003). We find that non-industrialized countries pursuing the *de jure/de facto* floating (Match Float) grew faster than those pursuing *de jure/de facto* fixing (Match Peg). However, it is the Fear of Floating (de facto fixing under de jure floating) exchange rate policy, which is the most growth promoting. The estimates for industrialized countries are statistically insignificant, but the sizes of the coefficients suggest that Match Float is associated with the highest real GDP growth for this group of countries.

Our results on CPI inflation illustrate a clear trade-off between growth promoting and inflation reducing exchange rate policies. Relative to Match Peg, both Match Float and Fear of Floating policies are associated with a significantly higher CPI inflation. These findings support the argument made by the Barro-Gordon inspired literature that explicit exchange rate pegging (represented by the Match Peg category in our analysis) is the most transparent and easily understood policy, that provides a good nominal anchor for stabilizing inflationary expectations and reducing inflationary bias (see Fatas et al. (2007) for an overview).

Moving to macroeconomic volatility performance, we find that the trade-off between exchange rate policies that seek to stabilize the second moments of output and inflation is less clear-cut. Our results demonstrate that Fear of Floating exchange rate policy is associated with the highest reduction in output volatility without sacrificing inflation volatility. On the contrary, countries that pursue Match Float policies exhibit the highest volatility of inflation relative to other categories without any gain on output stabilization.

We attribute the overall results regarding Fear of Floating policies to inflation targeting lite (ITL) policies pursued by the central banks in non-industrialized countries. This type of policy takes place under a publicly announced floating exchange rate when central banks adopt the package of domestic measures directed at offsetting foreign shocks that de facto stabilize the exchange rate. Our results suggest that relative to Match Peg (which represents the successful quantitative target), this policy results in significantly higher economic growth but also higher CPI inflation. At the same time, the inflation volatility performance of Fear of Floating countries is not significantly different from that of countries pursuing Match Peg policy. Coupled with a better output volatility performance, this suggests that Fear of Floating might be the most advantageous exchange rate policy for non-industrialized countries.

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Appendix A. List of countries with duration of the exchange rate regimes.

Table A1. Exchange rate policies of the non-industrialized countries by years

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Albania		1994-1996 1998-2001	1991-1993 1997		
Algeria			1994	1973-1993	1995-2001
Antigua and Barbuda	1971-2001				
Argentina	1991-2001		1971-1978 1981-1984 1986-1990		1979-1980 1985
Armenia	1992-1995				1996-2001
Azerbaijan			1993-1995		1996-2001
Belarus			1992-2001		
Benin	1971-2001				
Bolivia		1987	1973-1974 1980-1986	1971-1972 1975-1979	1988-2001
Bosnia and Herzegovina	1995-2001				
Botswana	1971-2001				
Brazil	1995-1996	1973 2000-2001	1975-1994 1999	1971-1972 1974	1997-1998
Bulgaria	1997-2000		1991-1996		
Burkina Faso	1971-2001				
Burundi	1971-1985	1999-2001	1996	1986-1995 1997-1998	

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Cameroon	1971-2001				
Central African Republic	1971-2001				
Chad	1971-2001				
Chile	1979-1981	1983-2001	1971-1977 1982		1978
China	1974-1978 2000-2001	1991-1992		1971-1973 1979-1990	1993-1999
Colombia		1984-2001			1975-1983
Congo			1975-1997	1971-1974	
Costa Rica	1974-1980	1984-1990	1981-1983	1971-1973	1991-2001
Cote d'Ivoire	1971-2001				
Cyprus	1971-1997				1998-2001
Czech Republic	1990-1995	1997-2001	1996		
Dominica	1971-2001				
Dominican Republic	1971-1978	1986 1992	1985 1987-1991	1979-1984	1993-2001
Ecuador	1971-1981 2000-2001	1985-1986 1994-1996	1982-1983 1987-1993 1998-1999	1984	1997
Egypt		1991		1971-1990	1992-2001
El Salvador	1971-1982 1994-2001	1985 1989		1983-1984 1986-1988	1990-1993
Equatorial Guinea	1971-2001				
Estonia	1993-2001		1992		
Gabon	1971-2001				

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Gambia	1971-1980	1987-1991	1986		1992-2001
Georgia		1999-2001	1992-1996		
Ghana	1971	1984-1985 1988-1989 1991-1993 1997-1999 2001	1974-1983 1986-1987 1990 1994-1996 2000	1972-1973	
Grenada	1971-2001				
Guatemala	1971-1984		1985-1986 1989-1990	1987-1988	1991-2001
Guinea	1975-1982	2000-2001		1971-1974	1986-1999
Guinea-Bissau	1977-1983 1997-2001				1984-1992
Guyana	1971-1980 1984-1987		1988-1991		1981-1983 1995-2001
Haiti	1971-1988	1991-1992 1995-2001	1993-1994	1989-1990	
Honduras	1971-1984	1991-1998	1990	1985-1989	1999-2001
Hungary	1994	1999-2001		1981-1993	1995-1998
Iceland	1971-1972 1987 1989-1999	1976 1984-1986 2001	1973-1975 1977-1983		1988 2000
India	1971-1978				1979-2001
Indonesia	1971	1978 1999-2001	1971-1974 1998	1975-1977	1979-1997
Iran	1971-1976	1978-1979 1992-1993	1994-1995	1977 1980-1991 1996-2001	
Iraq	1971-1981			1982-1998	

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Israel	1986-1988 1990	2000-2001	1974-1985	1971-1973 1989 1991-1999	
Jamaica	1971-1977 1979-1982 1989	1993	1978 1991-1992 1998		1983-1988 1990 1994-2001
Jordan	1971-1988 1993-2001			1989-1992	
Kazakhstan			1992-1995		1996-2001
Kenya	1971-1986	1994-2001	1992-1993	1987-1991	
Korea	1974-1979	1999-2001	1998	1971-1973	1980-1997
Kuwait	1971-2001				
Kyrgys Republic			1992-1999		2000-2001
Lao PDR	1972		1988-1989 1997-1999	1971 1973-1987	1990-1996
Latvia	1995-2001		1992-1993		1994
Lebanon	1971-1972 2000-2001	1976-1983	1984-1991		1973-1975 1992-1999
Lesotho	1971-2001				
Liberia	1971-1987				1998-2001
Libya	1971			1972-1998	
Lithuania	1995-2001		1992-1994		
Madagascar	1971-1984	1986-1990 1996-2001	1994-1995	1985 1991-1993	
Malawi	1971-1973	1993 2000-2001	1994 1998-1999	1974-1992	1995-1997
Malaysia	1971-1972 1975-1992 1999-2001	1998			1973-1974 1993-1997
Mali	1971-2001				

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Malta	1971			1972-2001	
Mauritania	1971-1983	1993-1994		1984-1992	1995-2001
Mauritius	1976-1981 1993-1994			1982-1992	1995-2001
Mexico	1971-1975	1994 1996-2001	1982-1988 1995		1976-1981 1989-1993
Mongolia			1993-1997	1991-1992	1998-2001
Morocco	1971-1977 1979 1991-2001				1978 1980-1990
Myanmar	1971-1973		1974-1975 1988-1990 1993 1997-1998	1976-1987 1991-1992 1994-1996	
Nepal	1974-1977 1982-1991 1993-2001			1978-1981 1992	
Nicaragua	1971-1978 1991-1992		1983-1990	1979-1982	1993-2001
Niger	1971-2001				
Nigeria	1971	1974-1976 1978-1982 1985-1990 1997-2001	1983-1984 1991-1995	1972-1973 1977 1996	
Pakistan	1972-1981 1999				1988-1998 2000-2001
Panama	1971-2001				
Paraguay	1971-1973	1999-2001	1985 1989-1990	1974-1984 1986-1988	1991-1998
Peru			1976-1993		1994-2001

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Philippines		1973-1983 1993-1995 1998-2001	1984	1971-1972	1985-1992 1996-1997
Poland	1990	2000-2001	1988-1989 1991-1992	1995-1999	
Romania		2001	1990-2000		
Russia			1992-1999		2000-2001
Saudi Arabia	2000-2001				1988-1999
Senegal	1971-2001				
Singapore	1971-1986	1999-2001			1987-1998
Slovak Republic	1993-1997	1999-2001		1998	
Slovenia			1992		1993-2001
South Africa	1971-1972	1980-1985 1995-2001		1973-1978	
Sri Lanka	1973-1976	2000-2001		1971-1972	1977-1999
St. Kitts and Nevis	1988-2001				
St. Lucia	1971-2001				
St. Vincent and the Grenadines	1971-2001				
Suriname	1971-1974	1996-1997	1986-1987 1991-1995 1998-2000	1979-1985 1988-1990	
Swaziland	1971-2001				
Syria	1971-1973			1974-2001	
Tajikistan			1993-1997 1999-2001		1998

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Tanzania	1971	1986-1990 1994-2001	1974 1984 1992-1993	1972-1973 1975-1983 1985 1991	
Thailand	1971-1981 1984-1996	1998-2001	1997		1982-1983
Togo	1971-2001				
Tunisia	1971-1985				1986-2001
Turkey	1971	1975-1976 1981-1983 1998-2000	1977-1980 1984-1997 2001	1972-1974	
Turkmenistan			1993-1997		
Uganda	1971 1987-1989	1983 1993-2001	1981-1982 1984-1986 1990-1992	1972-1980	
Ukraine		1999	1992-1996		2000-2001
Uruguay			1971-1978 1983-1990 1992-1995		1979-1982 1991 1996-2001
Venezuela	1971-1982	1990-1992	1987-1989 1993-1996	1983-1986	1997-2001
Zambia	1971		1985-2001	1972-1983	
Zimbabwe	1980-1982 2001	1995-1997	1991-1994 1998	1983-1990	1999-2000

Table A2. Exchange rate policies of the industrialized countries by years

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
Australia	1971-1982	1984-2001		1983	
Austria	1971-1995 1999-2001				1996-1998
Belgium	1971-1972 1999-2001				1973-1998
Canada	1971-1972				1973-2001
Hong Kong, China	1971-1974 1983-2001				1975-1982
Denmark	1971-1972				1973-2001
Finland	1971-1991 1999-2001				1992-1998
France	1971-1972 1999-2001	1973-1974			1975-1998
Germany	1972 1999-2001	1973-1998		1971	
Greece	1971-1972 1974 2000-2001	1981-1984			1973 1975-1980 1985-1999
Ireland	1971-1978 1999-2001				1979-1998
Italy	1971-1972 1999-2001	1976-1982			1973-1976 1983-1998
Japan	1971-1972	1978-2001			1973-1977
Netherlands	1971-1972 1999-2001				1973-1998

	Words and Deeds Exchange Rate Policies				
	Match Peg	Match Float	Free Falling	Broken commitment	Fear of floating
New Zealand	1971-1984	1985-2001			
Norway	1971-1972	1973-1977 1992-2001		1978-1991	
Portugal	1971-1972 1999-2001	1973-1980			1981-1998
Spain	1971-1976 1999-2001				1977-1998
Sweden	1971-1972 1978-1991	1993-2001			1973-1977 1992
Switzerland	1971-1972	1973-1981			1982-2001
United Kingdom	1971	1973-1990 1993-2001		1972	1991-1992
United States	1971	1978-2001		1972	1973-1977

Appendix B. List of Fear Floaters and countries classified as pursuing Inflation Targeting Lite policies.

Fear Floating Policy[a]	Inflation Targeting[b]
Algeria, 1995-2001	Lite
Armenia, 1996-2001	
Azerbaijan, 1996-2001	
Bolivia, 1988-2001	
China, 1993-1999	
Costa Rica, 1991-2001	
Cyprus, 1998-2001	
Dominican Republic, 1993-2001	Lite
Egypt, 1992-2001	
Gambia, 1992-2001	
Guatemala, 1991-2001	
Guinea, 1986-1999	
Guyana, 1995-2001	
Honduras, 1999-2001	Lite
Hungary, 1995-1998	Full-fledged
India, 1979-2001	
Indonesia, 1979-1997	Lite
Jamaica, 1994-2001	Lite
Kazakhstan, 1996-2001	Lite
Korea, 1980-2001	Full-fledged
Lebanon, 1992-1999	
Malaysia, 1993-1999	
Mauritius, 1995-2001	Lite
Nicaragua, 1993-2001	
Pakistan, 1988-2001	
Paraguay, 1991-1998	
Peru, 1994-2001	Lite
Philippines, 1996-1997	Lite
Russia, 2000-2001	Lite
Saudi Arabia, 1988-1999	
Singapore, 1987-1998	Lite
Slovenia, 1993-2001	Lite
Sri Lanka, 1977-1999	Lite
Tunisia, 1986-2001	
Uruguay, 1996-2001	Lite
Venezuela, 1997-2001	Lite

Note: a Sample is restricted to non-industrialized countries.
b Inflation targeting (IT) policy according to Carare and Stone (2003)

Appendix C. Variables and Sources

Variable	Definition and Sources
GDP growth	Rate of growth of real per capita GDP (constant LCU) (Source: WDI, series code: NY.GDP.PCAP.KN)
Inflation	Inflation CPI (Source: WDI, series code: FP.CPI.TOTL.ZG)
Terms of trade growth	Change in terms of trade - exports as a capacity to imports (constant LCU) (Source:WDI, series code:NY.EXP.CAPM.KN)
Terms of trade volatility	Centered moving standard deviation of terms of trade growth over five-year period
Population	Rate of growth of the total population (Source: WDI, series code: SP.POP.TOTL)
Investment to GDP	Fixed Capital Formation (Source: WDI,) series code: NE.GDI.TOTL.ZS
Openness	Ratio of export+import to GDP
GDP per capita in dollars	GDP per capita (constant 2000 US$) (Source: WDI, series code: NY.GDP.PCAP.KD)
M2 as per cent of GDP	Money and quasi money (M2) as % of GDP (Source: WDI, series code: FM.LBL.MQMY.GD.ZS)
Civil Liberty	Index of civil liberties (measured on a 1 to 7 scale) (Source: Freedom House)
Political constraint	Index of political constraint (Source: Henisz (2005))
Economy size	GDP in dollars over US GDP

Discussion on "Linkages between exchange rate policy and macroeconomic performance"

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This paper is an empirical analysis of the relationship between exchange rate policy and macroeconomic performance. The authors use panel data of 137 countries from 1971-2002 and test whether exchange rate regime can explain differences in macroeconomic performance in terms of GDP growth, CPI inflation, and their volatilities. Unlike previous papers on this topic, this paper categorizes exchange rate regime depending on both de facto (actual) and de jure (claimed) exchange rate regimes.

The estimation results show that exchange rate policy does not affect macroeconomic performance in industrialized countries but significantly affect in non-industrialized country sample. Among developing countries, countries with "matched fix" (de jure and de facto fixed exchange rate regime) achieve the lowest inflation rates among sample countries. Floating rate (both de jure and de facto) countries achieve the highest volatility in GDP growth rates and inflation. "Fear-of-floating" (de jure floating, de facto fixed) countries achieve the highest GDP growth rate and lowest volatility, best macroeconomic performance.

In general, this paper is well written and presents clear results. One main question in terms of contribution or policy implication of this paper is that how much we can generalize the conclusion. Does the main result that "fear of floating" regime shows best macroeconomic performance indicate that developing countries should adopt this regime? It is hard to imagine that certain exchange rate regime is best for all countries. Best regime should depend on specific economic conditions of each country. Therefore, more interesting task (which was not covered in this paper) is to find economic conditions that make certain exchange rate regime better than the others for each country.

I also have several minor comments: First, the estimation period ends at 2001 (because of availability of empirical results presented in other papers). If one extends the estimation period up to 2006, the regression results may change. For example, in this paper, many East Asian countries are considered as "fear of floating." However, according to

Kim and Kim (2008), some East Asian countries adopted floating rate regime (both de jure and de facto) since 2000. Second, the authors tried to control endogeneity problem (exchange rate regime may depend on macroeconomic performance) by using exchange regime variables lagged by 2 years as one of the control variables. However, this may not be enough to control for the endegeneity problem. The authors may want to perform formal causality test or running regressions with exchange rate regime as dependent variables and GDP growth rate as independent variable. Third, there can be potentially important but missed variables for control variables in the regression. For example, financial market openness or degree of financial market liberalization can seriously affect exchange rate regime and macroeconomic performance at the same time. Finally, the table 5 shows that fear-of-floating countries show lower GDP volatility than Matched fixed, which is against economic intuition. There is no explanation on this.

Reference

Kim, Soyoung and Sunghyun Kim, 2008, "Fear of floating in East Asia?" Pacific Economic Review, forthcoming.

CHAPTER I-2

Threshold Cointegration and the Monetary Model of Exchange Rates

by
Junsoo Lee*

Abstract

The long-run validity of the monetary model of nominal exchange rates has been an issue in the literature. Although the existence of a cointegrating relationship among the fundamental variables is the backbone of the monetary model, the empirical results often fail to show evidence of cointegration among the fundamental variables in the model. These results cast doubt on the monetary model of nominal exchange rates see Rapach and Wohar (2002, Journal of International Economics). In this paper, we examine the long-run validity of the monetary model by taking into account of nonlinear behavior. Nonlinearities in exchange rate dynamics might arise, for example, if reaction to fundamentals and adjustment depends on the magnitude or sign of the deviation from a long-run equilibrium. To our surprise, no previous works have tested the validity of their nonlinear model with for nonlinear cointegration. Thus, we advance the literature by performing formal tests for nonlinear cointegration with two different threshold specifications. We model these different regimes by including threshold effects that depend on the size of the level and first-difference in the error-correction term, where the threshold value is endogenously determined for each country. To perform our tests, we utilize quarterly data from eighteen countries over the time period

1973-1997. Overall, in spite of allowing for nonlinear threshold effects, we find evidence that the monetary model has a stable long-run equilibrium in only three to six

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of the eighteen countries.

Keywords: Exchange rates, Monetary model, Threshold cointegration
JEL Classifications: C22, F31

I. Introduction

In this paper, we examine the long-run validity of the monetary model of nominal exchange rate determination in a threshold cointegrating framework. Macroeconomic theory suggests that nominal exchange rates between two countries will be determined by important macroeconomic "fundamentals" including relative money supplies, incomes, prices, and interest rates. These important macroeconomic variables are the foundation of the monetary model, and changes in these fundamentals should lead to predictable affects on nominal exchange rates. Theoretically speaking, the monetary model of exchange rates is intuitive and appealing. An early reference to the monetary model is Mussa (1976). In spite of its broad appeal, however, empirical support for the monetary model often remains elusive and controversial. While numerous early works found empirical support for the monetary model (e.g., Frenkel 1976, Bilson 1978, Hodrick 1978, and Dornbusch 1979), many later works questioned these findings. In a seminal paper, Meese and Rogoff (1983) found that a simple random walk provided better forecasts of nominal exchange rates than the monetary model. This important finding suggests that macroeconomic fundamentals are not much use to predict nominal exchange rates.

Mark (1995) inspired new hope for macroeconomic fundamentals by finding better out-of-sample forecasts with the monetary model than a random walk at long horizons. In response, Berben and van Dijk (1998) and Berkowitz and Giorgianni (2001) argued that Mark's (1995) support for the monetary model hinges on the existence of a valid cointegrating relationship between nominal exchange rates and the fundamental variables in the model. Since Mark (1995) was unable to find evidence of cointegration among the fundamental variables in the model, these papers again cast doubt on the monetary model. Many other empirical studies also fail to find support for a cointegrating relationship between nominal exchange rates and the fundamental variables of the monetary model see Meese (1986), Baillie and Selover (1987), and Sarantis (1994), among others.

The existence of a cointegrating relationship among the fundamental variables is the backbone of the monetary model, since its validity depends on the existence of a long-run equilibrium relationship. Perhaps the failure to find wide support for cointegration in the monetary model is due to low power in the tests. To increase power, Groen (2000) and Mark and Sul (2001) test the monetary model using panel cointegration tests. By combining time series data for a number of OECD countries, these authors find support for cointegration in the monetary model. However, there is a fundamental weakness of these panel data tests- rejection of the null indicates only that at least one of the monetary models in the panel is cointegrated. Thus, given a rejection of the panel data null, it is possible that cointegration will not hold for many, or most, of the countries in the panel. Recently, Rapach and Wohar (2002) advance the literature by considering univariate cointegration tests using long-span annual data from approximately 1880-1995 for 14 industrialized countries. In contrast to previous univariate test results, Rapach and Wohar (2002) find moderate or strong support for cointegration in 5 or 6 of the 10 countries examined. One limitation of their study is that they exclude potentially I(0) variables after conducting unit root tests on each of the variables in the model[1]. Clearly, it is desirable not to exclude important variables describing the theoretical model, and we wish to improve on this limitation in our suggested testing procedure. Overall, the empirical results are mixed, but most studies fail to find strong support for the validity of the monetary model.

In this paper, we adopt an alternative approach to testing the monetary model. Recognizing that potential nonlinearities in exchange rate dynamics can play an important role, we examine the validity of the monetary model while allowing for nonlinear dynamics. Actually, there has emerged a growing body of literature documenting nonlinear behavior among many macroeconomic and financial time series.

This motivation stems from the observation that many macroeconomic and financial time series exhibit regime shifts and/or asymmetric dynamics (e.g., Florio, 2006, Boivin, 2006, Dolado, Maria-Dolores Pedrero, and Ruge-Murcia, 2004, Cover, 1992, Ball and Mankiw, 1994). Specific to monetary model, a number of recent studies document evidence of nonlinear dynamics in nominal exchange rates (e.g., Taylor and Alan 1992, Taylor and Peel, 2000, Guerra, 2001, and Kilian and Taylor, 2003). As suggested above, nonlinearities in exchange rate dynamics might arise, for example, if reaction to fundamentals and adjustment depends on the magnitude or sign of the deviation from a long-run equilibrium. In this regard, Dumas (1992) develops a theoretical model where nonlinearities in exchange rate dynamics arise from transactions costs caused by market frictions (see also Sercu, Uppal, and Van Hulle, 1995). For instance, foreign exchange traders might consider small deviations from equilibrium to be less important than large deviations, thus leading to a more rapid adjustment in exchange rates following large changes in the fundamentals of relative money supplies, prices, interest rates, and outputs. In this regard, Taylor and Peel (2000) find empirical evidence that

1) Rapach and Wohar (2002) initially consider fourteen countries, but some of the models contain a mix of I(0) and I(1) variables that cannot be cointegrated, and in one country, The Netherlands, all of the variables in the model are I(0) so cointegration tests are not performed on these countries.

deviations in exchange rates from the monetary model follow a nonlinear adjustment process see also Michael, Nobay, and Peel (1997), and Wu and Chen (2001). Although Taylor and Peel (2000) note that a tractable way to model nonlinear adjustment is to adopt a threshold autoregressive (TAR) model, they adopt an exponential smooth transition autoregressive (ESTAR) type of model, perhaps for convenience of estimation. In a related vein, Kilian and Taylor (2003) find that ESTAR dynamics can explain purchasing power parity (PPP) better than linear models.

Despite a growing body of empirical evidence in favor of nonlinear dynamics in exchange rates; an important question has not yet been addressed in the literature. Is there a nonlinear cointegrating relationship in the monetary model of exchange rates? If no cointegrating relationship exists between the nominal exchange rate and its underlying fundamentals, then empirical estimation of a linear or nonlinear model can give spurious results. Thus, it is important to check for cointegration for the validity of the monetary model regardless of the specification. The extant nonlinear empirical papers that test the monetary model (implicitly) assume the existence of nonlinear cointegration, but do not provide empirical evidence for its existence. To date, the literature has been silent on this question. For example, empirical studies sometimes report hypothesis tests for linearity versus nonlinear model specification, but the validity of the analysis is most often predicated on the assumption that nonlinear cointegration exists. However, in the absence of linear cointegration the tests for linearity will have spurious power and reject the null of linearity too often. In other cases, researchers sometimes first perform their tests for cointegration in a linear framework and then proceed to test a nonlinear version of the monetary model of exchange rates. Again, if the model is truly nonlinear, but the tests for cointegration are linear, then spurious findings may occur. In sum, the previously documented empirical results may not provide a credible answer to the underlying question about the validity of the monetary model as a credible theory of exchange rates.

To advance the literature, we will adopt an alternative approach to test for cointegration in the monetary model. Recognizing that potential nonlinearities in exchange rate dynamics can play an important role, we test for cointegration while allowing for different behavior depending on the nature of the deviations from fundamentals. It is quite possible that the empirical results in previous studies assuming linearity in the long-run equilibrium of the monetary model could be altered if nonlinear dynamics are controlled for. For example, we expect that cointegration tests that assume linearity will lose power when the underlying model takes a nonlinear form.

To examine the validity of the monetary model, we utilize augmented distributed lag

(ADL, hereafter) tests for threshold cointegration that allow for different regimes characterized by deviations from the system equilibrium. Two different threshold effects are considered that are hypothesized to arise from asymmetric policies and transactions costs. In particular, we model the threshold variable as the level and growth rate in the deviations from the system equilibrium. We endogenously determine the point of regime change from the estimated deviations from the system equilibrium. To the best of our knowledge, this is the first paper to formally test for the existence of a nonlinear cointegrating relationship among the fundamental variables in the monetary model.

To perform our empirical tests, we examine quarterly observations on exchange rates from eighteen countries for the period 1973-1997. This time span is utilized to provide the clearest period of flexible exchange rates among industrialized countries prior to the creation of a single currency within the ECU. After performing unit root tests for each time series, we test for cointegration with the monetary model. Overall, we find support for a stable long- run equilibrium in the monetary model in only three to six of the eighteen countries.

The remainder of our paper proceeds as follows. Section II describes the monetary model of exchange rate determination and issues related to testing for cointegration. We also discuss the procedures of various threshold cointegration tests in more detail. Section III describes the data and discusses our empirical findings. Section IV summarizes and concludes.

II. Monetary Model of Exchange Rates and Testing for Threshold Cointegration

The monetary model of exchange rates implies that the nominal exchange rate between two countries depends on relative prices and the supply and demand for monies. To derive the model, we combine foreign and domestic money demand with purchasing power parity as follows:

$$m_t = p_t = a_1 y_t + \alpha_2 i_t \quad (1)$$
$$m_t^* - p_t^* = a_1 y_t^* + a_2 i_t^* \quad (2)$$
$$e_t = p_t^* - p_t , \quad (3)$$

where m denotes the money supply, p denotes the price level, y denotes national output, i is the rate of nominal interest, and e is the nominal exchange rate (foreign currency per unit of domestic currency). By using '*' we denote the foreign country variables, and t is a time subscript. All variables are in natural logarithms except for i, and it is assumed that $a_1 > 0$ and $a_2 < 0$. Combining terms in (1), (2), and (3) gives (4) as follows:

$$e_t = (m_t^* - m_t) - \alpha_1 (i_t^* - i_t) - \alpha_2 (y_t^* - y_t). \tag{4}$$

Assuming (uncovered) interest rate parity, the difference in interest rates is equal to the expected depreciation (Δe_{t+1}) given information available at time t, which we denote as Ω_t. Assuming that $\Delta e_{t+1} = 0$ in the long-run equilibrium, $(i_t^* - i_t) = E(\Delta e_{t+1} \mid \Omega_t) = 0$. Thus, in the long-run equilibrium, the monetary model can be estimated by testing:

$$e_t = \alpha_0 + \alpha_1 (m_t^* - m_t) + \alpha_2 (y_t^* - y_t). \tag{5}$$

Assuming that e_t, $(m_t^* - m_t)$, and $(y_t^* - y_t)$ are each I(1), the long-run equilibrium implies that these three variables are cointegrated. Cointegration implies that $[e_t = \alpha_0 - \alpha_1 (m_t^* - m_t) - \alpha_2 (y_t^* - y_t)] = u_t$ is stationary. Following Engle and Granger (1987), one may consider the following regression to test for cointegration:

$$\triangle \hat{u}_t = \rho \hat{u}_{t-1} + \varepsilon_t, \tag{6}$$

where $\hat{u}_t$ is the residual using the estimated coefficients from the regression in (5). This is the Engle and Granger (EG, hereafter) test for cointegration. As noted by Kremers et al. (1992), the EG test imposes a common factor restriction (CFR) that is not valid in most cases. That is, the long-run coefficients in the regression (5) in levels are usually different from the short-run coefficients that can be obtained from the same regression in first differences. The CFR assumes that these two sets of coefficients are the same. As a consequence, the EG test loses power under the alternative when this CFR does not hold.[2] If the variables are cointegrated we can alternatively describe an error correction model (ECM) as follows:

$$\triangle e_t = \beta_0 + \beta_1 \ddot{u}_{t-1} + \beta_2 \triangle (m_t^* - m_t) + \beta_3 \triangle (y_t^* - y_t) + v_t. \tag{7}$$

2) When the CFR does not hold, the EG type test loses power as the signal-noise ratio increases. The signal-noise ratio refers to the ratio of the variance of the first differences of the regressors in (5) to the ratio of the error variance in the short-run regression in differences; see Im, Lee, and Enders (2005) for more details.

We may add lags of $\triangle e_t$, $\triangle(m_t^* - m_t)$, and $\triangle(y_t^* - y_t)$ in the above equation to allow for serially correlated errors. This is a linear error correction model that can be valid if there is linear cointegration among the variables in (5).

Recently, we have witnessed a growing interest in modeling nonlinear adjustment to the long-run equilibrium. For example, Balke and Fomby (1997) assume that cointegration exists only within a certain range of deviations from the long-run equilibrium implied by the null. Thus, the cointegration relationship might be valid only when the magnitude of the deviation from the long-run equilibrium, u_{t-1}, is beyond some threshold. As such, the adjustment process could differ in two regimes as follows:

$$\boldsymbol{\rho} = 1, \text{ if } |u_{t-1}| \leq \boldsymbol{\gamma} \quad \text{and} \quad \boldsymbol{\rho} = \boldsymbol{\rho}^+, \text{ with } |\boldsymbol{\rho}^+| < 1 \quad \text{if } |u_{t-1}| > \boldsymbol{\gamma}, \qquad (8)$$

where $\boldsymbol{\gamma}$ represents the threshold. When $|u_{t-1}| \leq \boldsymbol{\gamma}$, it is assumed that u_t has a unit root and cointegration does not occur. On the other hand, it is assumed that when $|u_{t-1}| > \boldsymbol{\gamma}$, u_t is a stationary process and cointegration exists. Cointegration implies that the system has a tendency to revert to its equilibrium path. Balke and Fomby note that in such a system, u_t can have a unit root locally while still being stationary in a global sense. However, Balke and Fomby did not provide a est for threshold cointegration.

Enders and Siklos (2001) suggest an alternative threshold specification that permits asymmetric adjustment in the error correction term. They provide relevant critical values to test for threshold cointegration in this framework and consider:

$$\triangle \hat{u}_t = \boldsymbol{\rho}_1 I_t \hat{u}_{t-1} + \boldsymbol{\rho}_2 (1-I_t) \hat{u}_{t-1} + \varepsilon_t, \qquad (9)$$

where

$$I_t = 1 \quad \text{if } \hat{u}_{t-1} \geq \boldsymbol{\gamma} \quad \text{and} \quad I_t = 0 \quad \text{if } \hat{u}_{t-1} < \boldsymbol{\gamma}. \qquad (10)$$

Thus, adjustment is symmetric if $\rho_1 = \rho_2$ and the model becomes the popular linear EG model. They also consider the so-called momentum threshold cointegration model where the two regimes depend on the change in the path of the long-run equilibrium. That is, the indicator function is defined as:

$$I_t = 1 \quad \text{if } \hat{u}_{t-1} \geq \boldsymbol{\gamma} \quad \text{and} \quad I_t = 0 \quad \text{if } \hat{u}_{t-1} < \boldsymbol{\gamma}. \qquad (10)$$

Since the distribution varies, critical values can be tabulated for each different circumstance. The authors provide relevant critical values to perform their tests.

Hansen and Seo (2002) suggest a procedure to estimate and test for the existence of threshold effects in a vector ECM. Taking one equation of their model, we can express it as:

$$\Delta e_t = \beta_0 + \rho_1 \mathrm{I}_t \hat{u}_{t-1} + \rho_2 (1 - \mathrm{I}_t) \hat{u}_{t-1} + v_t. \tag{12}$$

As in (7), we may add lags of Δe_t, $\Delta(m_t^* - m_t)$, and $\Delta(y_t^* - y_t)$ to adjust for serially correlated errors. I_t is similarly defined as in (10). Comparing this model with (7), we observe that equation (12) omits the contemporaneous terms of the regressors $\Delta(m_t^* - m_t)$ and $\Delta(y_t^* - y_t)$. Omitting these terms results in the same loss of power as in the EG type cointegration test under the alternative when the signal-noise ratio increases.

There are some econometric issues that may be more specific to testing the monetary model of exchange rates. As such, some further discussion may be warranted.

First, we note that the regressors $(m_t^* - m_t)$ and $(y_t^* - y_t)$ are assumed to be I(1). These variables are given as deviations in money supply and output between two countries. It is possible that each of these variables can be I(0). If so, then the money supplies in the two countries will be cointegrated. This possibility may be higher for output deviations between the two corresponding countries. In either case, there is a difficulty in employing the usual cointegration tests even in the linear framework, as the tests cannot allow for stationary covariates. In the presence of stationary covariates, the distributions in the usual cointegration tests can depend on the nuisance parameter. Thus, new critical values should be developed but this poses a problem due to the presence of the nuisance parameter. Due to this problem, these variables are usually considered to be I(1) in empirical studies of the monetary model, or the deviations in output variable is sometimes omitted from the cointegration test see, for example, Rapach and Wohar (2002) who examined the existence of cointegration in 14 industrialized countries. In the next section, we utilize new cointegration tests that are free of this problem. The IV threshold cointegration test can allow for stationary covariates in the cointegration model while the distribution of the resulting test statistics still does not depend on the nuisance parameter.

Second, it has been typical to consider a regime classification rule that depends on the deviation from the long-run equilibrium path. Equation (10) has been most popular, while equation (11) allows for a momentum threshold cointegration. These specifications allow for the case of asymmetric effects where positive and negative values of u_{t-1}, or Δu_{t-1}, have different effects. For example, when Δu_{t-1} is used, the indicator function can be described as one that tests for asymmetries in long-run adjustment that depend on whether nominal exchange rates or appreciating or depreciating relative to their fundamentals. We will consider these indicator functions in our analysis. In the present paper, we also wish to improve upon these more familiar classifications and allow for other more general regime classifications. For example, it is very possible that we can have different monetary regimes that depend on other factors affecting macroeconomic fundamentals. Following a change, we expect that exchange rates will adjust to their equilibrium only when the benefits of doing so exceed the transactions costs. For example, exchange rates may not significantly respond to small changes in relative money growth. However, when the change in relative money growth is large enough the exchange rate will adjust to a new equilibrium as suggested by the model. Therefore, one may have different regimes depending on changes in relative money growth, rather than the entire long-run equilibrium path in the system. We may also consider another scenario of nonlinear dynamics. Given that relative money growth and relative price growth are closely related, one can hypothesize that the monetary model will respond to only relatively large changes in relative inflation rates. Thus, it follows that in an environment of low and stable inflation rates the monetary model might be a poor predictor of nominal exchange rates. Given the global movement towards low and stable inflation rates in the 1990s, this outcome suggests considering a monetary model of exchange rates with threshold effects related to the inflationary environment. The existing threshold cointegration tests do not permit us to consider such definitions for regime classification. However, using the new tests, we can allow for a variety of different regime classifications.

More specifically, we can consider the case where the existence of a stable long-run equilibrium hinges on the magnitude of the inflation difference between the foreign and home country. If so, we can describe the following indicator function:

$$I_t = 1 \quad \text{if } (\pi_t^* - \pi_t) \geq |\gamma| \qquad \text{and} \qquad I_t = 0 \quad \text{if } (\pi_t^* - \pi_t) < |\gamma|, \tag{13}$$

where π_t^* and π_t are the foreign and U.S. inflation rates, respectively. Thus, equation (13) suggests that beyond some threshold of absolute differences in inflation the exchange rate will adjust to a long-run stable equilibrium as suggested by the monetary model. Given transactions costs of adjusting to deviations, the equation (13) suggests that u_{t-1} will behave as a nonstationary random walk when $|\gamma|$ is small. Such classification rules could not be considered in the existing threshold cointegration tests because the distribution of the resulting threshold cointegration test statistic varies with the description of the threshold effect. In this case, new critical values would need to be simulated if the relevant asymptotic distributions can be possibly developed. Using the IV threshold cointegration tests, we can avoid such difficulties since the distributions remain standard normal regardless of different indicator functions. Thus, the IV threshold cointegration tests are quite flexible in the sense that the indicator function can be defined without having to define two different regimes based only on the magnitude of the deviations from the long-run equilibrium.

Third, the existing EG type cointegration tests entail subtle econometric problems. As noted previously, the EG based tests lose power when the CFR does not hold. A possible solution is to add the contemporaneous terms $\Delta(m_t^* - m_t)$ and $\Delta(y_t^* - y_t)$ in the testing regression (9). This makes sense, since in practice, any cointegration test that omits the contemporaneous terms in the testing regression will be faced with the same problem, as we examine in the next section. An example is the ECM test based on equation (12). Further, it is clear that all EG type tests have the same problem. On may consider revising the EG type regression to be:

$$\Delta\hat{u}_t = \mathrm{I}_t\,[\rho_1\,\hat{u}_{t-1} + b_1\Delta(m_t^* - m_t) + b_2\Delta(y_t^* - y_t)] +$$
$$(1-\mathrm{I}_t)\,[\rho_2\,\hat{u}_{t-1} + d_1\Delta(m_t^* - m_t) + d_2\Delta(y_t^* - y_t)] + \mathrm{v}_t. \qquad (14)$$

and add lags of $\Delta\hat{u}_t$, $\Delta(m_t^*-m_t)$, and $\Delta(y_t^*-y_t)$ to correct for serial correlations. However, the resulting threshold cointegration tests will have the same problem as the ECM based tests. That is, the distribution of the ECM based tests still depends on the nuisance parameter indicating the weight of two different distributions of the nonstandard DF type and the standard normal. As in the ECM framework, it is simply difficult to construct a valid threshold cointegration test from equation (14).

ADL Threshold Cointegration Tests

We seek to resolve these several different subtle econometric issues in testing for threshold cointegration. In short, it is possible to resolve these issues because threshold IV cointegration tests have the same asymptotic standard normal distribution. In contrast to previous cointegration tests, the stationary IV cointegration test has the distinct advantage that the asymptotic distribution is standard normal, in spite of different deterministic terms, different number of regressors, different (known) threshold effects, or different definitions of the indicator I_t; see Enders, Lee, and Strazicich (2007) for more details of the IV based ADL threshold cointegration tests.

In this regard, we consider two auto-distributed lag (ADL) threshold cointegration tests. We will consider both OLS and IV estimation of the following ADL model:

$$\Delta e_t = I_t\,[\rho_1 e_{t-1} + c_1 (m_t^* - m_t) + c_2(y_t^* - y_t) + b_1\Delta(m_t^* - m_t) + b_2\Delta(y_t^* - y_t)] +$$

$$(1-I_t)\,[\rho_2 e_{t-1} + \delta_1 (m_t^* - m_t) + \delta_2(y_t^* - y_t) + d_1\Delta(m_t^* - m_t) + d_2\Delta(y_t^* - y_t)] + v_t. \qquad (15)$$

Note that the regressors appear in both levels and first differences. We may also add lags of Δe_t, $\Delta(m_t^* - m_t)$, and $\Delta(y_t^* - y_t)$ to correct for serial correlations. There are clear advantages of using ADL models. We will see that the ADL based threshold cointegration tests are free of the problems noted for the EG and ECM type tests. Under the null, the ADL type tests are free of the nuisance parameters found for the ECM based tests. In addition, under the alternative, they do not lose power when the signal-noise ratio increases. In contrast, the power of the ADL based threshold cointegration tests increases when the signal-noise ratio increases. We will test the following null hypothesis in all three regressions:

$$H_o: \quad \rho_1 = 0 \text{ and } \rho_2 = 0 \qquad \text{vs.} \qquad H_1: \text{at least one of these is not zero.}$$

We employ the usual *t*-statistics for the significance of ρ_1 and ρ_2. The usual Wald type statistics to test the joint hypothesis $\rho_1 = \rho_2 = 0$ can also be considered as in Enders, Lee, and Strazicich (2007). Although we do not examine these tests in the present paper, the distribution of the F-test is the usual standard F-distribution.

For the ADL based test, we may use OLS estimation to estimate equation (15) or we may utilize IV estimation. One potential limitation of the OLS based ADL test is that the distribution is nonstandard.[3] As an alternative, we may use the ADL IV test with two sets of instruments:

$$[I_t(e_{t-1} - e_{t-m}),\ (1-I_t)(e_{t-1} - e_{t-m})]' \qquad \text{for } [I_t e_{t-1},\ (1-I_t)\, e_{t-1}]', \text{ and}$$

$$[I_t\,(y_{2,t-1} - y_{2,t-m}),\ (1-I_t)(y_{2,t-1} - y_{2,t-m})]' \quad \text{for } [I_t\, y_{2,t-1},\ (1-I_t)\, y_{2,t-1}], \qquad (16)$$

where m is a fixed number and y_{2t} denotes the regressors $[(y_t^* - y_t),\ (m_t^* - m_t)]'$. Then, we can have:

3) Therefore, we have simulated critical values of the ADL-OLS test and provide them in the Appendix. We also report simulated critical values of the ECM-OLS test as well as the EG-OLS test. The latter two tests are compared with the ADL-OLS test and IV tests for threshold cointegration.

$$t_{\rho 1} = \frac{\hat{\rho}_{1iv}}{s(\hat{\rho}_{1iv})} \quad \text{and} \quad t_{\rho 2} = \frac{\hat{\rho}_{1iv}}{s(\hat{\rho}_{1iv})}, \tag{17}$$

where $\hat{\rho}_{1iv}$ and $\hat{\rho}_{2iv}$ are the IV estimates, and $s(\hat{\rho}_{1iv})$ and $s(\hat{\rho}_{2iv})$ are the corresponding standard errors. Following the result in Enders, Lee, and Strazicich (2007), we have under the null of no cointegration

$$t_{\rho 1} \rightarrow N(0, 1) \ \ and \ \ t_{\rho 2} \rightarrow N(0, 1).$$

The proof is omitted, but it can be shown as a special case of the result in Enders, Lee, and Strazicich (2007). We can also consider the following test statistic for joint insignificance under the null hypothesis:

$$F_i = \text{usual F-statistic for } \rho_1 = \rho_2 = 0. \tag{18}$$

In addition, we may consider the usual t-statistic or F-statistic to test the hypothesis that $\rho_1 = \rho_2$ in order to test for linearity. These statistics follow the usual standard t or F- distributions. It is useful to note that this test can be undertaken regardless of whether the null of no threshold cointegration is rejected, although it is necessary to conduct the linearity test in existing threshold models only when the null of no threshold cointegration is rejected.

The standard normal property is a very convenient result. We now discuss the features of these new threshold cointegration tests and explain how they can resolve the problems and limitations of the existing tests.

First, the limiting distributions of IV threshold cointegration tests do not depend on the number of regressors or on the deterministic terms in (5). Regardless of different model specifications, with or without a constant, trend, polynomial trend, and different numbers of integrated regressors, one can use the same asymptotic critical values from the standard normal distribution, such as -1.645 at the 5% significance level. This is an important feature that cannot be found in the existing OLS based cointegration tests. This result also implies that the distribution remains the same regardless of using different indicator functions.

Second, the threshold cointegration tests are quite flexible in the sense that the indicator function can be defined without having to relate the criterion term directly to the long-run equilibrium path. That is, we can have any variable Zt-1 to define the indicator function as follows:

where Z_{t-1} can be a variable that enters the system of y_t, or some other variable from outside the system. These indicator variables need not enter the system directly in (5).

$$I_t = 1 \quad \text{if } Z_{t-1} \geq \gamma \qquad \text{and} \qquad I_t = 0 \qquad \text{if } Z_{t-1} < \gamma, \tag{19}$$

When Z_{t-1} takes the form of $\hat{u}_{t-1}$ or $\Delta\hat{u}_{t-1}$, we have the usual indicator functions (10) and (11), respectively. It is useful to have $Z_{t-1} = |\pi_t^* - \pi_t|$ as in (13). For instance, in our monetary model of the exchange rate, we may define different regimes using different inflation rates. We may consider the difference between the foreign and U.S. inflation rate as the conditioning variable and examine a nonlinear adjustment in the exchange rate system for high and low differences in inflation. In previous threshold cointegration tests, this type of indicator function could not be considered due to the nuisance parameter problem.

Third, the standard normality result is maintained even if we add stationary variables to the testing regression. The inclusion of stationary variables could not be previously undertaken in the existing cointegration tests without complicating the distribution of the test, since the distribution depends on the added stationary variable. One may consider adding a stationary covariate to the ADL model. Hansen (1995) initially showed that while the use of stationary covariates can enhance thepower of unit root tests, the distribution depends on the nuisance parameter expressed in terms of the signal-noise ratio $\sigma_s^2/\sigma_\varepsilon^2$. Thus, the existence of the nuisance parameter invalidates the resulting unit root or cointegration test. However, if we adopt the IV estimation approach, the asymptotic distribution remains standard normal even when stationary covariates are included.

Fourth, the standard normality result allows us to test for nonlinearity regardless of whether the underlying model is cointegrated or not. The linearity condition implies that $\rho_1 = \rho_2$ in (9) or (14). When OLS estimation is used, one may test for (non-)linearity only in the case of cointegration, but not in the case of no cointegration. It is well known that the regression in (1) will be spurious if there is no cointegration. In this case, the t-statistics for $\rho_1 = 0$ and $\rho_2 = 0$ in (9) or (14) will have nonstandard distributions. In other words, any test for linearity that assumes cointegration can be invalid if there is no cointegration, and vice versa. We can consider four possible cases as discussed in Balke and Fomby (1997):

Linear versus Threshold Behavior

Case 1 Linearity, No cointegration ($\rho_1 = \rho_2$; $\rho_1 = 0$ and $\rho_2 = 0$)	Case 2 No Threshold, No cointegration ($\rho_1 = 0$ and $\rho_2 = 0$)
Case 3 Linearity, Cointegration ($\rho_1 = \rho_2$; $\rho_1 < 0$ or $\rho_2 < 0$ or both)	Case 4 Threshold, Cointegration ($\rho_1 \neq \rho_2$; $\rho_1 < 0$ or $\rho_2 < 0$ or both)

Note that Case 2 cannot be separately identified from Case 1. Clearly, testing for linearity implies Cases 1 and 3 versus Case 4. However, it has been typical to test the null of linearity with cointegration (Case 3) against the alternative of threshold effects with cointegration (Case 4), i.e., assuming cointegration under both the null and alternative hypotheses (Hansen and Seo (2002)). This can pose a problem, since this is a test for local versus local. If cointegration does not exist but linearity holds (Case 1), then the null will be spuriously rejected.[4] However, with the IV estimation method we are free of such problems since the distribution of the statistic testing for linearity is the same standard normal distribution regardless of whether the variables are cointegrated.

Fifth, the asymptotic normality result in the IV threshold cointegration tests implies that we can provide a solution to the problem of nuisance parameters in the cointegration model with structural changes. It is well known that the distribution of the usual cointegration tests depends on nuisance parameters indicating the number of breaks and their locations. It is simply troublesome to simulate different critical values for all different combinations of break locations. In the IV cointegration tests, the asymptotic distribution remains standard normal, regardless of the number of breaks and their locations. However, we donot explicitly examine structural change in the present paper.

4) We also note in passing that a similar conceptual problem exists in the OLS based threshold cointegration test that takes the null of no cointegration (Case 1 or 2) against the alternative of threshold cointegration (Case 4). If linear cointegration occurs, then the test will have trivial power. But, the rejection does not necessarily imply threshold cointegration, as it is possible that there is a linear cointegration.

1. Finite Sample Properties

We investigate the finite sample properties of the IV threshold cointegration tests by using Monte Carlo simulations. For comparison purposes, we also examine the OLS based tests. In addition, we also examine the IV tests based on the EG and ECM models. Details of our simulation results are described in Appendix A, but we note our major findings here.

First, it is clear from our simulations that the OLS based ECM test cannot be used to test for threshold cointegration. As noted previously, the linear ECM test depends on the nuisance parameter indicating the ratio of the two error variances. The ECM-OLS test shows serious size distortions. This finding may also imply that the estimation results based on the nonlinear ECM can be considered questionable because the distribution of the parameter estimates depends on the nuisance parameter indicating the signal-noise ratio, which is related to a mixture of nonstandard and standard normal distributions. However, the ADL and EG type tests are not subject to this problem, even when they are estimated with OLS. Both the OLS based ADL and EG type tests have reasonable size properties in all cases. On the other hand, the problem of the EG based tests is loss of power under the null. The EG- OLS test loses power as the signal-noise ratio increases. The same loss of power is observed for the ECM and ADL based tests if the contemporaneous terms are omitted from the testing regression.

Second, the IV tests are reasonably robust to different model specifications. As noted, our tests do not critically depend on the number of integrated regressors or different deterministic terms. The same 5% critical value of -1.645 is used in all simulations for the IV threshold tests. We note that the standard normal distribution is an asymptotic result, and in finite samples the distribution can be mildly affected by different model specifications. Nevertheless, the simulation results indicate that the size and power properties do not deteriorate much with different numbers of regressors, different signal-noise ratios, different indicator functions, and different sample sizes. Although we did not specifically examine structural breaks, we expect that similar results will follow. Most important, as expected, the IV tests are invariant to the same nuisance parameters that make the OLS based tests invalid. The IV cointegration tests do not depend on the signal-noise ratio under the null, and their power increases as the signal-noise ratio increases under the alternative.

Third, while the ADL-OLS test has a nonstandard distribution, its performance is fairly good. Using the corresponding critical values in Table A.1, the OLS based ADL test shows good properties throughout. Overall, the two ADL threshold cointegration tests have the most desirable properties in our simulations. However, the ADL-OLS tests do not have all of the desirable properties of the ADL-IV test, which has a standard normal distribution.

III. Empirical Results of Testing the Monetary Model of Exchange Rates

We will now examine the results of testing the monetary model of exchange rates with our newly developed threshold cointegration tests. We wish to test for the existence of a long-run stable equilibrium in the monetary model. To perform our tests, we utilize the data in Mark and Sul (2001).[5] The data consists of quarterly observations on eighteen countries over the time period 1973:1-1997:1. All nominal exchange rates are measured in foreign currency units per U.S. dollar.

Prior to performing our threshold cointegration tests, we utilize two types of unit root tests to check the order of integration in our variables. First, we utilize the standard augmented Dickey and Fullertest. Since Perron (1989) demonstrated that failure to consider existing structural breaks will lead to a bias against rejecting the unit root when it should be rejected, we include structural breaks in our second set of unit root tests. To do so, we utilize the two-break LM unit root test developed by Lee and Strazicich (2003). One may consider the one-break unit root test, but using the two break test allows for a more general model. The test jointly determines the location of two breaks in intercept and trend while testing the null hypothesis of a unit root. In both tests, we determine the number of lagged augmented terms by following a general-to-specific rule beginning with a maximum of eight lagged terms. In the two-break LM test, the number of lagged augmented terms and the break locations are jointly determined. Our unit root test results are summarized in Table 1. Using the ADF unit root test, we are unable to reject the null of a unit root in any case for the nominal exchange rate (e) and relative money supply (m* - m). However, we reject the unit root for relative output (y* - y) in two of the eighteen countries (Norway and Spain) at the 5%level of significance.[6]

We next examine the two-break LM unit root test results. We are unable to reject a unit root in exchange rates in any country at the 5% level of significance. With

5) We are grateful to Nelson Mark for providing the data.

6) We also conducted unit root tests on the variables after taking the first difference. All series were stationary. These results are available upon request.

regards to the (log) difference of the foreign and U.S. money variable, after including breaks we reject the unit root hypothesis in six countries (Australia, Korea, Norway, Finland, Greece, and the U.K.) at the 5% level of significance. For the (log) relative output variable, we can reject the unit root in seven countries (Italy, Austria, Korea, Denmark, Sweden, Greece, and the U.K.) at the 5% level of significance. The finding of stationary relative money supplies implies that foreign and U.S. money supplies are cointegrated in each of the six countries, as the difference is stationary. The same is truefor relativeoutputs in the seven countries; U.S. output tends to be cointegrated with foreign output. This happens when the economies of two countries are closely related by a long-run relationship. The immediate implication of this finding for the monetary model of exchange rates is that it is not always proper to consider relative money supplies and outputs as I(1). However, assuming that the relative money supply and output variables are I(1) has often been the practice so that the usual cointegration tests can be employed. In other cases, when unit root tests indicate that relative output is I(0) for some countries, the authors omit this variable from their cointegration tests (e.g., Rapach and Wohar (2002)). One limitation of the usual cointegration tests is that they require that all regressors be non-stationary. It may be possible to allow for stationary covariates in the cointegration regression, but the distribution of the resulting cointegration test is unknown because it depends on the added covariates. Perhaps due to this limitation, it might have been necessary in previous studies to treat all of the relative money and output variables as I(1). However, in our newly proposed (threshold) tests based on IV estimation, it is possible to add stationary covariates without affecting the distribution of the cointegration test. As such, in conducting our empirical estimations that follow, this feature permits us to treat some of these variables as I(0) in the threshold cointegration test.

Given that the ADL tests have the most desirable properties in our simulations, we will utilize the ADL-OLS and ADL-IV threshold cointegration tests to perform our empirical estimations. Other test results are generally similar to the results from these tests; they are available upon request. For each test using the OLS based test, we will need to determine the optimal number of lags in the testing regression to assure a proper treatment of serial correlations. We employ the Schwarz information criteria (SIC) to determine the optimal lag. In using the IV tests, we need to determine jointly the optimal value of m to construct a proper IV (w_t) and the optimal number of lags to correct for serial correlations. As a first step, we search for the optimal lag for a given value of m, for m = 1, and $maxm$, where $maxm$ is given as $T^{0.5}$. Then, we determine the optimal value of m that minimizes the residual sum of squares (RSS) from the regression that utilizes the optimal number of lags. We report the estimated values of *m* and the optimal lagged terms in the relevant tables. In each table, we also report the t-test statistic that tests the null hypothesis that the coefficients on the error correction terms are the same ($\rho_1 = \rho_2$).

2. Asymmetric Momentum Threshold Effects

We first examine results of describing asymmetric threshold effects according to the changes in deviations from the monetary model equilibrium. In this regard, we consider a momentum threshold model where positive (depreciating relative to fundamentals) and negative (appreciating relative to fundamentals) changes in the deviation from equilibrium have different impacts on exchange rate adjustment. This is the general momentum threshold indicator as described by Enders and Siklos (2001). We describe these effects by letting $I_t = 1$ if $\Delta u_{t-1} \geq 0$, and $I_t = 0$ if $\Delta u_{t-1} < 0$.

Thus, adjustment to equilibrium in the monetary model depends on whether the nominal exchange rate is appreciating ($\Delta u_{t-1} < 0$) or depreciating ($\Delta u_{t-1} \geq 0$) relative to fundamentals. For example, central banks and foreign exchange traders may respond differently depending on whether exchange rates are depreciating or appreciating. The results are displayed in Table 2. Looking at the results from the ADL- OLS threshold cointegration test, we observe that 3 of the 18 countries reject the null of no cointegration in at least one regime (Korea, the Netherlands, and Switzerland) at the 10% level of significance. In all three of these cases, the null of no cointegration is rejected only in the regime where $\Delta u_{t-1} < 0$, or when the nominal exchange rate is appreciating. There is less support for cointegration using the ADL-IV test. Using the ADL-IV test the null of no cointegration is rejected in only one country (the Netherlands) and, again, only when the nominal exchange rate is appreciating. Examination of the t-test statistics that $\rho_1 = \rho_2$ in the ADL-OLS results finds limited support for asymmetric effects from Δu_{t-1}. The null that $\rho_1 = \rho_2$ is rejected in only (the same) 3 countries. Using the ADL-IV test, the null that $\rho_1 = \rho_2$ is rejected in only 1 country using the ADL-IV test (the Netherlands). Overall, these results offer support for cointegration in the monetary model in only 1 to 3 countries.

3. Asymmetric Deviation Threshold Effects

In the threshold cointegration model, one popular threshold is to allow for different regimes using the indicator function (10), where $I_t = 1$ if $u_{t-1} \geq \gamma$ and $I_t = 0$ if $u_{t-1} < \gamma$; see equation (5). Thus, the adjustment process depends on whether the deviation from the long- run equilibrium path is greater or less than the threshold. This specification mimics the spirit of the model proposed by Balke and Fomby (1997), who assumed that cointegration exists only within a certain range of deviations from the long-run equilibrium implied by the null. However, it might be necessary to estimate the threshold parameter (γ) in this case. Searching for the optimal value of the threshold parameter, while desirable, is beyond the scope of the present analysis. As such, we assume in (1) that the threshold parameter is the mean (μ_u) of u_{t-1}. The mean equals zero if the residual from the first stage regression is used. We report the results of testing in Table 3. Again, using the ADL-OLS test, we can reject the null of no cointegration in at least one regime in 5 of the 18 countries (Austria, Canada, Denmark, the Netherlands, and U.K.) at the 10% level of significance. In all these cases, the null of no cointegration is rejected only in the regime where $u_{t-1} < \mu_u$, implying that the deviation from the long-run equilibrium is negative. There is less support for cointegration using the ADL-IV test. Using the ADL-IV test the null of no cointegration is rejected in only 2 countries (Austria and U.K.).

4. Allowing For Stationarity of Output Deviations

As the unit root test results indicate that the output deviation variable y* - y might be stationary for some countries, we examine the case where this variable is treated as I(0). This implies that y* - y does not enter the cointegrating regression (5), but instead enters the short- run dynamic regression. Previously we found that the relative money supply variable is also stationary for six countries, but there is a conceptual flaw when treating both right-hand variables as I(1). When the dependent variable is I(1), it is not feasible to have only stationary right-hand variables. In this case, the error term of the regression would be non- stationary, which eliminates the possibility of cointegration. Therefore, we do not consider such a case, and examine only the case where y*-y is treated as I(0). The results reported in Table 4 are valid only for the 7 countries (underlined) for which y* - y rejects the unit root (using the LM test). Using the ADL-OLS test, we can reject the null of no cointegration in at least one regime for

2 of the 7 countries (Korea and U.K.) at the 10% level of significance. Using the ADL-IV test, the null is rejected only for the U.K. data.

5. Inflation Regimes

As previously noted, we wish to examine if the existence of a stable long-run equilibrium in the monetary model depends on the inflationary environment. As noted in Section I, previous researchers have often been unable to find evidence of a long-run stable relationship between nominal exchange rates and the fundamental variables in the monetary model. Given that some researchers have suggested possible threshold effects in exchange rate adjustments due to transaction costs, we want to determine if adjustment to a stable long-run equilibrium is predicated by the magnitude of the differences in inflation rates ($\pi^* - \pi$). This type of threshold cointegration test was not previously possible due to the nuisance parameter problems noted above. To perform our tests, we let I_t =1 if the absolute value of the difference in foreign and U.S. quarterly inflation rates is greater than 0.25, and I_t = 0 otherwise. Then we allow the threshold to take a higher inflation difference by letting I_t = 1 if $(\pi^* - \pi) \geq |1.0|$ indicates, and 0 otherwise. This translates roughly into an absolute inflation differential between each country and the U.S. of 1% and 4% at annual rates. Given transactions costs in the foreign exchange market, we expect to find stronger evidence of cointegration as the difference in inflation rates increases. We will not go beyond (π^* - π) = 1.0, as the number of observations in each regime would be quite limited in our data. The hypothesis that the magnitude of differences in inflation rates matters can be additionally examined by considering the values of ρ_1 and ρ_2 in the cointegration test results. If the magnitude of the difference in inflation rates were not important then we would expect that $\rho_1 = \rho_2$. As noted in Section II, we will examine one other type of threshold effect that depends only on the magnitude of the U.S. inflation rate (the medium quarterly rate of 1.1%).

The results of testing with different inflation regimes are shown in Tables 5 through 7. We first consider results of testing for threshold cointegration when the absolute value of the difference in quarterly inflation rates $(\pi_t^* - \pi_t)$ is greater than or equal to 0.25. The results are reported in Table 5. We first examine the results using the ADL-OLS test. In 3 of the 18 countries we can reject the null of no cointegration in at least one inflationary regime (at the 10% level of significance). In 2 of the 18 countries we can reject the null of no cointegration only when inflation differences are high (Germany and the U.K.). These results imply that for these 2 countries, a stable long-run equilibrium in the monetary model exists only when the differences in inflation are large. Otherwise, cointegration does not occur and the monetary model does not provide a valid long-run equilibrium model. In this case, the deviations from equilibrium would be nonstationary with no tendency to revert to a stable equilibrium following a shock. In 1 of the 18 countries we can reject the null of no cointegration only when inflation differences are low (Canada). No results are available for Greece due to the fact that the proportion of observations in the low inflation difference regime is too low to estimate the test statistics. We next consider the ADL-IV test results by examining the $t_{\text{ADL-IV}}$ *t*-test statistic. Note that *m* denotes the number of lags utilized in the stationary IV. The null of no cointegration is rejected in at least one inflation regime in 3 of the 18 countries (at the 10% level of significance). This is the same number of rejections as in the ADL-OLS test, although the countries differ. In 1 of the 18 countries we can reject the null of no cointegration only in the high inflation difference regime (France). In 2 of the 18 countries we can reject the null of no cointegration only when inflation differences are low (Denmark and Spain). Again, no results are available for Greece due to insufficient data in the low inflation difference regime. Examining the t-test statistics that $\rho_1 = \rho_2$ provides almost no evidence that the coefficients on the error correction terms differ in each regime. The t-test statistic rejects the null of equal coefficients only for Canada at the usual significance levels. Overall, these results provide support for the existence of a stable long- run equilibrium in the monetary model for only 3 countries. In addition, there is little evidence that the inflationary environment affects the adjustment to equilibrium in the monetary model.

We next examine the results in Table 6 where the difference in inflation rates is greater than or equal to approximately 4% at an annual rate. This case allows for the greatest difference in inflationary environments in our sample. We first examine the results using the ADL-OLS threshold cointegration test. Compared to the results in Table 5, we find more evidence of cointegration as the null of no cointegration is rejected in 5 of the 18 countries (at the 10% level of significance). In 2 of the 18 countries we can reject the null of no cointegration only in the high inflation difference regime (Germany and the Netherlands). In 3 of the 18 countries we can reject the null of no cointegration only in the low inflation difference regime (France, Italy, and Spain). Again, no results are available for Greece due to insufficient observations in one regime. We next consider the ADL-IV test statistic. The null of no cointegration is rejected in at least one inflation regime in 5 of the 18 countries. Again, the number of rejections is the same as for the ADL-OLS test, although 4 of the 5 countries differ. In 4 of the 18 countries we can reject the null of no cointegration only in the high inflation difference regime (Australia, Austria, the Netherlands, and Switzerland). Again, no results are available for Greece due to insufficient data in both regimes. Using the ADL-IV test, we can reject the null of equal coefficients in only 1 country (the Netherlands). Overall, by using a larger threshold for inflation differences we find some additional support that the inflationary regime affect the existence of a stable long-run equilibrium in the monetary model. However, in spite of this greater support, the support for the monetary model remains modest.

We next examine our test results when the threshold effect depends only on the magnitude of the U.S. inflation rate. In this case, we construct the indicator function I_t = 1 if the U.S. quarterly inflation rate is greater than or equal to 1.1%, and I_t = 0 otherwise. We utilize this inflation rate because it represents the medium quarterly inflation rate over the sample period of our data. The test results are displayed in Table 7. We first examine the ADL-OLS test results. Similar to the results in Tables 5 and 6, the results in Table 7 reject the null of no cointegration for only 3 of the 18 countries in at least one inflationary regime (at less than the 10% level of significance). In all three of these countries we reject the null of no cointegration only in the high U.S. inflation regime (Canada, Korea, and the U.K.). We next consider the ADL-IV test statistic. The null of no cointegration is not rejected in any case using the ADL-IV test. Examining the t-statistic that $\rho_1 = \rho_2$, we see almost no support for the proposition that ρ_1 and ρ_2 are significantly different. The null that the two error correction coefficients are equal is rejected in only one case (Canada) with the ADL-OLS test. The null is not rejected in any case using the ADL-IV test. Overall, we find support for the monetary model in only 3 of the 18 countries.

IV. Summary and Conclusion

In this paper, we utilize new threshold cointegration tests based on estimation using stationary IVs. In contrast to existing tests, the stationary IV threshold cointegration test is unaffected by nuisance parameters and is asymptotically standard normal. This is the case regardless of the number of regressors, trend, the type of threshold effect, or the presence of stationary covariates in the cointegration test. We have provided the small sample properties of various IV tests and found that the ADL type test performs better. The simulations are generally robust to the asymptotic properties and perform well in terms of size and power. We then utilize the ADL threshold cointegration tests to test for a stable long-run equilibrium in the monetary model of exchange rates.

While previous researchers have considered nonlinear versions of the monetary model, they were unable to test the null of no cointegration in a nonlinear framework due to nuisance parameter problems in the existing cointegration tests. As a result, previous researchers generally assumed nonlinear cointegration and/or performed linear cointegration tests. In this paper, we strive to make a contribution towards filling this gap in the literature by examining the threshold cointegration tests and testing the long-run validity of the monetary model. The methodology advanced in this paper is new and can be utilized in many other studies.

In our tests of the monetary model of exchange rates, we consider a variety of threshold effects that were not possible to consider with previous cointegration tests. Foremost, we examine the hypothesis that a high or low inflationary environment will affect the adjustment of the monetary model to its long-run equilibrium. In addition, we consider different asymmetric effects by examining the deviations from macroeconomic fundamentals in the model. Testing is performed using quarterly data from eighteen countries for the time period of 1973-1997. Overall, our empirical results find evidence that the monetary model describes long-run adjustments in nominal exchange rates in 3 to 6 of the 18 countries examined. In addition, we find little evidence that high or low inflation, or asymmetries in adjustment, help to explain the long-run adjustment of nominal exchange rates. While, in general, our empirical findings are discouraging for the monetary model, extensions might reveal different results. We leave such extensions for future research.

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Table 1. Unit Root Test Results

Var.	Country	*ADF t-test stat.*	*Two-Break LM t-test statistic*	$\hat{T}_B$	Country	*ADF t-test stat.*	*Two-Break LM t-test statistic*	$\hat{T}_B$
e	Australia	-1.67	-4.50	79:4, 84:3	Italy	-1.92	-4.42	82:4, 87:3
m^*-m		-1.82	-6.23**	84:3, 91:3		-1.14	-5.34*	80.2, 91:2
y^*-y		-2.04	-4.74	81:3, 92:1		-2.85	-5.95**	76:4, 89:2
e	Austria	-2.74	-5.29	80:3, 86:1	Japan	-3.03	-4.68	77:2, 80:1
m^*-m		-2.99	-5.19	78:3, 85:4		-2.66	-4.48	82:2, 89:2
y^*-y		-3.27*	-5.60**	76:3, 77:2		-1.84	-4.68	79:2, 92:4
e	Belgium	-2.42	-4.92	80:3, 85:3	Korea	-2.36	-4.79	79:3, 87:3
m^*-m		-1.05	-3.80	82:2, 89:2		-3.00	-6.20**	80:2, 86:2
y^*-y		-2.87	-4.89	76:3, 90:2		-1.73	-5.87**	79:2, 88:3
e	Canada	-2.16	-4.59	80:1, 91:3	Nether-lands	-2.68	-5.34*	80:3, 86:1
m^*-m		-2.43	-4.93	79:2, 87:1		-2.12	-4.18	76:4, 85:4
y^*-y		-3.20*	-4.82	82:1, 85:1		-3.00	-5.63*	76:4, 90:4
e	Denmark	-1.87	-5.21	80:3, 85:2	Norway	-2.46	-4.84	82:1, 86:4
m^*-m		-2.71	-5.09	79:4, 85:1		-2.74	-5.84**	82:2, 93:3
y^*-y		-1.97	-6.85***	79:1, 87:4		-3.79**	-5.57*	76:3, 79:4
e	Finland	-2.82	-5.30	82:1, 87:3	Spain	-2.03	-4.76	81:4, 88:3
m^*-m		1.24	-6.14**	84:1, 88:4		-2.59	-5.36*	82:3, 88.2
y^*-y		-2.73	-5.63*	81:1, 91:1		-3.61**	-5.01	77:1, 89:3
e	France	-2.24	-4.89	80:3, 85:3	Sweden	-3.02	-5.39*	83:3, 92:1
m^*-m		-2.17	-5.60*	81:1, 91:3		-1.88	-4.83	80:2, 86:2
y^*-y		-3.18*	-4.61	85:1, 90:4		-3.02	-6.29**	82:3, 91:1
e	Germany	-2.76	-5.11	80:3, 86:1	Switzer-land	-2.98	-5.44*	79:3, 85:3
m^*-m		-2.25	-4.49	82:2, 89:4		-1.69	-4.59	78:3, 90.3
y^*-y		-3.16*	-5.37*	87:2, 90:4		-2.44	-5.57*	77:4, 90:4
e	Greece	-1.85	-4.67	78:2, 84:1	UK	-3.09	-5.12	81:1, 87:3
m^*-m		-1.70	-6.15**	89:1, 94:1		-1.08	-6.08**	76:2, 84:3
y^*-y		-1.44	-7.01***	83:4, 92:3		-2.87	-6.28**	77:2, 86:2

Note: The time period of the data is 1973:4-1997:1. All unit root tests include a constant and trend. In the two-break LM unit root test, $\hat{T}_B$ denotes the estimated break years. The critical values in the LM test with two breaks in intercept and trend depend (somewhat) on the location of the breaks $\lambda = (T_{B1}/T,\ T_{B2}/T)$, and are symmetric around λ and $(1-\lambda)$. As such, we utilize critical values corresponding to the break locations. The two-break LM test critical values come from Table 2 in Lee and Strazicich (2003). *, **, and *** denote a rejection of the unit root null at the 10%, 5%, and 1% levels of significance, respectively.

Table 2. Threshold Cointegration Test Results, $I_t = 1$ if $\varDelta u_{t-1} \geq 0$ and $I_t = 0$ if $\varDelta u_{t-1} < 0$

Country		ADL-OLS				ADL-IV				
		coeff	$t_{ADL\text{-}OLS}$	t-stat $\rho_1=\rho_2$	lag	coeff	$t_{ADL\text{-}IV}$	t-stat $\rho_1=\rho_2$	lag	m
Australia	ρ_1	-0.03	-0.48	0.11	1	-0.05	-0.42	0.32	2	7
	ρ_2	-0.03	-0.74			-0.25	-0.41			
Austria	ρ_1	-0.02	-0.40	0.84	0	-0.01	-0.008	-0.36	2	9
	ρ_2	-0.10	-1.58			0.14	0.36			
Belgium	ρ_1	-0.01	-0.23	1.35	1	0.09	0.06	0.06	5	7
	ρ_2	-0.14	-2.10			-0.01	-0.02			
Canada	ρ_1	-0.05	-1.15	1.06	0	0.03	0.54	1.27	1	4
	ρ_2	-0.11	-2.59			-0.21	-1.16			
Denmark	ρ_1	-0.05	-0.96	0.20	1	-0.10	-0.68	-0.20	0	3
	ρ_2	-0.07	-1.27			-0.04	-0.17			
Finland	ρ_1	-0.05	-0.84	0.99	1	-0.002	-0.02	-0.30	2	6
	ρ_2	-0.12	-2.38			0.07	0.32			
France	ρ_1	-0.09	-1.87	0.39	1	-0.06	-0.95	-0.06	0	9
	ρ_2	-0.12	-2.14			-0.05	-0.54			
Germany	ρ_1	-0.12	-1.58	-0.11	1	-0.04	-0.49	0.04	0	9
	ρ_2	-0.11	-2.04			-0.05	-0.48			
Greece	ρ_1	-0.05	-0.85	-0.20	1	-0.46	-0.98	-0.76	4	8
	ρ_2	-0.03	-0.64			-0.04	-0.14			
Italy	ρ_1	-0.12	-2.25	-0.97	1	-0.10	-0.88	-0.68	0	6
	ρ_2	-0.05	-0.92			0.03	0.22			
Japan	ρ_1	-0.03	-0.83	-0.16	1	0.01	0.14	0.12	0	8
	ρ_2	-0.02	-0.66			0.001	0.02			
Korea	ρ_1	-0.005	-0.13	3.76***	1	-0.01	-0.05	0.20	0	9
	ρ_2	-0.24	-4.72***			-0.04	-0.89			
Nether-	ρ_1	0.02	0.39	2.92***	1	0.05	0.60	1.87*	1	6
lands	ρ_2	-0.20	-3.85***			-0.18	-1.90**			
Norway	ρ_1	-0.10	-1.19	0.55	1	0.02	0.18	0.17	0	9
	ρ_2	-0.16	-2.38			-0.15	-0.15			
Spain	ρ_1	-0.04	-0.86	0.13	1	-0.06	-0.31	-0.36	2	6
	ρ_2	-0.05	-1.36			0.02	0.22			
Sweden	ρ_1	0.01	0.10	1.71*	1	0.01	0.04	0.40	0	8
	ρ_2	-0.13	-2.30			-0.07	-0.68			
Switzer-	ρ_1	0.01	0.13	2.44**	1	0.03	0.26	1.15	0	9
land	ρ_2	-0.19	-3.11**			-0.30	-1.14			
UK	ρ_1	-0.13	-1.49	0.52	1	-0.01	-0.08	0.14	1	9
	ρ_2	-0.19	-2.49			-0.05	-0.24			

Note : Critical values in Table A.1 were used for the ADL-OLS test. Asymptotic standard normal critical values were used for the ADL-IV test (−2.326, −1.645, and −1.282 at the 10%, 5%, and 1% levels of significance, respectively). The value of m in the ADL-IV test was chosen from the model with the minimum sum of squared residuals. All models include a constant without trend. The t-statistic tests the null that $\rho_1 = \rho_2$. Here, *, **, and *** denote rejection of the no cointegration null at the 10%, 5%, and 1% levels of significance, respectively.

Table 3. Threshold Cointegration Test Results, $I_t = 1$ if $u_{t-1} \geq \mu_u$ and $I_t = 0$ if $u_{t-1} < \mu_u$

Country		*ADL-OLS*				*ADL-IV*				
		coeff	$t_{ADL\text{-}OLS}$	*t-stat* $\rho_1=\rho_2$	*lag*	*coeff*	$t_{ADL\text{-}IV}$	*t-stat* $\rho_1=\rho_2$	*lag*	*M*
Australia	ρ_1	-0.158	-2.30	-0.707	0	-0.270	-1.61	-0.016	0	9
	ρ_2	-0.065	-0.58			-0.262	-0.540			
Austria	ρ_1	0.047	0.426	2.41^{***}	0	0.017	0.006	0.216	0	9
	ρ_2	-0.356	-2.85^{**}			-0.631	-1.98^{**}			
Belgium	ρ_1	-0.002	-0.22	2.02^{***}	0	0.264	0.349	0.222	1	9
	ρ_2	-0.335	-2.63^{**}			-0.087	-0.063			
Canada	ρ_1	-0.041	-0.556	1.70^{**}	0	0.036	0.171	0.468	3	4
	ρ_2	-0.273	-2.38			-0.374	-0.440			
Denmark	ρ_1	-0.044	-0.604	2.75^{***}	0	0.023	0.229	0.564	2	6
	ρ_2	-0.458	-3.48^{**}			-0.235	-0.526			
Finland	ρ_1	0.122	1.42	2.11^{***}	0	0.193	0.859	-0.151	1	5
	ρ_2	-0.195	-1.59			0.279	0.529			
France	ρ_1	-0.094	-1.03	-0.551	0	-0.037	-0.288	-0.396	0	8
	ρ_2	-0.107	-0.163			0.037	0.273			
Germany	ρ_1	-0.084	-0.867	1.36	0	-0.052	-0.155	-0.334	3	9
	ρ_2	-0.288	-2.53			0.110	0.312			
Greece	ρ_1	-0.046	-0.590	0.701	0	0.122	0.973	0.596	2	7
	ρ_2	-0.137	-1.31			-0.234	-0.401			
Italy	ρ_1	0.077	1.09	2.51^{***}	0	0.289	1.90	0.198	2	5
	ρ_2	-0.230	-2.29			0.072	0.067			
Japan	ρ_1	-0.135	-1.40	-0.278	0	-0.432	-1.25	-0.122	3	5
	ρ_2	-0.102	-1.56			-0.375	-1.14			
Korea	ρ_1	-0.016	-0.143	1.54	0	-0.034	0.393	0.366	0	9
	ρ_2	-0.203	-2.42			-0.021	-0.169			
Nether-lands	ρ_1	-0.015	-0.180	2.31^{***}	0	0.078	0.114	0.106	2	3
	ρ_2	-0.334	-3.08^{**}			-0.112	-0.068			
Norway	ρ_1	-0.101	-1.08	2.17^{***}	0	-0.141	-0.616	-0.291	3	9
	ρ_2	-0.447	-3.46^{**}			-0.026	-0.083			
Spain	ρ_1	-0.104	-1.42	-0.088	0	0.145	0.472	0.418	1	6
	ρ_2	-0.094	-1.05			0.003	0.024			
Sweden	ρ_1	-0.033	-0.309	0.081	0	0.217	1.37	-0.086	2	8
	ρ_2	-0.044	-0.498			0.234	1.75			
Switzer-land	ρ_1	0.132	1.22	2.22^{***}	0	0.144	0.512	0.073	0	4
	ρ_2	-0.221	-1.90			0.106	0.246			
UK	ρ_1	-0.191	-1.82	2.27^{***}	0	-0.010	0.031	1.76^{**}	0	6
	ρ_2	-0.540	-4.80^{***}			-0.757	-2.46^{***}			

Note : See notes to Table 2. The threshold value (μ_u) is given as the mean of $\hat{u}_{t,}$ which is zero. Critical values in Table A.1 were used for the ADL-OLS test.

Table 4. Threshold Cointegration Test Results, y*-y is treated as I(0); $I_t = 1$ if $\Delta u_{t-1} > 0$, $I_t = 0$ if $\Delta u_{t-1} \leq 0$

Country		*ADL-OLS*				*ADL-IV*				
				t-stat				*t-stat*		
		coeff	$t_{ADL\text{-}OLS}$	$\rho_1=\rho_2$	*lag*	*coeff*	$t_{ADL\text{-}OLS}$	$\rho_1=\rho_2$	*lag*	*m*
Australia	ρ_1	-0.03	-0.50	-0.05	1	-0.12	-0.14	-0.12	3	6
	ρ_2	-0.02	-0.52			-0.01	-0.07			
<u>Austria</u>	ρ_1	-0.03	-0.59	0.53	1	-0.01	-0.12	0.24	0	9
	ρ_2	-0.08	-1.23			-0.04	-0.36			
Belgium	ρ_1	-0.01	-0.15	1.45	1	0.24	1.63*	1.28	0	9
	ρ_2	-0.14	-2.16			-0.03	-0.17			
Canada	ρ_1	-0.05	-1.15	1.10	0	0.05	0.73	0.52	1	4
	ρ_2	-0.11	-2.63*			-0.07	-0.33			
<u>Denmark</u>	ρ_1	-0.06	-1.01	0.26	1	0.01	0.02	0.22	6	7
	ρ_2	-0.08	-1.44			-0.13	-0.70			
Finland	ρ_1	-0.06	-1.05	0.82	1	-0.03	-0.40	0.10	0	9
	ρ_2	-0.12	-2.37			-0.04	-0.33			
France	ρ_1	-0.08	-1.80	0.45	1	-0.02	-0.14	0.57	5	6
	ρ_2	-0.12	-2.10			-0.22	-0.74			
Germany	ρ_1	-0.04	-0.60	0.86	1	0.05	0.49	0.57	0	9
	ρ_2	-0.11	-2.05			-0.03	-0.32			
<u>Greece</u>	ρ_1	-0.05	-0.82	-0.03	1	0.01	0.05	0.14	0	3
	ρ_2	-0.04	-0.85			-0.05	-0.14			
<u>Italy</u>	ρ_1	-0.12	-2.24	-0.97	1	-0.15	-1.29*	-0.77	0	6
	ρ_2	-0.05	-0.96			0.01	0.08			
Japan	ρ_1	-0.004	-0.11	0.36	1	-0.01	-0.04	0.07	0	8
	ρ_2	-0.02	-0.62			-0.02	-0.29			
<u>Korea</u>	ρ_1	-0.004	-0.10	4.22***	1	-0.06	-0.29	0.59	2	7
	ρ_2	-0.26	-5.32***			-0.17	-3.12***			
Nether-lands	ρ_1	0.03	0.45	2.71***	1	0.04	0.50	1.25	1	6
	ρ_2	-0.19	-3.44**			-0.12	-1.20			
Norway	ρ_1	-0.09	-1.21	0.80	1	-0.05	-0.26	0.61	0	9
	ρ_2	-0.17	-2.49			-0.29	-0.88			
Spain	ρ_1	-0.05	-1.10	0.09	1	-0.14	-0.10	-0.15	0	6
	ρ_2	-0.06	-1.51			0.07	0.22			
<u>Sweden</u>	ρ_1	-0.005	-0.09	1.49	1	0.04	0.45	1.00	0	9
	ρ_2	-0.11	-2.29			-0.10	-0.90			
Switzer-land	ρ_1	0.01	0.22	2.68***	1	0.10	1.10	1.34	0	9
	ρ_2	-0.20	-3.47**			-0.28	-1.03			
<u>UK</u>	ρ_1	-0.10	-1.16	0.76	1	0.002	0.02	0.76	0	9
	ρ_2	-0.18	-2.64*			-0.12	-1.11			

Note: See notes to Table 2. The indicator function is defined as: $I_t = 1$ if $\Delta u_{t-1} > 0$, $I_t = 0$ if $\Delta u_{t-1} \leq 0$; The deviation variable, y* -y, is treated as I(0), as it is not included in the long-run regression but is included in the short-run regression.

Table 5. Threshold Cointegration Test Results, Quarterly Inflation Rates, $I_t = 1$ if $(\pi^* - \pi) \geq |0.25|$

Country		*ADL-OLS*				*ADL-IV*				
				t-stat				*t-stat*		
		coeff	$t_{ADL\text{-}OLS}$	$\rho_1=\rho_2$	*lag*	*coeff*	$t_{ADL\text{-}IV}$	$\rho_1=\rho_2$	*lag*	*m*
Australia	ρ_1	-0.04	-1.19	-0.46	0	-0.05	-0.22	-0.22	2	7
	ρ_2	0.03	0.20			0.32	0.20			
Austria	ρ_1	-0.03	-0.51	-0.59	0	0.02	0.02	-0.03	0	8
	ρ_2	0.03	0.37			0.05	0.48			
Belgium	ρ_1	-0.04	-0.86	1.63	0	0.02	0.19	0.75	3	8
	ρ_2	-0.20	-2.31			-0.14	-0.76			
Canada	ρ_1	-0.02	-0.54	2.08**	0	-0.16	-0.16	0.55	1	9
	ρ_2	-0.15	-3.45**			-0.62	-0.62			
Denmark	ρ_1	-0.03	-0.71	1.22	0	-0.01	-0.07	0.86	0	6
	ρ_2	-0.13	-2.04			-0.17	-1.51*			
Finland	ρ_1	-0.07	-1.61	0.42	0	-0.01	-0.11	-0.21	2	9
	ρ_2	-0.11	-1.15			0.07	0.19			
France	ρ_1	-0.08	-1.78	1.15	0	-0.08	-1.30*	-0.09	0	8
	ρ_2	-0.17	-2.39			-0.06	-0.35			
Germany	ρ_1	-0.11	-2.67*	-0.22	0	-0.04	-0.52	0.65	0	9
	ρ_2	-0.08	-0.61			-0.16	-0.99			
Greece	ρ_1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	ρ_2	n/a	n/a			n/a	n/a			
Italy	ρ_1	-0.06	-1.55	-0.10	0	-0.04	-0.74	0.50	1	9
	ρ_2	-0.02	-0.04			-0.43	-0.55			
Japan	ρ_1	-0.02	-0.68	-0.12	0	0.003	0.02	-0.74	0	4
	ρ_2	-0.01	-0.06			0.35	0.80			
Korea	ρ_1	-0.06	-1.49	0.19	0	0.00	0.05	0.14	0	9
	ρ_2	-0.10	-0.48			-0.03	-0.14			
Nether-lands	ρ_1	-0.10	-1.93	0.0004	0	0.05	0.54	-0.15	0	8
	ρ_2	-0.10	-1.17			0.08	0.48			
Norway	ρ_1	-0.12	-2.37	0.78	0	-0.04	-0.32	-0.43	1	4
	ρ_2	-0.23	-1.82			0.12	0.34			
Spain	ρ_1	-0.06	-2.43	0.71	0	-0.18	-0.18	1.42	1	7
	ρ_2	-0.16	-1.21			-1.50	-1.50*			
Sweden	ρ_1	-0.05	-1.35	-0.25	0	-0.03	-0.31	0.92	3	5
	ρ_2	-0.02	-0.24			-0.96	-0.96			
Switzer-land	ρ_1	-0.10	-1.84	-0.92	0	0.01	0.08	0.17	0	8
	ρ_2	-0.02	-0.37			-0.02	-0.26			
UK	ρ_1	-0.15	-2.66*	-0.59	0	-0.09	-1.09	-1.39	0	9
	ρ_2	-0.08	-0.82			0.15	0.99			

Note: See notes to Table 2. $I_t = 1$ if $(\pi^* - \pi) \geq |0.25|$ indicates that p_1 tests the null of no cointegration when the difference in foreign and U.S. inflation is greater than approximately 1% at an annual rate. $I_t = 0$ if $(\pi^* - \pi) < |0.25|$ indicates that ρ_2 tests the null of no cointegration when difference in foreign and U.S. inflation is less than approximately 1% at an annual rate.

Table 6. Threshold Cointegration Test Results, Quarterly Inflation Rates,
$I_t = 1$ if $(\pi^* - \pi) \geq |1.0|$

Country		*ADL-OLS*				*ADL-IV*				
		coeff	$t_{ADL\text{-}OLS}$	*t*: $\rho_1=\rho_2$	*lag*	*coeff*	$t_{ADL\text{-}IV}$	*t*: $\rho_1=\rho_2$	*lag*	*m*
Australia	ρ_1	-0.37	-1.86	-1.58	0	-0.68	-1.59*	-1.47	3	8
	ρ_2	-0.05	-0.99			0.11	0.34			
Austria	ρ_1	-1.45	-2.11	-2.07**	0	-1.18	-1.48*	-1.37	0	8
	ρ_2	-0.02	-0.59			0.02	0.06			
Belgium	ρ_1	-0.35	-1.09	-0.81	0	-0.62	-1.10	-1.13	1	7
	ρ_2	-0.09	-1.89			0.03	0.32			
Canada	ρ_1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	ρ_2	n/a	n/a			n/a	n/a			
Denmark	ρ_1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	ρ_2	n/a	n/a			n/a	n/a			
Finland	ρ_1	-0.17	-1.06	-0.55	0	-0.44	-0.25	-0.24	1	6
	ρ_2	-0.08	-1.97			-0.02	-0.09			
France	ρ_1	0.25	0.95	1.31	0	0.60	0.80	0.87	0	7
	ρ_2	-0.10	-2.69*			-0.05	-0.86			
Germany	ρ_1	-1.07	-2.70*	-2.43**	0	-2.11	-0.92	-0.90	1	9
	ρ_2	-0.10	-2.22			-0.04	-0.53			
Greece	ρ_1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	ρ_2	n/a	n/a			n/a	n/a			
Italy	ρ_1	-0.07	-1.49	1.82*	0	-0.02	-0.22	0.25	0	9
	ρ_2	-0.25	-2.94*			-0.11	-.30			
Japan	ρ_1	0.01	0.06	0.15	0	-2.14	-1.32*	-1.27	1	9
	ρ_2	-0.02	-0.89			-0.08	-1.55*			
Korea	ρ_1	-0.18	-2.59	-2.01**	0	-0.05	-0.39	-0.36	2	5
	ρ_2	-0.01	-0.28			0.005	0.06			
Nether-lands	ρ_1	-1.66	-3.45**	-3.3***	0	-3.06	-1.79**	-1.75*	1	5
	ρ_2	-0.08	-1.95			-0.07	-0.70			
Norway	ρ_1	-0.33	-1.01	-0.61	0	-0.45	-0.51	-0.35	2	6
	ρ_2	-0.13	-2.54			-0.14	-1.16			
Spain	ρ_1	-0.08	-1.66	0.80	0	-0.03	-0.25	0.34	1	4
	ρ_2	-0.13	-2.77*			-0.16	-0.42			
Sweden	ρ_1	-0.08	-0.97	-0.21	0	-0.04	-0.37	-0.36	0	7
	ρ_2	-0.06	-1.41			0.01	0.11			
Switzer-land	ρ_1	-0.20	-1.34	-0.98	0	-0.25	-1.36*	-0.33	0	7
	ρ_2	-0.05	-1.20			-0.02	-0.03			
UK	ρ_1	-0.07	-0.49	0.44	0	n/a	n/a	n/a	n/a	n/a
	ρ_2	-0.14	-2.62			n/a	n/a			

Note: See notes to Table 2. $I_t = 1$ if $(\pi^* - \pi) \geq |1.0|$ indicates that ρ_1 tests the null of no cointegration when the difference in foreign and U.S. inflation is greater than approximately 4% at an annual rate. $I_t = 0$ if $(\pi^* - \pi) < |1.0|$ indicates that ρ_2 tests the null of no cointegration when the difference in foreign and U.S. inflation is less than approximately 4% at an annual rate.

Table 7. Threshold Cointegration Test Results, Quarterly Inflation Rate, I_t = 1 if U.S. π > 1.1%

Country		*ADL-OLS*				*ADL-IV*				
		coeff	$t_{ADL\text{-}OLS}$	*t*: $\rho_1=\rho_2$	*lag*	*coeff*	$t_{ADL\text{-}IV}$	*t*: $\rho_1=\rho_2$	*lag*	*m*
Australia	ρ_1	-0.02	-0.35	0.25	1	-0.21	-0.98	-0.16	4	5
	ρ_2	-0.04	-0.68			-0.10	-0.17			
Austria	ρ_1	-0.08	-1.18	0.13	1	-0.03	-0.12	-0.04	0	9
	ρ_2	-0.09	-1.32			-0.10	-0.09			
Belgium	ρ_1	-0.10	-1.31	-0.82	1	-0.16	-0.17	-0.21	2	6
	ρ_2	-0.02	-0.32			0.04	0.32			
Canada	ρ_1	-0.14	-3.36**	-2.20**	0	-0.15	-0.59	-0.45	6	9
	ρ_2	0.01	0.14			-0.02	-0.19			
Denmark	ρ_1	-0.03	-0.38	0.56	1	0.03	0.08	0.14	2	5
	ρ_2	-0.08	-1.38			-0.03	-0.17			
Finland	ρ_1	-0.04	-0.58	0.83	1	0.19	0.68	0.47	4	9
	ρ_2	-0.12	-2.09			-0.01	-0.04			
France	ρ_1	-0.07	-1.12	0.70	1	-0.04	-0.21	0.09	0	8
	ρ_2	-0.13	-2.18			-0.05	-0.81			
Germany	ρ_1	-0.13	-1.71	-0.30	1	0.02	0.17	0.35	0	9
	ρ_2	-0.10	-1.56			-0.03	-0.37			
Greece	ρ_1	-0.01	-0.22	0.74	1	0.04	0.15	-0.84	0	6
	ρ_2	-0.09	-1.39			0.07	0.59			
Italy	ρ_1	-0.07	-1.03	-0.09	1	-0.08	-0.48	-0.30	0	5
	ρ_2	-0.06	-0.97			-0.02	-0.17			
Japan	ρ_1	-0.03	-0.49	0.08	1	-0.02	-0.08	-0.08	0	6
	ρ_2	-0.04	-0.73			-0.001	-0.01			
Korea	ρ_1	-0.15	-2.89*	-1.54	1	-0.02	-0.53	-0.14	0	8
	ρ_2	-0.04	-0.82			-0.001	-0.00			
Nether-	ρ_1	-0.10	-1.12	-0.56	1	0.01	0.07	-0.16	0	9
lands	ρ_2	-0.04	-0.60			0.03	0.50			
Norway	ρ_1	-0.18	-2.15	-0.42	1	-0.09	-0.26	-0.03	2	9
	ρ_2	-0.13	-1.69			0.003	0.001			
Spain	ρ_1	-0.13	-2.15	-0.60	1	-0.02	-0.20	0.35	0	8
	ρ_2	-0.08	-1.29			-0.06	-0.71			
Sweden	ρ_1	-0.03	-0.53	1.15	1	0.01	0.02	-0.17	1	7
	ρ_2	-0.13	-1.91			0.07	0.61			
Switzer-	ρ_1	-0.12	-1.40	-0.76	1	-0.32	-0.88	-1.08	3	6
land	ρ_2	-0.90	-0.90			0.09	0.86			
UK	ρ_1	-0.22	-3.14**	-1.35	1	-0.13	-0.99	-1.03	0	9
	ρ_2	-0.08	-0.96			0.09	0.54			

Note: See notes to Table 2. I_t = 1 if $(\pi^* - \pi) > 1.1\%$ indicates that ρ1 tests the null of no cointegration when U.S. annual inflation is greater than approximately 4.4%, which is the medium U.S. annual inflation rate 1973-1997. I_t = 0 if $(\pi^* - \pi) \leq 1.1$ indicates that ρ_2 tests the null of no cointegration when U.S. annual inflation is less than or equal to approximately 4.4%.

Appendix A. Simulation Design and Results

We consider four IV threshold cointegration test statistics: t_{ECM}, t_{ADL}, the modified version test t_{EG}^{+}, and the unmodified version test t_{EG}. We also examine performance of the OLS based tests. We denote these as $t_{ECM\text{-}O}$, $t_{ADL\text{-}O}$, and $t_{EG\text{-}O}$, where the subscript "o" is added to signify the use of OLS estimation. The $t_{ECM\text{-}O}$ test is new to the literature. However, the ECM test based on OLS estimation entails a nuisance parameter problem as we shall see shortly. The ADL type tests have not been previously considered to test for threshold cointegration, while they are available to test the linear cointegration hypothesis. The EG type threshold tests were first considered in Enders and Siklos (2001). Our $t_{EG\text{-}O}$ test is slightly different from their test. The $t_{EG\text{-}O}$ test that we consider corresponds to the individual t-statistics on ρ1 and ρ2 as in Enders and Siklos (2001), but we do not consider the t-Max test. We consider individual t-tests in order to be consistent with the IV cointegration tests.

To perform our simulations, we adopt the following data generating process (DGP) as in Kremers et al. (1992):

$$\Delta y_{1t} = \varphi' \Delta y_{2t} + \delta_1 (y_{1t} - d_t - \beta' y_{2t}) + v_t, \tag{A.1}$$

$$\Delta y_{2t} = u_t,$$

where $v_t \sim N(0, \sigma_v^2)$ and $u_t \sim N(0, \sigma_u^2)$.

We assume that v_t and u_t are uncorrelated. All simulation results are based on 20,000 replications. When $\delta_1 = 0$, the null is true and the DGP implies no cointegration. When $\delta_1 < 0$, the DGP implies cointegration. We consider two different models; one is the drift model with $d_t = c_1$ and the other is the trend model with $d_t = c_1 + c_2 t$. In examining the performance of the tests, we focus on the drift model in our simulations. We examine the effect of using different signal-noise ratios on the size and power of each test and set $\sigma_v^2 = 1$ and $\beta = 1$. We denote $s = \sigma_u/\sigma_v$ and define the signal-noise ratio as $q = -(\varphi-1)s$. Then, we examine the cases with (φ, s) = (1.0, 1), (0.5, 6), and (0.5, 16) such that q = 0, 3, and 8. How each threshold cointegration test reacts to the signal-noise ratio is an important question of interest.

As most of the OLS based tests are also new, we simulate critical values for the OLS based tests for different values of k, T, with and without a trend. We denote k as the number of integrated regressors, via the row dimension of y_{2t}. We then use the critical values to compute the size and power of each test. The simulated critical values, which were obtained via 50,000 replications, are provided in Table A.1. They are obtained assuming that σ_u^2 = 1 and σ_u^2 = 1,implying that s = 1. The indicator function (11) is used thus, these tests are a version of the momentum threshold cointegration test utilized in Enders and Siklos (2001). For the IV tests, we use the asymptotic one-sided standard normal 5% critical value of -1.645 in all cases. Following this, we examine whether the tests are sensitive to the number of integrated regressors by considering k = 1, 2, and 3. We use the same values of ((φ, s) for all integrated regressors. We give special attention to checking the robustness of the standard normal result for the IV tests under different model specifications and different values of q. In each model, we report results with T = 100 and 500.

In Table A.2, we first consider the size properties under the null of no cointegration with k = 1, 2, and 3, and T = 100. The OLS based tests should have the correct size given that we use the customized critical values in Table 1 and q = 0. However, the $t_{ECM\text{-}O}$ test exhibits serious size distortions when q > 0 (q = 3 and 8). It is clear from our simulations that the OLS based ECM test cannot be used to test for threshold cointegration. However, the ADL and EG type tests are not subject to this problem even when estimated with OLS. Both the OLS based ADL and EG type tests have reasonable size properties in all cases. We now examine the IV tests. In all IV tests, the value of m is selected to minimize the sum of squared residuals. The ADL type test has the best size properties among the IV tests. In all cases, the IV based ADL type test has reasonable size properties. In contrast, the unmodified EG test shows serious size distortions as k increases. The modified EG test shows good size properties at k = 1, but tends to reject the null too often as the number of integrated regressors increases. The IV based ECM test has reasonable size properties at q = 0, but tends to under reject the null as q increases.

We next examine power properties of the threshold cointegration tests when $\delta_1 = -0.1$ in the DGP. The results are displayed in the lower half of Table A.2. In all cases, we observe that the OLS based EG tests lose power quickly as q increases. The power of the EG tests, both in the OLS and the unmodified IV type tests, decreases as q increases. While under the null these tests do not depend on the signal-noise ratio q, they depend on q under the alternative. A similar finding for the OLS based EG test was discussed in Kremers et al. (1992). The source of this problem is that these tests omit the term Δy_{2t} from the testing regression. However, the modified EG test t^+_{EG} is not subject to this problem since Δy_{2t} is included in the testing regression. Including Δy_{2t} in the EG procedure amounts to relaxing the common factor restriction (CFR). In the OLS framework, we cannot add Δy_{2t} since this leads to the nuisance parameter problem noted in the ECM tests. In contrast, the power of the ADL based tests increases significantly as q increases. The same is true for the ECM tests, while the ECM-OLS test was already shown to be invalid. The power of the modified EG test (t^{+}_{EG}) also increases as the signal-noise ratio increases.

The simulation results in Table A.2b are shown for the case with T = 500. These results reinforce our findings with T = 100. Also, it is apparent that the size and power of the IV tests do not change much with k = 2 or 3 when compared to k = 1. This result supports our proposition that the IV tests are invariant to k, the number of integrated regressors in the model. It is shown that the size properties of the IV version of the ECM tests are less sensitive to the signal-noise ratio (q) in larger samples, while the corresponding OLS based test ECM test remains critically dependent on q. The ADL and (modified) EG type IV tests also seem insensitive to different values of q under the null.

In Table A.3a we examine simulation results with T = 100 for the same tests as in Table A.2a, except that we utilize the alternative indicator as described in (10). The simulation results are very similar to those in Table A.2a, implying that using different indicator functions does not affect the distribution of the threshold cointegration tests. Again, the OLS version of the ECM test shows serious size distortions as q increases. As before, the power increases as q increases for the ADL tests and the three IV based tests. The important finding here is that properties of size and power are unaffected by the type of indicator employed in the threshold cointegration model. Table A.3b shows results of using a larger sample size of T = 500. Similar to Table A.2b, the results in Table A.3b reinforce the findings of Table A.3a. Again, with the larger sample of T = 500 the properties of size and power are more invariant to k and, overall, show more accurate size and better power.

In Tables A.4a and A.4b we examine in more detail the effects of omitting the variable Δy_{2t} from the cointegration testing regression. In each case, we see deterioration in the size and power properties when omitting the Δy_{2t} term. In particular, we see a large drop in power in many of the tests. This outcome can be expected, as noted in section III, since Δy_{2t} acts as a stationary covariate and increases power. While power increases as the sample size increases in Table A.4b, the power is still lower than in Table A.2b.

In summary, the IV threshold cointegration tests are reasonably robust to different model specifications. This is an expected outcome due to the fact that the IV cointegration tests do not depend critically on the usual deterministic terms. Most important, the IV tests are invariant to the nuisance parameters that make the OLS based tests invalid. The IV cointegration tests do not depend on the signal-noise ratio under the null, and their power increases as the signal-noise ratio increases under the alternative. In addition, using the critical values in Table A.1, the OLS based ADL test shows good properties throughout. Overall, the two ADL tests appear to have the most desirable properties in our simulations.

Table A.1. Critical Values ofthe OLS based Threshold Cointegration Tests

Type	T	Test	k	1%	5%	10%
Level	100	$t_{\text{ECM O}}$	1	-3.258	-2.586	-2.249
			2	-3.241	-2.588	-2.239
			3	-3.257	-2.578	-2.230
		$t_{\text{ADL O}}$	1	-3.522	-2.826	-2.475
			2	-3.674	-3.011	-2.644
			3	-3.941	-3.174	-2.831
		$t_{EG\ O}$	1	-3.590	-2.951	-2.627
			2	-3.880	-3.242	-2.920
			3	-4.173	-3.541	-3.186
	500	$t_{\text{ECM O}}$	1	-3.210	-2.585	-2.254
			2	-3.264	-2.602	-2.259
			3	-3.185	-2.578	-2.240
		$t_{\text{ADL O}}$	1	-3.490	-2.822	-2.474
			2	-3.682	-3.026	-2.674
			3	-3.903	-3.184	-2.833
		$t_{EG\ O}$	1	-3.575	-2.925	-2.593
			2	-3.872	-3.236	-2.903
			3	-4.093	-3.457	-3.151
Trend	100	$t_{\text{ECM O}}$	1	-3.705	-3.019	-2.689
			2	-3.676	-3.008	-2.675
			3	-3.686	-2.996	-2.659
		$t_{\text{ADL O}}$	1	-3.858	-3.190	-2.840
			2	-4.010	-3.330	-2.984
			3	-4.172	-3.458	-3.097
		$t_{EG\ O}$	1	-3.872	-3.182	-2.948
			2	-4.124	-3.428	-3.204
			3	-4.365	-3.646	-3.418
	500	$t_{\text{ECM O}}$	1	-3.607	-2.996	-2.675
			2	-3.638	-2.998	-2.675
			3	-3.583	-2.997	-2.663
		$t_{\text{ADL O}}$	1	-3.798	-3.169	-2.839
			2	-3.972	-3.332	-3.004
			3	-4.143	-3.471	-3.135
		$t_{EG\ O}$	1	-3.900	-3.232	-2.924
			2	-4.139	-3.491	-3.165
			3	-4.319	-3.706	-3.394

Note: The DGP implies equation (A.1). The indicator function is equation (11). We assume that $\sigma_u^2 = 1$ in simulating these critical values. The critical values of the ECM test based on OLS estimation will change when σ_u^2 varies. The ADL and EG tests based on OLS estimation are invariant to σ_u^2 under the null. The ADL test is new in the literature. The EG test corresponds to the individual t-statistics on ρ_1 and ρ_2 in Enders and Siklos (2001), but differs from the t-Max test which we do not consider. In contrast, the critical values of the standard normal distribution are used for the IV tests in all cases (i.e., -2.326, -1.645 and -1.282 at the 1, 5, and 10% levels of significance, respectively).

Table A.2a. Size and Power of the Threshold Cointegration Tests (T = 100)

Type	T	Test	k	1%	5%	10%
Level	100	$t_{ECM\ O}$	1	-3.258	-2.586	-2.249
			2	-3.241	-2.588	-2.239
			3	-3.257	-2.578	-2.230
		$t_{ADL\ O}$	1	-3.522	-2.826	-2.475
			2	-3.674	-3.011	-2.644
			3	-3.941	-3.174	-2.831
		$t_{EG\ O}$	1	-3.590	-2.951	-2.627
			2	-3.880	-3.242	-2.920
			3	-4.173	-3.541	-3.186
	500	$t_{ECM\ O}$	1	-3.210	-2.585	-2.254
			2	-3.264	-2.602	-2.259
			3	-3.185	-2.578	-2.240
		$t_{ADL\ O}$	1	-3.490	-2.822	-2.474
			2	-3.682	-3.026	-2.674
			3	-3.903	-3.184	-2.833
		$t_{EG\ O}$	1	-3.575	-2.925	-2.593
			2	-3.872	-3.236	-2.903
			3	-4.093	-3.457	-3.151
Trend	100	$t_{ECM\ O}$	1	-3.705	-3.019	-2.689
			2	-3.676	-3.008	-2.675
			3	-3.686	-2.996	-2.659
		$t_{ADL\ O}$	1	-3.858	-3.190	-2.840
			2	-4.010	-3.330	-2.984
			3	-4.172	-3.458	-3.097
		$t_{EG\ O}$	1	-3.872	-3.182	-2.948
			2	-4.124	-3.428	-3.204
			3	-4.365	-3.646	-3.418
	500	$t_{ECM\ O}$	1	-3.607	-2.996	-2.675
			2	-3.638	-2.998	-2.675
			3	-3.583	-2.997	-2.663
		$t_{ADL\ O}$	1	-3.798	-3.169	-2.839
			2	-3.972	-3.332	-3.004
			3	-4.143	-3.471	-3.135
		$t_{EG\ O}$	1	-3.900	-3.232	-2.924
			2	-4.139	-3.491	-3.165
			3	-4.319	-3.706	-3.394

Note: The DGP implies equation (A.1). The indicator function is equation (11). For the OLS based tests, the corresponding 5% critical values in Table 1 were used. For the IV tests, -1.645 was used for all cases. For the IV tests, the value of m was chosen from the model where the sum of squared residuals was minimized. The model with a constant is used in all simulations.

Table A.2b. Size and Power of the Threshold Cointegration Tests (T = 500)

				OLS			IV			
δ	k	q		$t_{ECM\text{-}O}$	$t_{ADL\text{-}O}$	$t_{EG\text{-}O}$	t_{ECM}	t_{ADL}	t_{EG}	t^{+}_{EG}
0.0 (size)	1	0	ρ_1	0.051	0.050	0.051	0.026	0.039	0.052	0.042
			ρ_2	0.050	0.054	0.050	0.025	0.035	0.051	0.046
		3	ρ_1	0.014	0.053	0.051	0.017	0.037	0.052	0.042
			ρ_2	0.011	0.055	0.050	0.017	0.038	0.051	0.046
		8	ρ_1	0.009	0.048	0.051	0.017	0.035	0.052	0.042
			ρ_2	0.007	0.053	0.050	0.016	0.037	0.051	0.046
	2	0	ρ_1	0.048	0.057	0.053	0.026	0.053	0.092	0.067
			ρ_2	0.050	0.048	0.056	0.026	0.051	0.099	0.064
		3	ρ_1	0.008	0.056	0.053	0.017	0.050	0.092	0.067
			ρ_2	0.010	0.051	0.056	0.017	0.049	0.099	0.064
		8	ρ_1	0.005	0.056	0.053	0.014	0.051	0.092	0.067
			ρ_2	0.006	0.048	0.056	0.018	0.049	0.099	0.064
	3	0	ρ_1	0.051	0.053	0.051	0.025	0.064	0.141	0.091
			ρ_2	0.056	0.052	0.049	0.027	0.056	0.141	0.086
		3	ρ_1	0.008	0.052	0.051	0.019	0.059	0.141	0.091
			ρ_2	0.006	0.055	0.049	0.017	0.064	0.141	0.086
		8	ρ_1	0.006	0.046	0.051	0.016	0.060	0.141	0.091
			ρ_2	0.005	0.051	0.049	0.015	0.063	0.141	0.086
-0.1 (power)	1	0	ρ_1	0.908	0.871	0.872	0.821	0.704	0.859	0.853
			ρ_2	0.906	0.866	0.867	0.814	0.694	0.853	0.845
		3	ρ_1	1.000	1.000	0.802	1.000	0.988	0.822	1.000
			ρ_2	1.000	1.000	0.804	1.000	0.986	0.819	1.000
		8	ρ_1	1.000	1.000	0.797	1.000	0.998	0.815	1.000
			ρ_2	1.000	1.000	0.798	1.000	0.997	0.814	1.000
	2	0	ρ_1	0.902	0.821	0.802	0.816	0.659	0.861	0.851
			ρ_2	0.907	0.823	0.797	0.814	0.651	0.863	0.854
		3	ρ_1	1.000	1.000	0.679	1.000	0.985	0.806	1.000
			ρ_2	1.000	1.000	0.686	1.000	0.986	0.811	1.000
		8	ρ_1	1.000	1.000	0.685	1.000	0.996	0.801	1.000
			ρ_2	1.000	1.000	0.671	1.000	0.997	0.806	1.000
	3	0	ρ_1	0.913	0.787	0.737	0.813	0.637	0.873	0.860
			ρ_2	0.901	0.780	0.738	0.807	0.617	0.869	0.853
		3	ρ_1	1.000	1.000	0.578	1.000	0.981	0.801	1.000
			ρ_2	1.000	1.000	0.590	1.000	0.988	0.804	1.000
		8	ρ_1	1.000	1.000	0.581	1.000	0.997	0.792	1.000
			ρ_2	1.000	1.000	0.587	1.000	0.998	0.800	1.000

See Table A.2a note.

Table A.3a. Effects of Using Alternative Indicator (T = 100)

				OLS			IV			
δ	k	q	*coeff*	$t_{ECM\text{-}O}$	$t_{ADL\text{-}O}$	$t_{EG\text{-}O}$	$t_{TR\text{-}ECM}$	t_{ADL}	t_{EG}	t^{+}_{EG}
0.0 (size)	1	0	ρ_1	0.054	0.048	0.059	0.042	0.055	0.082	0.067
			ρ_2	0.053	0.053	0.060	0.047	0.060	0.083	0.065
		3	ρ_1	0.013	0.048	0.059	0.021	0.055	0.082	0.067
			ρ_2	0.014	0.053	0.060	0.023	0.060	0.083	0.065
		8	ρ_1	0.010	0.048	0.059	0.02	0.055	0.082	0.067
			ρ_2	0.009	0.053	0.060	0.017	0.060	0.083	0.065
	2	0	ρ_1	0.043	0.050	0.060	0.041	0.070	0.142	0.090
			ρ_2	0.051	0.054	0.069	0.042	0.073	0.151	0.101
		3	ρ_1	0.014	0.050	0.060	0.019	0.070	0.142	0.090
			ρ_2	0.012	0.054	0.069	0.023	0.073	0.151	0.101
		8	ρ_1	0.009	0.050	0.060	0.016	0.070	0.142	0.090
			ρ_2	0.010	0.054	0.069	0.019	0.073	0.151	0.101
	3	0	ρ_1	0.049	0.053	0.061	0.045	0.087	0.232	0.141
			ρ_2	0.050	0.049	0.056	0.045	0.088	0.235	0.140
		3	ρ_1	0.008	0.053	0.061	0.021	0.087	0.232	0.141
			ρ_2	0.010	0.049	0.056	0.019	0.088	0.235	0.140
		8	ρ_1	0.007	0.053	0.061	0.020	0.087	0.232	0.141
			ρ_2	0.005	0.049	0.056	0.016	0.088	0.235	0.140
-0.1 (power)	1	0	ρ_1	0.177	0.154	0.163	0.206	0.183	0.259	0.241
			ρ_2	0.189	0.160	0.166	0.203	0.186	0.252	0.239
		3	ρ_1	0.940	0.775	0.071	0.826	0.598	0.131	0.452
			ρ_2	0.941	0.764	0.071	0.825	0.609	0.132	0.448
		8	ρ_1	1.000	0.996	0.064	0.998	0.914	0.115	0.658
			ρ_2	1.000	0.998	0.067	0.998	0.919	0.119	0.651
	2	0	ρ_1	0.180	0.140	0.135	0.197	0.170	0.312	0.277
			ρ_2	0.177	0.128	0.135	0.197	0.173	0.317	0.276
		3	ρ_1	0.994	0.835	0.059	0.948	0.663	0.166	0.468
			ρ_2	0.992	0.840	0.056	0.942	0.661	0.162	0.481
		8	ρ_1	1.000	0.999	0.053	0.998	0.928	0.155	0.587
			ρ_2	1.000	0.999	0.053	0.999	0.931	0.151	0.600
	3	0	ρ_1	0.178	0.125	0.123	0.203	0.183	0.374	0.307
			ρ_2	0.191	0.124	0.120	0.195	0.177	0.386	0.315
		3	ρ_1	0.998	0.829	0.051	0.977	0.675	0.208	0.423
			ρ_2	0.999	0.829	0.050	0.976	0.676	0.214	0.427
		8	ρ_1	1.000	0.999	0.048	1.000	0.932	0.206	0.497
			ρ_2	1.000	0.999	0.046	0.999	0.926	0.196	0.492

See Table A.2a note. The indicator function is equation (10).

Table A.3b. Effectsof Using Alternative indicator (T = 500)

				OLS			IV			
δ	k	q		$t_{ECM\text{-}O}$	$t_{ADL\text{-}O}$	$t_{EG\text{-}O}$	t_{ECM}	t_{ADL}	t_{EG}	t^{+}_{EG}
0.0 (size)	1	0	ρ_1	0.049	0.049	0.051	0.025	0.040	0.049	0.039
			ρ_2	0.059	0.057	0.059	0.028	0.040	0.053	0.042
		3	ρ_1	0.012	0.049	0.051	0.017	0.040	0.049	0.039
			ρ_2	0.014	0.057	0.059	0.017	0.040	0.053	0.042
		8	ρ_1	0.007	0.049	0.051	0.017	0.040	0.049	0.039
			ρ_2	0.008	0.057	0.059	0.015	0.040	0.053	0.042
	2	0	ρ_1	0.049	0.049	0.053	0.025	0.053	0.088	0.064
			ρ_2	0.050	0.046	0.051	0.028	0.053	0.094	0.065
		3	ρ_1	0.012	0.049	0.053	0.018	0.053	0.088	0.064
			ρ_2	0.010	0.046	0.051	0.019	0.053	0.094	0.065
		8	ρ_1	0.008	0.049	0.053	0.018	0.053	0.088	0.064
			ρ_2	0.006	0.046	0.051	0.017	0.053	0.094	0.065
	3	0	ρ_1	0.053	0.049	0.058	0.026	0.056	0.139	0.078
			ρ_2	0.053	0.047	0.046	0.024	0.057	0.138	0.079
		3	ρ_1	0.008	0.049	0.058	0.016	0.056	0.139	0.078
			ρ_2	0.007	0.047	0.046	0.017	0.057	0.138	0.079
		8	ρ_1	0.006	0.049	0.058	0.016	0.056	0.139	0.078
			ρ_2	0.006	0.047	0.046	0.015	0.057	0.138	0.079
-0.1 (power)	1	0	ρ_1	0.913	0.869	0.853	0.831	0.713	0.840	0.836
			ρ_2	0.922	0.885	0.873	0.844	0.722	0.855	0.852
		3	ρ_1	1.000	1.000	0.802	1.000	0.985	0.808	1.000
			ρ_2	1.000	1.000	0.803	1.000	0.985	0.813	1.000
		8	ρ_1	1.000	1.000	0.784	1.000	0.998	0.798	1.000
			ρ_2	1.000	1.000	0.800	1.000	0.999	0.813	1.000
	2	0	ρ_1	0.912	0.841	0.797	0.834	0.672	0.857	0.848
			ρ_2	0.915	0.841	0.792	0.833	0.672	0.855	0.848
		3	ρ_1	1.000	1.000	0.684	1.000	0.986	0.813	1.000
			ρ_2	1.000	1.000	0.680	1.000	0.986	0.803	1.000
		8	ρ_1	1.000	1.000	0.672	1.000	0.998	0.808	1.000
			ρ_2	1.000	1.000	0.674	1.000	0.998	0.800	1.000
	3	0	ρ_1	0.922	0.805	0.735	0.829	0.640	0.867	0.850
			ρ_2	0.917	0.806	0.737	0.831	0.643	0.874	0.860
		3	ρ_1	1.000	1.000	0.588	1.000	0.985	0.806	0.999
			ρ_2	1.000	1.000	0.591	1.000	0.987	0.797	1.000
		8	ρ_1	1.000	1.000	0.576	1.000	0.998	0.802	1.000
			ρ_2	1.000	1.000	0.589	1.000	0.998	0.797	1.000

See Table A.2a note.

Table A.4a. Effects of Omitting Δy_{2t} (T = 100)

				OLS			IV			
δ	k	q	*coeff*	$t_{ECM\text{-}O}$	$t_{ADL\text{-}O}$	$t_{EG\text{-}O}$	t_{ECM}	t_{ADL}	t_{EG}	t^{+}_{EG}
0.0 (size)	1	0	ρ_1	0.031	0.036	0.060	0.033	0.046	0.081	0.081
			ρ_2	0.032	0.033	0.056	0.031	0.043	0.078	0.078
		3	ρ_1	0.000	0.021	0.060	0.008	0.034	0.081	0.081
			ρ_2	0.000	0.018	0.056	0.004	0.028	0.078	0.078
		8	ρ_1	0.000	0.015	0.060	0.008	0.030	0.081	0.081
			ρ_2	0.000	0.012	0.056	0.005	0.026	0.078	0.078
	2	0	ρ_1	0.025	0.026	0.063	0.028	0.047	0.146	0.146
			ρ_2	0.021	0.022	0.061	0.026	0.049	0.147	0.147
		3	ρ_1	0.000	0.013	0.063	0.006	0.032	0.146	0.146
			ρ_2	0.000	0.015	0.061	0.008	0.037	0.147	0.147
		8	ρ_1	0.000	0.009	0.063	0.005	0.028	0.146	0.146
			ρ_2	0.000	0.011	0.061	0.006	0.030	0.147	0.147
	3	0	ρ_1	0.022	0.021	0.064	0.026	0.057	0.235	0.235
			ρ_2	0.017	0.019	0.054	0.025	0.056	0.223	0.223
		3	ρ_1	0.000	0.008	0.064	0.006	0.035	0.235	0.235
			ρ_2	0.000	0.007	0.054	0.007	0.030	0.223	0.223
		8	ρ_1	0.000	0.006	0.064	0.005	0.027	0.235	0.235
			ρ_2	0.000	0.006	0.054	0.007	0.024	0.223	0.223
-0.1 (power)	1	0	ρ_1	0.083	0.072	0.155	0.119	0.111	0.245	0.245
			ρ_2	0.086	0.073	0.160	0.120	0.120	0.247	0.247
		3	ρ_1	0.090	0.108	0.075	0.148	0.159	0.140	0.140
			ρ_2	0.087	0.099	0.073	0.133	0.149	0.131	0.131
		8	ρ_1	0.082	0.096	0.064	0.146	0.160	0.113	0.113
			ρ_2	0.079	0.090	0.063	0.126	0.152	0.109	0.109
	2	0	ρ_1	0.061	0.046	0.139	0.094	0.088	0.314	0.314
			ρ_2	0.052	0.041	0.133	0.087	0.089	0.301	0.301
		3	ρ_1	0.091	0.060	0.051	0.138	0.118	0.168	0.168
			ρ_2	0.090	0.066	0.056	0.134	0.120	0.168	0.168
		8	ρ_1	0.089	0.055	0.050	0.133	0.117	0.156	0.156
			ρ_2	0.092	0.062	0.045	0.140	0.120	0.155	0.155
	3	0	ρ_1	0.045	0.026	0.116	0.081	0.075	0.374	0.374
			ρ_2	0.047	0.030	0.119	0.079	0.076	0.365	0.365
		3	ρ_1	0.090	0.038	0.044	0.133	0.099	0.207	0.207
			ρ_2	0.088	0.036	0.049	0.138	0.103	0.211	0.211
		8	ρ_1	0.087	0.037	0.048	0.133	0.090	0.203	0.203
			ρ_2	0.088	0.034	0.045	0.136	0.100	0.202	0.202

See Table A.2a note. The indicator function is equation (11). The term Δy_{2t} is already omitted in the $t_{EG\text{-}O}$ and t_{EG} tests. When Δy_{2t} is omitted, the t^{+}_{EG} test becomes the t_{EG} test. Thus, the results for these tests are the same as those in Table A.2a, except for statistical errors. We observe loss of power as q increases. The purpose of this experiment is to examine the other tests, which clearly exhibit size distortions and loss of power when Δy_{2t} is omitted.

Table A.4b. Effects of Omitting Δy_{2t} (T = 500)

				OLS			IV			
δ	k	q		$t_{ECM\text{-}O}$	$t_{ADL\text{-}O}$	$t_{EG\text{-}O}$	t_{ECM}	t_{ADL}	t_{EG}	t^{+}_{EG}
0.0 (size)	1	0	ρ_1	0.032	0.036	0.051	0.023	0.034	0.052	0.052
			ρ_2	0.033	0.035	0.050	0.024	0.032	0.051	0.051
		3	ρ_1	0.000	0.018	0.051	0.010	0.023	0.052	0.052
			ρ_2	0.000	0.018	0.050	0.008	0.026	0.051	0.051
		8	ρ_1	0.000	0.012	0.051	0.008	0.020	0.052	0.052
			ρ_2	0.000	0.013	0.050	0.009	0.023	0.051	0.051
	2	0	ρ_1	0.020	0.024	0.053	0.020	0.036	0.092	0.092
			ρ_2	0.020	0.022	0.056	0.015	0.033	0.099	0.099
		3	ρ_1	0.000	0.013	0.053	0.008	0.027	0.092	0.092
			ρ_2	0.000	0.010	0.056	0.009	0.031	0.099	0.099
		8	ρ_1	0.000	0.008	0.053	0.009	0.024	0.092	0.092
			ρ_2	0.000	0.008	0.056	0.008	0.028	0.099	0.099
	3	0	ρ_1	0.021	0.020	0.051	0.022	0.039	0.141	0.141
			ρ_2	0.020	0.015	0.049	0.016	0.041	0.141	0.141
		3	ρ_1	0.000	0.006	0.051	0.009	0.028	0.141	0.141
			ρ_2	0.000	0.008	0.049	0.009	0.027	0.141	0.141
		8	ρ_1	0.000	0.004	0.051	0.009	0.026	0.141	0.141
			ρ_2	0.000	0.008	0.049	0.010	0.025	0.141	0.141
-0.1 (power)	1	0	ρ_1	0.519	0.439	0.872	0.521	0.445	0.859	0.859
			ρ_2	0.504	0.420	0.867	0.509	0.427	0.853	0.853
		3	ρ_1	0.737	0.701	0.802	0.726	0.670	0.822	0.822
			ρ_2	0.730	0.697	0.804	0.720	0.657	0.819	0.819
		8	ρ_1	0.719	0.686	0.797	0.709	0.668	0.815	0.815
			ρ_2	0.716	0.676	0.798	0.715	0.657	0.814	0.814
	2	0	ρ_1	0.303	0.196	0.802	0.374	0.293	0.861	0.861
			ρ_2	0.292	0.199	0.797	0.365	0.288	0.863	0.863
		3	ρ_1	0.712	0.591	0.679	0.717	0.596	0.806	0.806
			ρ_2	0.710	0.584	0.686	0.702	0.591	0.811	0.811
		8	ρ_1	0.704	0.583	0.685	0.710	0.592	0.801	0.801
			ρ_2	0.707	0.581	0.671	0.706	0.591	0.806	0.806
	3	0	ρ_1	0.232	0.108	0.737	0.302	0.227	0.873	0.873
			ρ_2	0.220	0.102	0.738	0.284	0.219	0.869	0.869
		3	ρ_1	0.721	0.517	0.578	0.715	0.550	0.801	0.801
			ρ_2	0.716	0.499	0.590	0.709	0.549	0.804	0.804
		8	ρ_1	0.714	0.508	0.581	0.714	0.539	0.792	0.792
			ρ_2	0.708	0.487	0.587	0.708	0.544	0.800	0.800

See Table A.4a note.

CHAPTER I-3

Global Dispersion of Current Accounts: Is the Universe Expanding?

by
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I. Introduction

Few external variables are as closely or widely watched as the current account balance. Rightly or wrongly, it has been used as a barometer for a wide range of economic conditions—from the state of the business cycle to the sustainability of external financing. In recent years, attention to current account imbalances has taken on a global dimension, reflecting concern over "global imbalances." At the center is a large (albeit moderating) current account deficit in the United States, reflecting a shortfall of domestic saving relative to investment on the order of five to six percent of GDP. As a counterpart, large and/or growing current account surpluses have been recorded in Japan, [Canada,] China and other emerging Asia, but less so in Europe (excluding Russia). Whether such a global constellation of widening external imbalances can be sustained and for how long constitutes a key macroeconomic risk facing the world economy.[1] Namely, the possibility of a hard landing in the U.S. dollar—the international currency of choice—has raised concerns in many parts of the world over the potential fallout from a disorderly global rebalancing.

A notable countervailing argument to such concerns was perhaps most notably voiced by former Fed Chairman Alan Greenspan. Turning matters around, he has argued that the unprecedented size of the U.S. deficit was itself a testimony to the increasingly efficient functioning of international capital markets and its ability to mobilize such a large share of net saving from the rest of the world to the United States. Specifically, he noted the following stylized fact regarding global trade and capital flows:

Uptrends in the ratios of external liabilities or assets to trade, and therefore to GDP, can be shown to have been associated with a widening dispersion in countries' ratios of trade and current account balances to GDP. A measure of that dispersion, the sum of the absolute values of the current account balances ...has been rising as a ratio to GDP at an average annual rate of about 2 percent since 1970 for the OECD countries, which constitute four- fifths of world GDP...

More generally, the vast savings transfer has occurred without measurable disruption to the balance of international finance...Accordingly, the trend...will likely continue as globalization proceeds [Remarks at 21st annual monetary conference at Cato Institute, November 2003].

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1) See IMF WEO (2005), Blanchard et. al (2005), Chinn and Lee (2005), Faruqee et al. (2006a,b), and Gourinchas and Rey (2005).

This paper reexamines the global distribution of current accounts viewed from a longer term perspective. Using a panel of over one hundred countries that comprise over 95 percent of world output, the analysis establishes a set of "stylized facts" regarding the individual and collective behavior of current accounts over the past four decades. In particular, we examine the dispersion properties of external imbalances and interpret these empirical regularities in the context of increasing openness in trade and financial flows—often referred to as "globalization." While an emergent literature on financial globalization has documented that gross financial flows (including international reserve accumulation) has increased dramatically in recent years, what does this imply (if anything) for net flows?[2] More specifically, the central issues that the paper addresses include the following:

- Is the universe of current accounts expanding or narrowing? And, at what rate? What component of the U.S. external deficit specifically (and global imbalances broadly) can be attributed to the underlying changes in global dispersion?
- What does changing global dispersion imply for current account persistence? What are the sources—trade or income?
- What economic factors help explain underlying trends in the dispersion of external imbalances?

Besides risk and policy implications, the question of rising dispersion has a direct bearing on the celebrated Feldstein-Horioka puzzle. Their basic finding that savings are closely correlated with investments across countries has remained more or less intact, despite several prominent exceptions (e.g., Blanchard and Giavazzi for Europe). Our query on rising dispersion would help to answer whether the background for the Feldstein-Horioka findings remains relevant. If there is no trend change in the dispersion of current accounts, Feldstein-Horioka correlations should continue to be confirmed in the data with statistical significance as strong as the original results. If instead a rising trend is identified in the dispersion of current accounts, it would suggest that these findings would likely weaken over time, though not necessarily becoming extinct.

The paper is organized as follows. Section 2 examines whether the global constellation of current accounts has been narrowing or expanding over time, using several convergence measures. Section 3 examines current account stationarity and persistence and the implications of increasing dispersion. Section 4 examines the role of

2) For recent studies on financial globalization see Prasad and other (2003), Kose and others (2006), and the references cited therein.

economic openness in expanding the universe of current account balances. Section 5 concludes. The appendix contains description of data, and two sections that are complementary to the paper's results.

II. Dispersion & Convergence

We first ask if the global constellation of current account imbalances has been expanding or narrowing over time. Conceptually, in the case of convergence, there is a universally unique end point—i.e., zero balance—around which all current accounts should converge (up to a discrepancy term). But predictions from economic theory are generally ambiguous on this or whether external balances should gravitate toward an alternative or, even, a degenerate distribution. The answer typically depends on the class of model—e.g., representative agent versus overlapping generations framework—and its assumptions regarding market completeness, initial conditions, and the history of shocks. Hence, whether current accounts actually converge or diverge and over what horizon are essentially empirical questions. To examine these issues more closely, we employ both non-parametric and parametric methods—including concepts from the growth literature on convergence—to determine if the universe of current accounts is expanding.

1. Unconditional Distributions

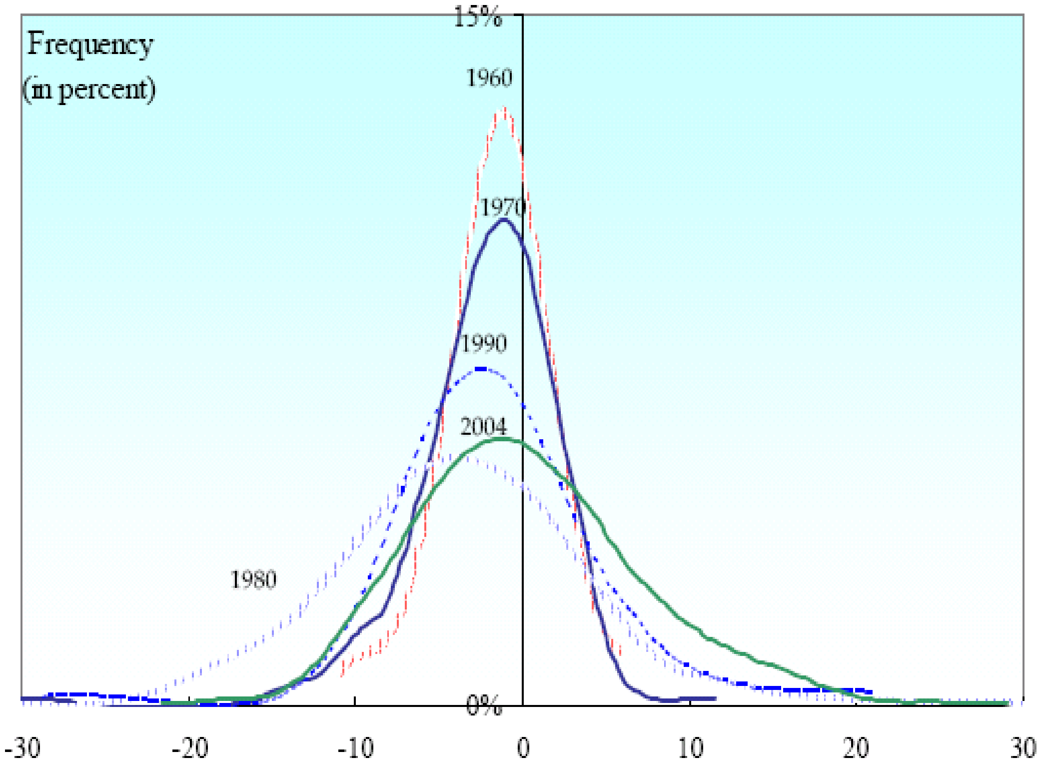
The unconditional distribution of current account ratios (in percent of GDP) at different points in time are shown in Figure1. Kernel density estimates of the cross-sectional distribution for 101 countries suggest that the universe of current accounts has been generally expanding.[3] As shown in the figure, the distribution of current accounts shows a steady increase in dispersion from 1960 to 2004, with the mass of the distribution being less concentrated in the area around zero and moving further

3) The kernel estimator for an arbitrary point xi in the distribution is:

$$f(x_i) = \frac{1}{Nh}\sum_{j=1}^{N} K\left[\frac{x_i - X_j}{h}\right],$$

where X_j is the *j*th data observation, *N* is the number of observations, *h* is the window size (i.e., the degree of smoothing), and *K* is the kernel or weighting function. The non- parametric estimates in Figure 1 are based on the Epanechnikov kernel; See Silverman (1986). Results using the less efficient Gaussian kernel (i.e., standard normal) are very similar.

Figure 1. Global Distribution of Current Accounts, 1960-2004



out toward the tails.[4] The notable exception to this progressive pattern of expansion is the year 1980, when presumably the effects of oil shocks widened the dispersion of current accounts temporarily beyond that seen in later years. Notice too that the distributions for each year are not exactly centered around zero (but a small negative value), consistent with the global current account discrepancy.[5]

4) Jarque-Bera tests strongly reject normality for each of these years. Skewness in the distribution was found significant for each of these years, except 1960; excess kurtosis (i.e., "fat tails") was statistically significant throughout.

5) The global current account discrepancy—ususally expressed in dollar terms or in percent of world imports or GDP—has tend to be negative since the early 1970s, reflecting discrepancies in both trade and income accounts; see Marquez and Workman (2001) for a discussion.

2. σ-convergence

Figure 2 presents supporting evidence from a time-series perspective. The figure plots annually two standard dispersion measures of current account ratios over the past 45 years.

They are the global standard deviation of current accounts (inpercent of GDP) or σ, and the global mean absolute deviation of the current account (in percent of GDP) or μ, both calculated across countries for each year.

Two features of the figure are worth noting. First, dispersion shows significant time variation from year to year. Consistent with the impression from the previous figure, notice the considerable increase in the global spread around the time of the two major oil shocks in the mid- and late-1970s. Second, an underlying trend increase in dispersion is apparent, consistent with the global distributions shown in Figure 1. Specifically, the universe of current account positions has been expanding on average by almost 2 percent per annum, measured by its standard deviation.[6] This latter finding suggests a lack of so-called "σ-convergence" in external positions over this time horizon.

Note that both measures are unweighted, treating each country symmetrically. For comparison, a third measure of dispersion Σ is shown in the figure by computing the global sum of current accounts (in absolute value) in percent of world GDP. This is equivalent to a weighted mean absolute deviation of current accounts (in dollar terms), where country weights are determined by own GDP (in dollar terms) as a share of world GDP (in dollar terms). All three measures are highly correlated (with correlation coefficients between (0.60 and 0.95). However, the third measure shows a steeper increase, particularly in recent years, well ahead of the other (unweighted) measures.[7] This corresponds to emergence of "global imbalances" where large deficits and surpluses emerged in the largest countries such as the United States and China.

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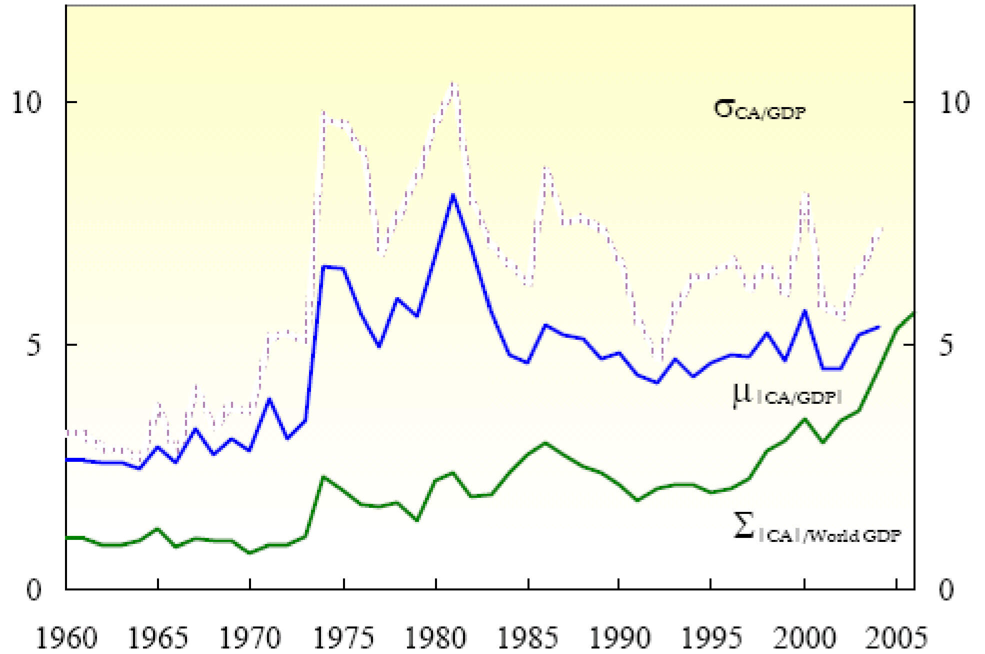
6) A regression of the (log) standard deviation on a time trend yields the following results (with corrected standard errors given in parentheses):
$\ln(\sigma_{CA/GDP}) = 1.4 + 0.017t + \varepsilon_t; R^2 = 0.33$.

7) Over the sample, the rate of increasing global dispersion is 1½ to 1¾ perent per year on an unweighted basis and 3¼ percent on a weighted basis.

Figure 2. Global Dispersion of Current Accounts, 1960-2004 (in percent of GDP)



Notes : σ denotes global standard deviation of current accounts (in percent of GDP)
μ denotes global average of absolute values of current accounts (in percent of GDP)
Σ denotes global s um of absolute values of current accounts (in percent of world GDP)

3. β-convergence

Another convergence perspective—commonly used in the growth literature—is the notion of "β-convergence." In the context of current accounts, β-convergence would require that countries accumulating past imbalances eventually unwind these positions. This would allow current accounts (and trade balances) globally to converge to more similar values around zero—i.e., the convergence point.[8] For example, countries with a large stock of net external debt, reflecting flow deficits in the past, would need to run current account surpluses in the future to pay down the debt or, at least, smaller current account deficits to decrease the share of debt relative to the overall economy.

8) A weaker form of convergence posits that current accounts, but not trade balances nor net foreign asset positions, converge toward balance. This would require that trade (not current account) surpluses be achieved in the years following current account deficits to stabilize the accumulation of net foreign liabilities. [We subsequently examine the trade balance and changes in net foreign assets.] Net foreign assets data are based on Lane and Milesi-Ferretti (2001 and 2007).

$$CA_{avg} = -\underset{(0.36)}{1.94} + \underset{(0.05)}{0.09}\ NFA_0 + v; \quad R^2 = 0.13; \quad NOBS = 94$$

Comparing the initial net foreign asset ratio to the average current account ratio in subsequent years, however, provides very little support for this type of convergence. The cross-country regressions, in fact, show that countries with larger net indebtedness are more likely to run larger (not smaller) current account deficits in the years that follow. See figure 3.[9] And the results of the cross section regression are: [to be updated]

Moreover, the slope of the line drawn is greater than typical estimates of nominal growth in GDP, suggesting these subsequent flow imbalances tend to augment the net stock of external assets or liabilities in relation to the size of the economy. Alternative coefficient estimates may be more comparable to nominal dollar growth rates. This would imply a reversion to the initial ratios of NFA to GDP, but this is still at variance with the notion of a convergence to a common value (e.g. zero balance).[10]

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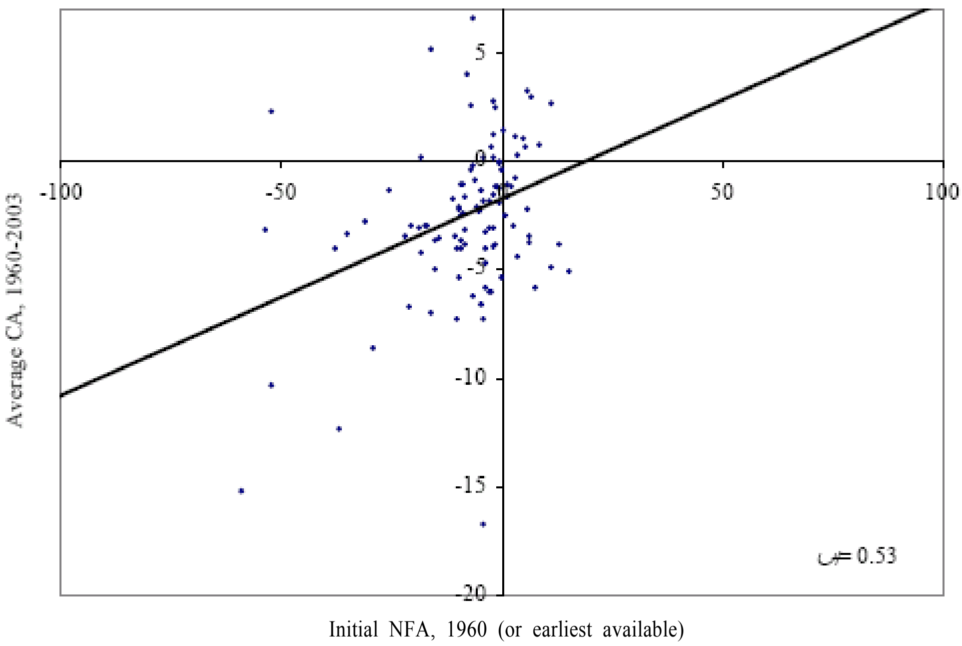
9) Chinn and Prasad (2002) find a similar effect of net foreign assets on current accounts based on multivariate panel estimation that controls for a wide range of explanatory variables (e.g., demographics, fiscal positions, economic development, etc).

10) Dropping outlier countries with average current account imbalances (net external assets) greater than 10 percent (50 percent) of GDP in absolute terms would slightly lower the coefficient on initial NFA (to 0.06) but raise its significance level (p-value = 3%).

Figure 3. Net Foreign Assets v. Current Accounts (in percent of GDP)



This result is comparable to the findings of Kraay and Ventura (2000). Using the data from less than 20 industrial countries, they found that current account imbalances are proportional to the net external balance sheet positions. In response to an increase in savings, a creditor country tended to run surplus while a debtor country tended to stay in deficit. They view this to be the result of a portfolio choice in the presence of a large investment risk. While data limitation makes it difficult to examine the validity of their prediction for a wider set of countries, their model is one possible explanation for the result that we find for a very large set of countries.

To recap, the distributional and convergence properties of current account balances suggest an expanding universe. The β-convergence results further suggest that countries who have had current account imbalances historically are the group more likely to run subsequent current account imbalances (of the same sign) in ensuing periods, leading to further accumulation of net foreign assets or liabilities.

III. Stationarity & Persistence

We now examine aspects of the time-series properties of current accounts—in particular, stationarity and persistence. Trehan and Walsh (1991) showed that the stationarity of the current account is a sufficient condition for the intertemporal budget constraint to hold.[11] Stationarity has since been an indirect test of the basic premise of the intertemporal view of the current account. Thus, this type of behavior would indicate whether the expanding global dispersion of current accounts has also been compatible with respecting intertemporal budget constraints.

To examine the stationarity and persistence properties of current accounts, a battery of unit root and stationarity tests were conducted. In particular, the well-known augmented Dickey- Fuller (ADF) test and non-parametric Phillips-Perron (PP) test for a unit root against a stationary alternative were applied to the individual country series for the current account ratio (in percent of GDP). In addition, the Kwiatowski et al (1992) (KPSS) test for stationarity against a unit root was also used. The corresponding test statistics and significance levels are shown in the appendix.[12]

Figure 4 summarizes the rejection and non-rejection rates (in percent) for these unit root tests. For more straightforward comparisons, the rejection of stationarity under the KPSS test is reported as a non-rejection of the unit root. Overall, the picture is quite mixed. One test finds the majority of current accounts to be non-stationary (ADF test), another tests finds the majority to be stationary (KPSS test), and the third test is split down the middle (PP test).

Individually, for nearly a quarter of the sample (22 of 101), these tests failed to reject both non-stationarity and stationarity for the same series (see appendix). This finding highlights two widely-known features of these tests and the time-series data: (1) unit root and stationarity tests tend to have low power (i.e., fail to reject too often) in finite samples, and (2) the current account is generally a very persistent series, making it difficult to distinguish between non-stationary and stationary alternatives over limited time spans.[13]

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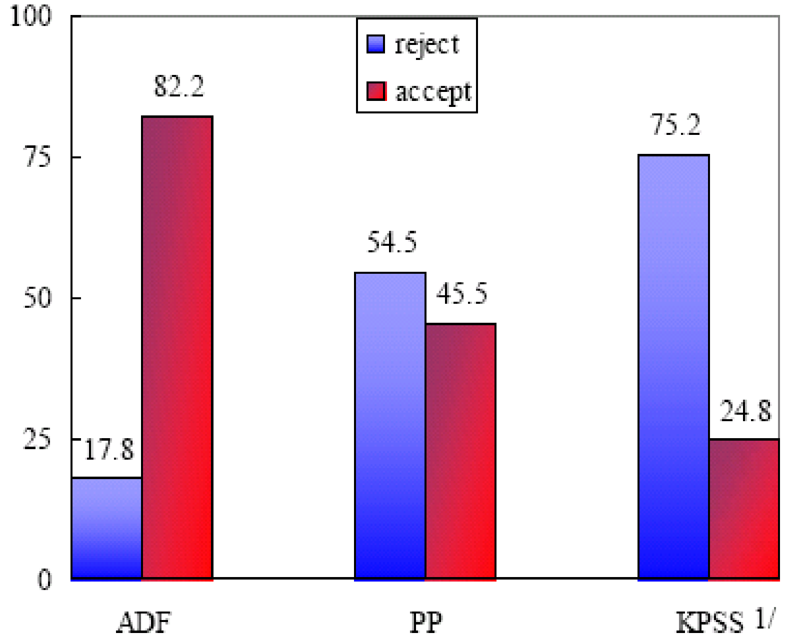
11) Trehan and Walsh showed that the stationarity of the current account was the necessary and sufficient condition, but the necessity was debated lately by Bohn (2006).

12) In all cases, the model specification includes a constant but no time trend. Including a time trend in the unit root tests marginally increase the number of rejections.

13) See Campbell and Perron (1991). A peculiar finding is that for three countries, these low- powered tests rejected both stationarity and non-stationarity for at least one unit root test.

Figure 4. Unit Root Test Rejection Rates (Variable = CA/GDP; in percent)



Note : 1/ Variable is CA-to-GDP ratio for KPSS test, failure to reject stationarity reported as rejection of unit root in the graph. N=101.

For 21 countries—including, notably, the United States and Japan, the tests indicated (at least, statistically) a non-stationary current account ratio over this time span. That is, the unit root tests failed to reject non-stationarity and the KPSS test further rejected stationarity. But for more than half of the sample (55 of 101 countries), at least one of the two unit root tests reject and the stationarity test accept their respective null hypotheses, suggesting a stationary series.

Moreover, on the basis of panel unit root tests (Table 1), non-stationarity is strongly rejected. The tests were applied to three panels comprising different groups of countries according to data availability. The first panel comprises data from 1960 to 1998 for 50 countries, the second panel comprises data from 1971 to 1998 for 82 countries, and the third panel comprises data from 1980 to 1998 for 94 countries (excluding Kuwait). The null of nonstationarity is strongly rejected for all possible specifications suggested by Levin and Lin (1992), Im, Pesaran and Shin (1995), and Breitung (2000); see appendix. Test statistics reported in the table correspond to specifications without time trend, but a unit root was rejected for specifications with time trend, too.

Overall, these various tests suggest that the current account is a stationary but persistent series. To further highlight this point, simple AR(1) specifications for the current account are reported in appendix (Table A2). The average autoregressive coefficient across country estimates is 0.58. From a panel perspective, pooled OLS and fixed effects estimates, respectively, yield the following equations (with corrected standard errors in parentheses):

$$CA_{it} = k + \underset{(0.02)}{0.75}\ CA_{it-1} + \varepsilon_t;\quad R^2 = 0.59 \tag{1}$$

$$CA_{it} = k_i + \underset{(0.01)}{0.60}\ CA_{it-1} + \varepsilon_t;\quad R^2 = 0.62 \tag{2}$$

Under either specification, there is significant AR(1) coefficient on the lagged current account, though with panel fixed effects, the degree of inertia is reduced somewhat.

But these specifications are, in a sense, incomplete—failing to recognize a common component associated with the particular pattern in the movement of global dispersion over the past several decades. Moreover, the β-convergence results indicate that countries with non-zero initial NFA positions continue to accumulate assets (liabilities) on a net basis by running current account surpluses (deficits) in subsequent periods. In other words, countries tend to run significant imbalances of the same sign (either positive or negative) as in the past. To introduce this trend feature into the analysis, we include a sign-preserving time trend (sptrend) constructed as follows:

$$sptrend_t = sign(CA_{t-1}) * t \text{ ; where } sign(CA_{t-1}) = CA_{t-1} / \left|CA_{t-1}\right|. \tag{3}$$

The time trend specifies increasing surpluses or deficits depending on the sign of the current account in the previous period. Note too that this sign-preserving trend is also broadly consistent with preserving current account adding-up, while a simple time trend is not.[14)]

Including this term into the panel fixed effects regression yields:

$$CA_{it} = k_i + \underset{(0.004)}{0.01}\ sptrend_t + \underset{(0.01)}{0.59} CA_{it-1} + \varepsilon_t;\quad R^2 = 0.63 \tag{4}$$

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14) Current account adding-up would be more apparent if balances were defined in a common unit, (say) U.S. dollars—but this would raise issues of nominal drift. Using the current account ratio to GDP broadly perserves the level of the current account discrepancy (in percent of GDP) provided that surplus and deficit countries (as respective groups) are of similar economic size.

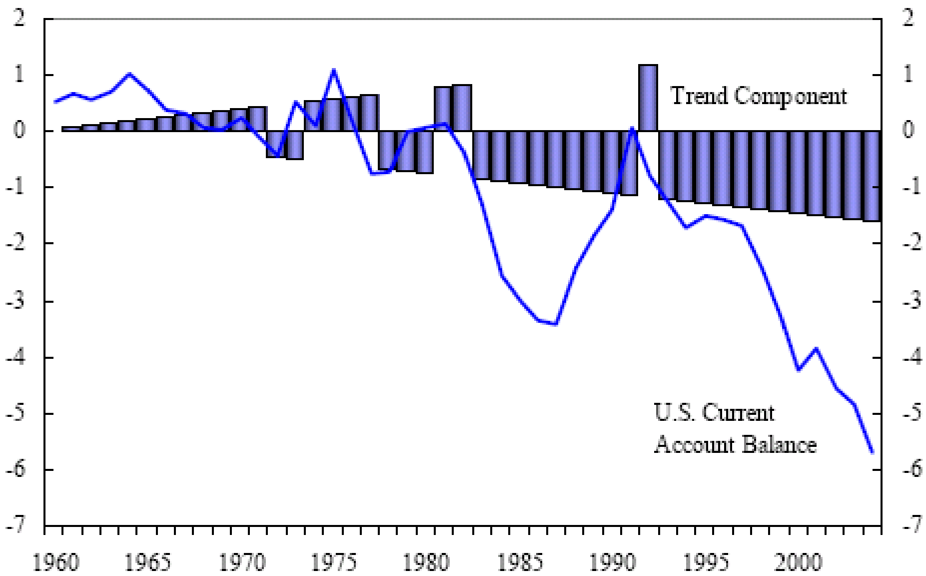
The trend capturing increasing dispersion is statistically significant (p value =0.08).[15] The fit of the equation is marginally improved and the persistence parameter (AR1 coefficient) is smaller, as one would expect.[16] In other words, some of the observed persistence in external balances appears to reflect an underlying trend phenomenon—a slowly increasing global dispersion. This is perhaps better viewed as an evolving longer-run process occurring over many decades rather than the inertia in external balances seen from year to year.

Taking an average trend estimate over different specifications, one can examine the extent to which the recent increase in the U.S. current account deficit is due to this underlying global trend. Figure 5 shows the observed U.S. current account deficit ratio to GDP (line) and the long-run contributions (bars) that obtain from equation (4), reflecting the common or global trend term on average. Accounting for increasing global dispersion goes part way to explaining the burgeoning U.S. deficit in past years, but clearly the widening imbalance has gone far beyond these considerations. In level terms, the long-run component (adding the trend and either a common or country-specific constant) would narrow but not nearly close the "gap" with the observed deficit.

15) Due to the unbalanced panel, the sign-preserving trend coefficient in (4) is estimated for the vast majority (but not all) countries. Including the full sample (which has countries with only few observations at the end of sample) would reduce the coefficient estimate given the accumulated value of the trend term itself. A "resetting" trend for these countries would raise the point estimate. For further sensitivity analysis, see the following footnote.

16) When the sign-preserving trend is constructed using the contemporaneous rather than lagged current account, the trend coefficient is always substantially larger and highly significant; and the AR1 coefficient is also substantially reduced.But this specification is susceptible to simultaneity issues. Across various specifications and samples, the range of trend estimates is roughly between 0.005 to 0.085. As a cross-check, the fitted values and implied rate of increase in global dispersion for a given trend estimate is compared to the rates from the non-parametric estimates disscussed earlier.

Figure 5. U.S. Current Account, 1960-2004 (in percent of GDP)



IV. Dispersion, Persistence, and Openness

We have seen that the cross section dispersion of current accounts has been rising while the time series of current accounts have remained stationary. In particular, equation (4) based on sign-preserving trends suggests that the cross-section distribution of long-run average current accounts (measured by the constant terms in AR(1) regression and the sign-preserving trends) has been spreading out. What are behind these trends? Are they in fact driven by the force of globalization, experienced as a rising integration of goods and financial markets across different countries?

We thus consider two economic variables that are likely to affect the behavior of external imbalances: openness to trade and financial flows. We measure trade openness by the ratio of exports and imports to GDP, and financial openness by the Chinn-Ito index, scaled to lie between 0 and 1 (see the appendix for details). As most economies have been opening up and increasing external flows in trade and finance, a deterministic time trend will capture a large part of the common trend toward greater openness. Country-specific measures of openness, however, will help us to extract more information on the role of openness by exploiting different speeds toward openness among countries.

Countries with more open trade regimes would find it easier to sell goods produced beyond the need for domestic consumption and to import goods for which demand exceeds domestic production. The trade imbalance is the aggregate accumulation of such imbalances over the whole economy. A country with more open trade regime will thus be more likely to run a trade imbalance, and also find it easier to finance them given the wider base for international lending and borrowing.

More directly, countries with more open financial account will find it easier to lend or borrow to balance its savings capacity and investment need. In addition to enabling countries to put savings to the most productive use and to finance investment needs in the most efficient manner, a greater availability of investment and funding opportunities will tend to stimulate savings and investment, and increase international financial flows further.

To fix ideas on how to incorporate their effects on the dispersion of current accounts, let us consider the following AR(1) representation of the current account of country *i*.

$$CA_{it} = \mu_i + \beta CA_{it-1} + \varepsilon_{it}$$

Idiosyncratic shocks ε_{it} are uncorrelated across countries and time (i and t), and have mean zero and unit variance $(\sigma^2(\varepsilon_{it}) = 1)$, evaluated over *i* at each point in time. The long-run average current account, μ_i , is allowed to differ across countries. Since the current accounts have been found to be stationary with its AR(1) coefficients lying between 0 and 1, we assume that $0 < \beta < 1$, and obtain the following MA representation of the current account.

$$CA_{it} = \mu_i + \sum_{l=0}^{\infty} \beta^l \varepsilon_{it-1}$$

The global dispersion of current account at time t is

$$\sigma^2(CA_{it}) = \sum_{l=0}^{\infty} \beta^{2l} \sigma^2(\varepsilon_{it-l}) + \sigma^2(\mu_i) = (1-\beta^2)^{-1} + \sigma^2(\mu_i)$$

There are two ways that the global dispersion of current accounts can increase. For one, the cross-section distribution of the long-run average current account can spread out over time, thereby increasing the global dispersion of the current account. Alternatively, a rise in the persistence of current account deviation from its long-run average can increase the observed global dispersion of current account as the effect of idiosyncratic shocks die out more slowly. (See Taylor (2001) for suggestive evidence of the latter channel for traditional OECD countries over a span of 100 years.)

We separate these two channels in our estimation. To allow the cross-section distribution to spread out, we construct sign-preserving indicators of openness. When "tradeopen" and "finopen" measure openness in trade and financial accounts, respectively, sign-preserving openness indictors are:

$$sptradeopen_t = sign(CA_{t-1}) * tradeopen_t$$

$$spfinopen_t = sign(CA_{t-1}) * finopen_t .$$

This leads to an expanded version of equation (4).

$$CA_{it} = \mu_i + \beta_1 sptrend_t + \beta_2 sptradeopen_{it} + \beta_3 spfinopen_{it} + \beta_4 CA_{it-1} + v_t \qquad (5)$$

To incorporate the effects of openness on the persistence of current accounts, we also stimate a version that includes three additional interaction terms between the lagged current account and these three variables, Here, the sign of current accounts does not matter and lagged current accounts are interacted with the original variables: $trend_t$, $tradeopen_t$, and $finopen_t$. The estimating equation becomes:

$$\begin{aligned} CA_{it} &= \mu_i + \beta_1 sptrend_t + \beta_2 sptradeopen_{it} + \beta_3 spfinopen_{it} + \beta_4 CA_{it-1} \\ &+ \beta_5 CA_{it-1} * trend_t + \beta_6 CA_{it-1} * tradeopen_{it} + \beta_7 CA_{it-1} * finopen_{it} + v_t \end{aligned} \qquad (6)$$

Table 2 reports the results of estimating various versions of this equation on the basis of data for 73 countries whose current account data are available starting in no later than 1975. In the upper panel, the openness in trade and finance was measured as the moving averages of the recent three years. In the lower panel, the openness was measured by the average over the whole sample period.

Columns I and II repeat the regressions that we estimated for the larger and longer sample of countries. The results coincide qualitatively, though with some quantitative difference. As in equation (4), countries have been able to run larger current imbalances over time, and the persistence of current account imbalances declines a little as the estimating equation incorporates the trend increase in dispersion.

In columns III and VI (in the lower panel), we introduce the openness measures as structural determinants that enable countries to run larger current account imbalances. The results indicate that the time trend must have reflected the effect of openness. In column III, the coefficient on time trend turns negative, while the coefficients on trade and financial openness are numerically large and statistically significant. In column VI, trade openness remains statistically significant while time trend and financial openness lose statistical significance. Between column III and column VI, using sample averages appears to have reduced a large part of variation in financial openness which has gone through particularly rapid changes since the late-1980s. In terms of their effect on persistence, the inclusion of openness measures further reduces the persistence parameter, again less strongly in column VI which uses the average measures of openness.

We examine the effects of these variables on the persistence parameter (AR1 coefficient). No strong prior applies to the direction of their effects. It is tempting to presume that a greater availability of financing will lead to a higher persistence of the shocks to current account, for countries will be able to finance their current account deficits more easily. However, the relaxation of financial constraints can also lead countries to fund their needs more quickly but at a larger scale. For example, a Solovian developing country that needs a large development financing will borrow a large amount in the beginning, if she can. Such response will imply a lower persistence of current account shocks and a larger dispersion of current account imbalances across countries. To summarize, a larger value of the persistence parameter is consistent with a more gradual financing, while a smaller value is consistent with a more rapid financing.

Starting with a regression that only uses time trend (column IV), the persistence parameter is found to have been declining over time. Countries are also found to have been able to run larger current account imbalances—deficit or surplus—over time. When we allow openness measures to affect persistence (columns V and VII), we uncover an interesting contrast in the effects of trade and financial openness. Trade openness, if any, increases the persistence of current account imbalance while financial openness reduces the persistence. And the effect of financial openness remains statistically significant even when the openness is measured by the average over the whole sample period. Most interesting is the joint effect of financial openness on persistence and the dispersion of long-run average current accounts. A financially more open—better integrated—country appears to be able to run a larger imbalance, but over a shorter duration. This is consistent with the possibility that financially better integrated countries can meet its international financing or investment need more quickly.

These findings are confirmed in Table 3, where the same relationships as in Table 2 were estimated by popular GMM estimates, considering the presence of lagged dependent variables on the right hand side. Trade openness is found to increase the persistence of current account imbalances, whereas financial openness is found to clearly decrease the persistence of current account imbalances.

V. Concluding Remarks

Examining current accounts for a wide spectrum of countries over the past four and a half decades, we can summarize our key findings or 'stylized facts' as follows:

- The universe of current accounts has been expanding over the past half century. Based on a variety of measures and methodologies, the global constellation of external current account positions has markedly widened over time. While dispersion can vary significantly from year to year—ostensibly in response to large international shocks, there is a steady, underlying rate of expansion of around 2 to 3 percent per year.
- In other words, in a context where global gross financial flows have grown rapidly, net flows have also increased (on a sustained basis) to individual countries. And sign reversals in the current account are occasional, but not frequent. Reflecting this persistence in current account imbalances, countries that have run larger external imbalances in the past also tend to run subsequent, larger imbalances (of the same sign), suggesting a extenuation of international lending or borrowing patterns. However, the underlying, long-run trend toward greater global dispersion suggests that inertia in current accounts from year to year may be overstated by simple estimates of persistence.
- Rising dispersion is also found to be closely associated with increasing financial integration of the world economy, among other things. At the same time, individual current account series and changes in net foreign assets (as ratios to GDP) are found to be stationary (albeit persistent), indicating that while dispersion is rising, basic intertemporal resource constraints are not likely violated for individual countries.
- Global imbalances though have run well ahead of underlying dispersion trends. The recent acceleration of external positions in major countries (including the United States) is clearly not fully accounted for by the trend behavior exhibited by the universal expansion.

From an economic standpoint, the results lend support to recent views that some, though not all, of the large global current account imbalances are due to the ongoing integration of the world economy. In particular, it is not surprising that we would see, in an increasingly integrated global economy, higher levels of current account deficits (including in the United States) and surpluses in key partner countries. The other side of this trend is the likely weakening in the statistical hold of the Feldstein-Horioka results. However, we also find that the underlying pace of the increase in global dispersion is not as fast as sometimes claimed and has bounds, indicating that a sizable part of today's global imbalances is likely in excess (relative to the underlying trend) and would probably be unwound to a significant degree. Some movements in that direction appear to have finally started in the United States, while the counterpart movements are less evenly distributed.

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Appendix A. Data Description

The main variable is the ratio of the current account to the GDP, both of which were obtained from various issues of International Financial Statistics (IMF) and World Development Indicator (World Bank). The capital account liberalization index was developed by Chinn and Ito (2005), and is the first principal component of several variables that reflect the ease of cross-border financial transactions. In our estimation, the index was normalized to take a value between 0 and 1, increasing with the liberalization of capital account regime. For each value of Chinn-Ito index CI_{it}, our

$$finopen_{it} = \frac{CI_{it} - Min\{CI_{it}\}}{Max\{CI_{it}\} - Min\{CI_{it}\}}$$

indicator is defined as follows.

Descriptive statistics for the ratio of the current account to GDP show:

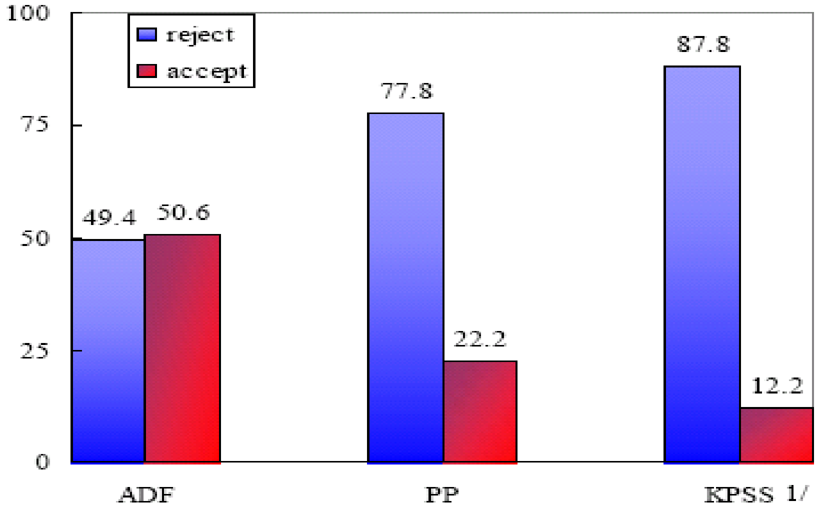
- Unconditional means in more than three-quarters (74 out of 94) of the countries statistically different from zero (p=0.05 or higher); see Table A0.
- Conditional means in more than half of the countries (64 out of 94), based country constants (i.e., fixed effects), are significantly different from 0 (p= 0.10 or higher).
- For higher moments, evidence of skewness or excess kurtosis ("fat tails") was found in 28 out of 94 countries (i.e., 30 percent of sample).

Appendix B. Alternative Measures of External Positions and Their Behavior

A related but distinct measure is the change in net foreign assets (NFA). It essentially differs from the current account by the amount of capital gains (valuation change), which is driven by asset price fluctuations, including exchange rate variations. Since these asset price movements are broadly described as a random walk, the change in NFA will contain a much larger white-noise component and exhibit smaller persistence than the current account. This is indeed confirmed by the data, as summarized in the following two charts. Note that due to data limitations regarding NFA, the sample size is smaller.

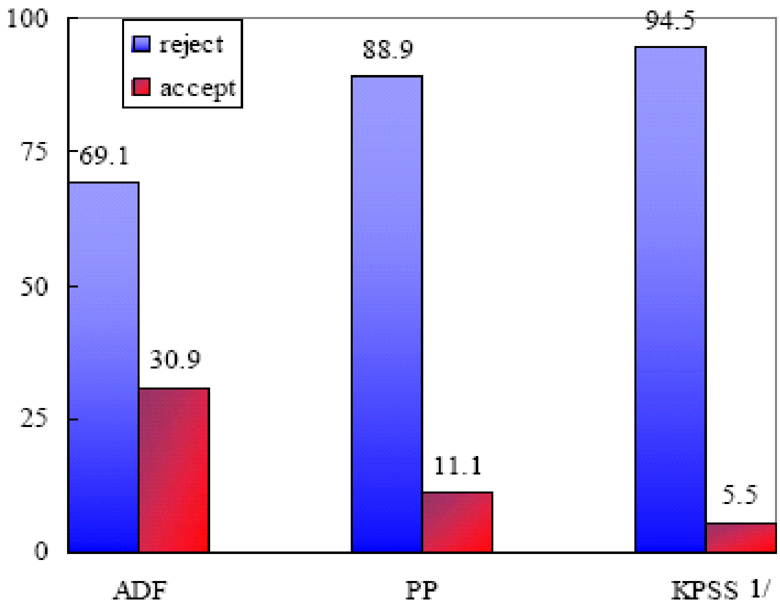
First, the change in NFA (in percent of GDP) is subjected to the same battery of stationarity and unit root tests as for the current account, summarized in Figure 4. The test results uniformly show a higher rejection rate of non-stationarity. See Figure A1. Second, for the change in the ratio of NFA to GDP—i.e., $\triangle$(NFA/y)—the indications toward stationarity are even stronger; see Figure A2. Changes in the ratio also include a growth term (related to the change in the scaling variable GDP). This helps toward finding stationarity in the ratio given that GDP (i.e., the denominator) is growing over time. Excluding the growth factor term (by considering $\triangle$NFA/y) weakens the stationarity finding, but does not overturn it. That is, the $\triangle$NFA concept appears to be much more stationary (less persistent) series than CA.

Figure A1. Unit Root Tests Rejection Rates (variable = △NFA/GDP in percent)



Note : 1/ Variable is change in NFA as a ratio to GDP for KPSS test, failure to reject s tationarity reported as rejection of unit root in the graph. N=81.

Figure A2. Unit Root Test Rejection Rates (variable = △(NFA/GDP) in percent)



Note : 1/ Variable is change in NFA-to-GDP ratio for KPSS test, failure to reject stationarity reported as rejection of unit root in the graph. N=81.

Appendix C. Expanding Dispersion and Financial Market Integration

Considering the pivotal role of the financial openness in expanding the global dispersion of current accounts, we present an illustrative (steady-sate) model where the ongoing integration in international financial markets increases the global dispersion of current accounts. Some form of heterogeneity is the necessary condition for global dispersion, and we introduce the heterogeneity in the discount rate. Combined with a small cost of financial intermediation, which represents financial market friction, we generate a non-degenerate steady-state distribution of net foreign assets. Further introducing growth in aggregate output, we show that the global dispersion of current accounts rises, as the cost of financial intermediation falls. And we assume a deterministic world.17)

World economy is assumed to be composed of N open economies, each of which commands a fixed stream of endowment (y_i) , and has an identical utility function u (c_{it}) but with a heterogeneous discount rate (β_i). The heterogeneity in the discount rate gives rises to international lending and borrowing (thus current account imbalances). It is further assumed that countries incur a financial transaction cost when they lend or borrow. The period-by-period budget constraint is written as:

$$a_{it+1} = (1+r_t)a_{it} - c_{it} + y_{it} - \frac{\gamma}{2}\left(a_{it}\right)^2 + \eta\left(a_{it}\right) ,$$

where a_{it} denotes the net foreign assets of country i , and r_t the world interest rate. The financial transaction cost, $\frac{\gamma}{2}\left(a_{it}\right)^2$, captures the cost needed to maintain a non-zero international asset position.18) The quadratic form is akin to the adjustment cost widely used in the macroeconomic literature, and is assumed to be the fee paid to competitive financial intermediaries when international financial position is adjusted away from the zero balance. The fees paid to competitive intermediaries are distributed

17) In deterministic setup, the ratio of the current account to GDP has a well-defined relationship to the steady-state ratio of NFA to GDP. In stochastic setting, stationary shocks to the current account (and change in NFA) will have a non-stationary effect on NFA, and the stochastic steady-state relationship between the current account and NFA remains unclear.

18) This transaction cost can be defined in terms of percent of GDP, to capture the idea that economic and financial development would lower the financial transaction cost as a share of GDP. That assumption determines the steady-state value of the ratio of the NFA to GDP, and is discussed in Ghironi et. al (2005).

back to each country $(\eta(a_{it}) = \frac{\gamma}{2}(a_{it})^2)$ ex post, and thus financial frictions affect the ex-ante decision making of each country without draining global resources.
The first condition for each country's consumption-saving choice is:

$$(\beta_i)^{t+1} u'(c_{it+1}) = (\beta_i)^t u'(c_{it})(1 + r_t - \gamma a_{it}) \qquad (7)$$

In the steady state, $c_{it+1} = c_{it} = \overline{c}_i$, and equation (7) simplifies to $\beta_i = 1 + r - \gamma \overline{a}_i$ and the net foreign asset position is determined by the difference between the world interest rate and the subjective discount rate:

$$\overline{a}_i = \frac{1}{\gamma}\left(1 + r - \frac{1}{\beta_i}\right)$$

The world interest rate is determined at a level that equates the global demand and supply of assets: $\sum_{i=1}^{N} \overline{a}_i = 0$:

$$1 + r = \sum_{i=1}^{N} \frac{1}{\beta_i}$$

In a no-growth economy just described, the steady-state current account remains in zero balance and there is no dispersion in current accounts. Introducing economic growth leads to a steady-state dispersion in current accounts. Now assume that each country's population grows at the same rate g . The aggregate output of a country at time t becomes:

$Y_{it} = (1+g)^t \overline{y}_i$, normalizing the time-0 population at unity. Denoting the aggregate net foreign assets by a capitalized letter, A_{it}, the change in the ratio of net foreign assets to GDP can be rewritten in terms of the current account as follows.

$$\frac{A_{it+1}}{Y_{it+1}} - \frac{A_{it}}{Y_{it}} = \frac{A_{it+1}}{Y_{it+1}}\left[1 - (1+g)\right] + \frac{A_{it+1} - A_{it}}{Y_{it}} = -g\frac{A_{it+1}}{Y_{it+1}} + \frac{CA_{it}}{Y_{it}}$$

In the steady state with the constant ratio of the aggregate net foreign assets to GDP,

$$\overline{\left(\frac{CA_i}{Y_i}\right)} = g\overline{\left(\frac{A_i}{Y_i}\right)} = g\overline{a}_i = \frac{g}{\gamma}\left[\left(\sum_{i=1}^{N}\frac{1}{\beta_i}\right) - \frac{1}{\beta_i}\right]$$

A tighter integration of international financial markets is represented as a decline in γ, which lowers the cost of international financial transactions. This will increase the dispersion in the ratio of current account to GDP.

Table 1. Stationarity of Current Accounts (current accounts in percent of GDP)

Panel Unit Root Test			
Country Group	LL[1/]	IPS[2/]	Breitung[3/]
Small Group [4/]	-19.37** -17.66**	-11.21**	-13.81**
Medium Group [5/]	-20.10** -16.85**	-10.33**	-14.28**
Large Group [6/]	-17.64** -13.55**	-8.87**	-8.32**

1/ Levin and Liu (1992). For each group, tests with time and individual fixed effects were reported.
2/ Inn, Pesaran, and Shin (1997).
3/ Breitung (2000)
4/ 50 countries, 1960 – 1998
5/ 82 countries, 1971-1998
6/ 94 countries, 1980 – 1998
An asterisk * (**) denotes statistical significance at 5(1) percent.

Table 2. Evolution of Current Account Dynamics (1971-2004)

	I	II	III	IV	V
CA(-1)	0.443 **	0.403 **	0.279 **	0.749 **	0.861 **
	(0.017)	(0.019)	(0.023)	(0.054)	(0.101)
CA(-1)*TimeTrend				-0.012 **	-0.014 **
				(0.002)	(0.003)
CA(-1)*TrOpen					0.177 *
					(0.090)
CA(-1)*FinOpen					-0.433 **
					(0.065)
SPTrend		0.032 **	-0.028 *	0.043 **	0.001
		(0.006)	(0.015)	(0.006)	(0.019)
SPTrOpen			2.183 **		-0.276
			(0.521)		(0.664)
SPFinOpen			1.055 *		2.474 **
			(0.607)		(0.682)

	VI	VII
CA(-1)	0.359 **	0.918 **
	(0.020)	(0.087)
CA(-1)*TimeTrend		-0.009 **
		(0.002)
CA(-1)*TrOpenAvg		0.120
		(0.084)
CA(-1)*FinOpenAvg		-0.602 **
		(0.057)
SPTrend	0.006	0.020
	(0.010)	(0.012)
SPTrOpenAvg	1.296 **	-1.020 *
	(0.396)	(0.501)
SPFinOpenAvg	-0.018	1.787 **
	(0.517)	(0.575)

Note : Statistically significant at 5 percent (**) and 10 percent (*). All regressions included country fixed effects. Based on the sample of 73 countries whose current account data were available starting before 1975.

Table 3. Evolution of Current Account Dynamics -- GMM Estimates (1971-2004)

	I	II	III	IV	V
CA(-1)	0.341 **	0.290 **	0.188 **	1.038 **	1.340 **
	(0.001)	(0.055)	(0.002)	(0.010)	(0.016)
CA(-1)*TimeTrend				-0.027 **	-0.023 **
				(0.002)	(0.001)
CA(-1)*TrOpen					0.020
					(0.035)
CA(-1)*FinOpen					-0.544 **
					(0.018)
SPTrend		0.055 **	-0.094 **	0.081 **	-0.011 **
		(0.001)	(0.005)	(0.002)	(0.005)
SPTrOpen			4.791 **		-0.217
			(0.181)		(0.273)
SPFinOpen			3.454 **		3.960 **
			(0.033)		(0.215)

	VI	VII
CA(-1)	0.180 **	0.912 **
	(0.002)	(0.014)
CA(-1)*TimeTrend		-0.021 **
		(0.001)
CA(-1)*TrOpenAvg		0.423 **
		(0.010)
CA(-1)*FinOpenAvg		-0.591 **
		(0.010)
SPTrend	-0.110 **	0.041 **
	(0.002)	(0.009)
SPTrOpenAvg	4.963 **	-1.973 **
	(0.148)	(0.221)
SPFinOpenAvg	3.667 **	4.294 **
	(0.070)	(0.120)

Note : Statistically significant at 5 percent (**) and 10 percent (*). All regressions included country fixed effects. Based on the sample of 73 countries whose current account data were available starting before 1975.

Table A0. Current Account Balances (in percent of GDP), 1960–1998
Summary Statistics

Country	Mean	Variance	Skew	Kurtosis	Country	Mean	Variance	Skew	Kurtosis
United States	-0.65**	1.64	-0.73	-0.47	Panama	-4.16**	32.54	1.21**	2.62**
United Kingdom	-0.39	2.51	-0.72	0.77	Paraguay	-3.19**	10.88	1.11**	3.08**
Austria	-1.10**	2.45	-1.18**	1.15	Peru	-3.57**	11.86	0.24	-0.21
Belgium-Luxembourg	1.15**	5.51	-0.13	-0.12	Venezuela	2.04	47.26	0.36	1.55
Denmark	-1.63**	4.65	0.62	-0.22	Jamaica	-5.48**	19.85	-0.18	-1.10
Germany	0.83**	2.70	0.86*	0.11	Trinidad-Tobago	-2.46**	60.16	0.27	-0.46
Italy	0.31	3.66	-0.30	-0.59	Iran	1.19	40.84	2.60**	9.00**
Norway	-0.87	18.85	-0.53	0.26	Israel	-4.07**	17.45	-0.27	0.66
Sweden	-0.49	2.65	0.21	-0.21	Jordan	-2.32*	37.08	0.51	1.06
Switzerland	2.41**	13.33	0.13	-0.34	Egypt	-3.48**	22.60	-0.65	2.38**
Canada	-2.34**	1.82	0.57	-0.22	Myanmar	-1.86**	5.45	-0.77	0.77
Japan	1.27**	2.21	-0.12	-0.71	Sri Lanka	-4.19**	12.86	-1.06**	2.63**
Finland	-1.28**	7.94	0.59	0.97	India	-1.19**	1.02	1.37**	2.19**
Greece	-3.30**	2.33	-0.49	1.27	Korea	-1.98**	22.35	0.84*	1.75*
Iceland	-2.57**	11.38	-0.64	0.23	Phillipines	-2.19**	10.56	0.16	-0.81
Ireland	-2.98**	16.45	-0.60	0.17	Ghana	-3.36**	13.29	-0.12	0.26
Spain	-0.85**	3.41	0.04	-0.78	Morocco	-3.55**	22.30	-1.10**	0.73
Turkey	-1.12**	2.89	-0.25	0.30	Nigeria	-1.11	29.01	1.52**	3.07**
Australia	-3.42**	2.72	0.60	0.12	Sudan	-3.63**	10.68	-0.72	0.43
Bolivia	-4.30**	11.91	0.56	0.97	Tunisia	-5.22**	14.62	-0.39	0.09
Brazil	-2.09**	4.57	-0.27	-0.70	Hong Kong 1/	5.00**	46.62	-0.27	-0.81
Chile	-3.99**	10.84	-1.03**	1.62	Malaysia 1/	-1.59	29.80	0.23	0.60
Columbia	-2.25**	9.01	0.33	-0.13	South Africa 2/	-0.28	11.31	-0.20	-0.59
Costa Rica	-7.19**	14.40	-0.55	-0.17	Argentina 2/	-1.12**	4.13	0.27	-0.59
Dominican Republic	-3.65**	12.32	0.81*	1.22	Mexico 2/	-2.31**	6.01	0.64	1.58
Ecuador	-4.16**	11.00	-0.33	-0.63	Uruguay 2/	-1.18**	5.59	-0.02	0.18
El Salvador	-2.19**	6.44	-0.87*	0.84	Taiwan, P.O.C. 2/	3.71**	34.74	1.08**	1.88*
Guatemala	-2.92**	3.62	-0.38	-0.70	Singapore 3/	-2.60	166.20	-0.12	-0.15
Haiti	-2.40**	8.19	-0.42	0.60	Kenya 3/	-3.98**	18.69	-0.63	0.63
Honduras	-5.43**	12.09	0.09	-0.72	Côte d'Ivoire 3/	-6.20**	29.04	-0.53	-0.88
Nicaragua	-16.31**	226.35	-0.46	0.37	Algeria 4/	-1.52*	19.23	-0.80	1.04

Table A0 (continued). Current Account Balances (in percent of GDP), 1960–1998
Summary Statistics

Country	Mean	Variance	Skew	Kurtosis	Country	Mean	Variance	Skew	Kurtosis
Mauritius 4/	-2.28*	29.22	-0.04	-0.25	Bangladesh 12/	-2.79**	5.42	-0.05	-0.69
Benin 5/	-5.06**	37.07	-1.97**	7.35**	Mauritania 12/	-10.19**	150.30	0.10	-0.44
Togo 5/	-5.45**	70.00	0.85*	4.63**	Baharain 13/	-4.03	101.34	-0.28	-0.84
Indonesia 6/	-2.16**	6.11	1.00*	1.77	Kuwait 13/	17.92	3268.04	-4.32**	20.15**
Thailand 6/	-3.50**	15.71	2.08**	7.84**	Oman 13/	1.73	83.35	-0.40	0.31
Uganda 6/	-1.89**	7.58	-0.14	-0.55	Botswana 13/	1.07	224.66	0.26	1.08
France 7/	0.04	1.14	0.80	1.32	Lesotho 13/	-3.04	226.82	-1.08*	0.02
Netherlands 7/	3.12**	3.52	0.02	0.00	Nepal 14/	-4.78**	10.32	0.29	-1.16
New Zealand 7/	-4.95**	13.59	-0.75	0.44	Poland 14/	-2.86**	8.92	0.63	0.98
Saudi Arabia 7/	2.07	326.30	1.15**	1.54	Albania 15/	-3.26**	20.78	-1.30*	1.37
Pakistan 7/	-4.28**	4.71	-0.89*	1.63	Bulgaria 15/	-1.16	11.53	-1.35*	2.48
Syrian Arab Rep. 8/	0.01	21.31	0.58	2.41**					
Gabon 8/	0.31	72.01	-1.07*	1.25					
Niger 8/	-5.53**	22.46	0.52	-0.70					
Senegal 8/	-7.29**	16.13	-0.66	0.96					
Gambia 9/	-3.58	138.40	-1.09*	1.34					
Madagascar 9/	-6.00**	20.55	-0.40	0.49					
Hungary 9/	-3.02**	10.44	-0.50	0.25					
Congo, Republic of 10/	-19.34**	142.30	-0.11	0.57					
Romania 10/	-1.46	17.83	0.00	-0.98					
Portugal 11/	-2.73**	19.63	-1.20*	2.17*					
Papua New Guinea 11/	-0.91	95.23	0.23	-0.57					

1/ data period 1961 – 1998. 2/ data period 1962 – 1998. 3/ data period 1963 – 1998. 4/ data period 1964 – 1998. 5/ data period 1965 – 1998. 6/ data period 1966 – 1998. 7/ data period 1967 – 1998.

8/ data period 1968 – 1998. 9/ data period 1970 – 1998. 10/ data period 1971 – 1998. 11/ data period 1972 – 1998. 12/ data period 1973 – 1998. 13/ data period 1975 – 1998. 14/ data period 1976 – 1998.

15/ data period 1980 – 1998.

An asterisk * (**) denotes that the mean, skewness or kurtosis statistic is significantly different from zero at the 5 (1) percent level.

Table A1. Current Account Balances (in percent of GDP), 1960–2004
Stationarity Tests (under revision)

Country	ADF 1/	PP 2/	KPSS 3/	Country	ADF 1/	PP 2/	KPSS 3/
United States	0.21	-0.15	1.16*	Argentina	-2.24	-3.45*	0.13
United Kingdom	-3.11*	-2.59	0.45	Taiwan	-1.70	-2.60	0.400
Austria	-3.03*	-3.04*	0.12	Côte d'Ivoire	-1.47	-2.39	0.32
Denmark	-2.18	-1.97	0.85*	Kenya	-2.40	-3.95*	0.30
Germany	-2.15	-2.42	0.08	Uruguay	-2.38	-3.24*	0.16
Italy	-2.90	-3.05*	0.21	Algeria	-0.75	-2.64	0.62*
Norway	-1.76	-1.46	0.97*	Mauritius	-2.52	-3.47*	0.15
Sweden	-0.07	-0.24	0.56*	Benin	-2.47	-4.84*	0.10
Switzerland	-0.36	-1.09	1.40*	Togo	-2.29	-4.05*	0.43
Canada	-1.06	-1.81	0.49*	Indonesia	-1.67	-2.47	0.52*
Japan	-1.90	-2.74	0.98*	Thailand	-2.05	-2.14	0.43
Finland	-1.39	-1.58	0.66*	Uganda	-1.49	-4.11*	0.94*
Greece	-2.69	-3.21*	0.22	France	-2.31	-2.77	0.53*
Iceland	-3.23*	-4.72*	0.10	Netherlands	-2.75	-3.07*	0.25
Ireland	-1.64	-2.08	0.58*	New Zealand	-3.05*	-3.41*	0.11
Spain	-3.92*	-3.25*	0.25	Saudi Arabia	-1.25	-2.14	0.40
Turkey	-2.32	-4.75*	0.13	Pakistan	-0.87	-2.68	0.55*
Australia	-1.60	-2.80	0.87*	Gabon	-1.81	-3.37*	0.19
South Africa	-3.57*	-3.48*	0.17	Niger	-2.83	-2.56	0.47*
Bolivia	-1.85	-4.43*	0.24	Senegal	-2.24	-2.76	0.32
Brazil	-2.05	-2.20	0.13	Gambia	-2.64	-2.88	0.20
Chile	-1.41	-3.08*	0.21	Madagascar	-2.67	-5.10*	0.11
Costa Rica	-2.19	-3.04*	0.46	Hungary	-1.53	-3.18*	0.33
Dominican Republic	-2.44	-4.73*	0.31	Congo	-0.91	-3.16*	0.33
El Salvador	-3.42*	-5.51*	0.07	Romania	-1.18	-2.35	0.39
Guatemala	-2.13	-4.15*	1.09*	Portugal	-1.31	-2.90	0.18
Haiti	-1.84	-2.31*	0.17	Papa New Guinea	-1.02	-2.24	0.42

Table A1 (continued). Current Account Balances (in percent of GDP), 1960–2004
Stationarity Tests (under revision)

Country	ADF 1/	PP 2/	KPSS 3/	Country	ADF 1/	PP 2/	KPSS 3/
Honduras	-2.87	-3.57*	0.28	Bangladesh	-1.48	-2.62	0.85*
Mexico	-3.28*	-3.49*	0.06	Mauritania	-1.44	-2.48	0.41
Panama	-2.22	-2.99*	0.26	Oman	-1.56	-3.81*	0.24
Paraguay	-2.75	-2.98*	0.20	Burkina Faso	-0.45	-2.11	0.56*
Peru	-4.29*	-3.80*	0.26	Bahrain	-3.35*	-2.79	0.18
Venezuela	-0.07	-4.27*	0.20	Kuwait	-2.55	-4.69*	0.23
Jamaica	-2.28	-3.32*	0.10	Bostwana	-1.91	-2.57	0.61*
Trinidad y Tobago	-3.06*	-3.02*	0.36	Lesotho	-1.53	-2.53	0.40
Israel	-2.08	-3.19*	0.39	Ecuador	-2.45	-4.08*	0.41
Jordan	-3.40*	-4.55*	0.11	Nepal	-0.67	-1.64	0.28
Egypt	-1.73	-2.26	0.68*	Poland	-1.80	-2.71	0.32
Myanmar	-2.63	-3.04*	0.42	Cameroon	-2.00	-4.67*	0.41
Sri Lanka	-3.04*	-3.73*	0.22	C. African Rep.	-2.82	-5.64*	0.14
India	-2.11	-2.32	0.18	Zimbabwe	-2.65	-3.41*	0.08
Korea	-1.28	-2.81	0.68*	Cambodia	-3.47*	-3.83*	0.09
Philippines	-1.70	-2.43	0.26	Lao P.D. Rep.	-3.40*	-2.86	0.13
Ghana	-2.25	-4.26*	0.15	Namibia	-3.12*	-4.39*	0.41
Morocco	-1.46	-2.35	0.34	Albania	-1.88	-4.05*	0.49*
Nigeria	-2.44	-4.86*	0.20	Bulgaria	-1.44	-3.09*	0.43
Sudan	-1.81	-3.43*	0.41	China P.R.: Mainland	-1.81	-2.74	0.41
Tunisia	-3.12*	-3.14*	0.27	Mongolia	-1.47	-1.27	0.61*
Colombia	-3.64*	-3.44*	0.05	Moldova	-1.78	-3.08*	0.13
Hong Kong	-2.48	-3.19*	0.29	Russia	-1.01	-1.72	0.40
Malaysia	-2.24	-2.46	0.28				

1/ Augmented Dickey-Fuller t-test statistic for unit root against level stationary alternative; lag length chosen based on Schwarz BIC.

2/ Phillips-Perron Zt test statistic for unit root against level stationary alternative.

3/ Kwiatowski, Phillips, Schmidt & Shin (1992) $\eta(\mu)$ test statistic for level stationarity against non-stationary alternative.

An asterisk * denotes statistical significance at the 5 percent level.

Table A2. Current Account Balances (in percent of GDP), 1960–2004
Autoregressive Coefficients (under revision)

Country	AR1 5/	R^2	LM[4] 6/	Stability 7/	Country	AR1 5/	R^2	LM[4] 6/	Stability 7/
United States	1.04		3.65	0.08	Panama	0.78		1.69	0.07
United Kingdom	0.61		5.15	0.12	Paraguay	0.71		7.41	0.07
Austria	0.61		9.22	0.03	Peru	0.57		8.45	0.15
Belgium-Luxembourg	0.83		5.00	0.14	Venezuela	0.18		8.34*	0.10
Denmark	0.60		4.34	0.10	Jamaica	0.61		3.16	0.15
Germany	0.50		11.54*	0.11	Trinidad-Tobago	0.75		4.63	0.14
Italy	0.57		4.61	0.09	Iran	0.10		2.88	0.18
Norway	0.70		4.45	0.06	Israel	0.63		12.08*	0.08
Sweden	0.78		4.98	0.09	Jordan	0.23		2.46	0.21
Switzerland	0.72		17.85*	0.37	Egypt	0.74		2.42	0.04
Canada	0.68		2.10	0.08	Myanmar	0.62		2.65	0.08
Japan	0.48		14.10**	0.39	Sri Lanka	0.57		3.40	0.07
Finland	0.69		4.00	0.14	India	0.76		1.81	0.07
Greece	0.62		3.89	0.07	Korea	0.76		6.24*	0.11
Iceland	0.28		11.39*	0.02	Phillipines	0.44		4.32	0.12
Ireland	0.78		3.68	0.03	Ghana	0.53		0.24	0.11
Spain	0.52		10.80*	0.07	Morocco	0.82		2.98	0.07
Turkey	0.14		2.49	0.36	Nigeria	0.35		6.15	0.13
Australia	0.30		8.58	0.67*	Sudan	0.39		1.12	0.26
Bolivia	0.17		4.86	0.29	Tunisia	0.66		4.33	0.16
Brazil	0.79		7.82	0.08	Hong Kong 1/	0.64		6.15	0.07
Chile	0.61		7.65	0.09	Malaysia 1/	0.73		1.60	0.09
Colombia	0.53		5.44	0.10	South Africa 2/	0.56		6.49	0.03
Costa Rica	0.78		1.69	0.18	Argentina 2/	0.67		4.09	0.26
Dominican Republic	0.39		1.38	0.08	Mexico 2/	0.60		4.71	0.03
Ecuador	0.26		1.90	0.03	Uruguay 2/	0.60		1.57	0.10
El Salvador	0.16		8.56	0.04	Taiwan, P.O.C. 2/	0.59		3.87	0.10
Guatemala	0.11		7.14	0.82**	Singapore 3/	0.80		2.81	0.05
Haiti	0.80		2.30	0.12	Kenya 3/	0.56		0.60	0.08
Honduras	0.64		1.98	0.08	Côte d'Ivoire 3/	0.78		1.55	0.08
Nicaragua	0.17		7.70	0.33	Algeria 4/	0.70		1.13	0.08

Table A2 (continued). Current Account Balances (in percent of GDP), 1960–2004
Autoregressive Coefficients (under revision)

Country	AR1 5/	R^2	LM[4] 6/	Stability 7/	Country	AR1 5/	R^2	LM[4] 6/	Stability 7/
Mauritius 4/	0.65		2.35	0.20	Bangladesh 12/	0.69		5.85	0.26
Benin 5/	0.27		1.46	0.08	Mauritania 12/	0.64		2.32	0.07
Togo 5/	0.27		2.35	0.11	Bahrain 13/	0.89		6.20	0.23
Indonesia 6/	0.49		0.95	0.09	Kuwait 13/	0.22		0.23	0.61
Thailand 6/	0.89		4.39	0.09	Oman 13/	0.04		0.19	0.13
Uganda 6/	0.04		7.66	0.94**	Botswana 13/	0.28		6.37	0.10
France 7/	0.65		2.26	0.88**	Lesotho 13/	0.70		4.17	0.23
Netherlands 7/	0.62		4.31	0.48*	Nepal 14/	0.81		0.89	0.89
New Zealand 7/	0.52		2.54	0.18	Poland 14/	0.63		1.66	0.34
Saudi Arabia 7/	0.72		1.62	0.03	Albania 15/	0.16		6.76	0.08
Pakistan 7/	0.65		0.60	0.10	Bulgaria 15/	-0.06		5.82	0.03
Syrian Arab Rep. 8/	0.13		9.73*	0.20					
Gabon 8/	0.43		0.88	0.18					
Niger 8/	0.68		3.98	0.07	*Average*	0.35		....	....
Senegal 8/	0.66		4.50	0.09	*Pooled OLS*	0.47		....	....
Gambia 9/	0.52		8.39	0.03	*Panel Fixed Effects*	0.50		....	....
Madagascar 9/	0.17		7.32	0.08					
Hungary 9/	0.55		2.85	0.09					
Congo, Republic of 10/	0.05		2.82	0.11					
Romania 10/	0.20		1.91	0.06					
Portugal 11/	0.62		3.60	0.05					
Papua New Guinea 11/	0.75		2.70	0.18					

1/ Estimation period 1965-2004. 2/ Estimation period 1970-2004. 3/ Estimation period 1975-2004. 4/ Estimation period 1980-2004.
5/ Coefficient on first-order autoregressive term. 6/ Test statistic from Lagrange Multiplier test against 4th-order serial correlation in the residuals.
7/ Denotes Hansen test for stability of the AR1 coefficient
An asterisk * (**) denotes statistical significance at the 5 (1) percent level.

Comments on "Global Dispersion of Current Accounts: Is the Universe Expanding?" by Faruquee and Lee

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This paper starts with the evidence that current account balances are widening in the world economy, notably summarized by global imbalances. The objective of the paper is to examine more thoroughly the global distribution of current accounts viewed from a longer term perspective.

This paper confirms that the global current accounts have been expanding over the past half century. The current account balances for some countries are quite persistence as well. The authors also find that the rising dispersion is closely associated with increasing financial openness of countries. Finally, the paper shows that the recent acceleration of external positions such as global imbalances is clearly not fully accounted for by the trend behavior exhibited by the universal expansion.

The paper is purely empirical. In this sense it achieved a remarkable success. It shows a number of interesting findings. However, my main concern is that most findings lack in the underlying theory that may have driventhe phenomena. For example, one of the major innovations of the paper is to examine the cross section dispersion of current account balances in the world. But what are the driving factors that enhance this CA dispersion?

As a related issue, sometimes it is difficult to interpret the estimated coefficients. This paper finds that a proxy for financial openness has a robust and significant explanatory power. However it is hardly believable to expect that the relationship is linear. The financial openness may affect CA balances differently depending on whether capital accounts are in surplus or in deficit. In addition, at the beginning of opening the financial markets, when the restrictions are likely to bind, CA balances respond more but not much afterwards. Also there may be other missing variables that may cause biased estimation.

Figure 2 shows three dispersion measures. The first two measures are distinguished from the last one in the sense that CA balances in the first two measures are normalized by individual country's GDP. In contrast, the third measure is normalized by the world GDP. While the third measure describes better the general feature of the world economy, a more relevant measure for a country would be the first two measures. Indeed, the authors mainly used the first measure in the empirical analyses. However, as clearly shown in the same figure, the first two dispersion indices increased suddenly in the early 1970s. In fact the peak of the indices liesin the 1970s. Then this observation leads to another question of what is the specialty of 1970s. We can think of the breakdown of the Bretton Woods system, high global inflation, high volatility due to oil shocks and so on. It would be interesting to investigate how each of these features contributes to the increase in the dispersion indices.

Finally the paper admits that the recent acceleration of external positions, i.e. global imbalances, is not fully accounted for by the trend behavior exhibited by the universal expansion.Since global imbalances are one of the main motivations of the paper, it would be interesting to examine further into this issue to see what other factors can explain the special features of the U.S. economy.

CHAPTER II-1

The Contribution Of Rising School Quality To U.S. Economic Growth*

by
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Abstract

This paper explores how much U.S. labor quality has increased due to rising school spending. Given a drastic increase in the U.S. public school spending per pupil during the 20th century, accounting only for the increases in mean years of schooling of the workforce may miss out on a significant part of labor quality growth. In order to estimate the impact of rising school spending on labor quality growth, I examine how earnings of younger cohorts compare to those of older cohorts, beyond the estimated Mincer return to schooling. My findings are that rising school spending is about half as important as increases in mean years of schooling for U.S. labor quality growth, and that labor quality growth explains about one quarter of the growth in labor productivity between 1967 and 2000. The growth in human capital of the workforce due to rising school spending explains only a quarter of the increases in empirical returns to schooling, and a rising skill premium explains the rest. Controlling for the rise in skill premium is important표failing to do so would double

* I am deeply indebted to Mark Bils for his generous support and encouragement. I also thank Mark Aguiar, Yongsung Chang, Jay H. Hong, and seminar participants in macro workshop at the University of Rochester, the State University of New York at Buffalo, the Federal Reserve Bank of Richmond, and in Midwest Macro Meetings 2007 for their valuable comments. All errors are mine.
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the estimated importance of the increased expenditure to growth in human capital.

Keywords : Rising School Quality, Labor Quality Growth, Growth Accounting
JEL Classifications : J24, 047, 051

I. Introduction

This paper explores how much U.S. labor quality has increased due to rising school spending. Schooling investments in the U.S. increased drastically during the 20th century. According to the Current Population Survey March Supplement, the mean years of schooling for the U.S. workforce rose from about 11 years in 1967 to more than 13 years in 2000. On top of that, the public school spending per pupil in elementary and secondary schools for the cohorts appearing in either survey more than tripled on average. While both of these are potential sources of real income growth in the U.S., the measure of labor quality growth used by the Bureau of Labor Statistics (BLS) is determined mainly by increases in the mean years of schooling, and fails to capture the impact of changes in education quality on the human capital of the workforce. The BLS reports that labor quality grew by 0.22 percent per year between 1967 and 2000 if the increased school spending improved school quality, then the BLS may miss a significant part of the contribution of labor quality growth to U.S. labor productivity growth.

In order to understand the role of school spending in human capital accumulation, I develop a simple schooling model. An important characteristic of the model is that human capital depends not only on the amount of time spent in school, but also on the level of expenditures while in attendance. The productivity of school spending is governed by the elasticity of human capital production with respect to school spending. In this study, I propose a new way of estimating this elasticity, and quantify the impact of the increased school spending per pupil on U.S. labor productivity growth.

To estimate the productivity of school spending in increasing the human capital of the workforce, I examine how earnings of younger cohorts compare to those of older cohorts who received their schooling at earlier dates. I also examine how the estimated Mincer return to schooling has evolved across cohorts. Empirical returns to schooling more than doubled for 1970 birth cohorts, compared to 1912 birth cohorts, while mean years of education increased. If we allow for the marginal return to schooling to decline with the level of education, then increased returns to schooling can only be explained by a rise either in school quality or in skill premiums. For illustration, suppose that individual human capital does not increase with experience at all. If school quality had indeed improved due to rising school spending, then in cross-sectional data we should observe higher earnings for younger cohorts than for older cohorts. Since experience has no effect on human capital, rising school quality could be quantified by accounting for earnings differences across cohorts in cross-sectional data, conditional on years of schooling. The increases in returns to schooling unexplained by the estimated increases in school quality could then be attributed to a rising skill premium.

Earnings do increase with work experience, because individuals accumulate human capital through work experience in addition to schooling, but the above logic is still valid. To be consistent both with rising school quality and with increasing experience-earnings profiles in cross-sectional data, it must be that individual human capital stocks increase very rapidly with work experience. Individual human capital profiles cannot be too steep after completion of schooling, however, or else individuals would leave school earlier than we observe, substituting expenditure on schooling for time in school. Individual post-schooling human capital profiles, identified in this manner, allow us to estimate the proportion of labor quality growth that is due to rising school expenditures by disentangling the impact of rising school quality and differences in work experience upon cross-sectional earnings differences across cohorts.

My findings are that rising school spending is about half as important as increases in mean years of schooling for U.S. labor quality growth, and that total labor quality growth explains about one quarter of the growth in labor productivity between 1967 and 2000. The growth in human capital of the workforce in response to rising school spending explains only a quarter of the increases in empirical returns to schooling, and a rising skill premium explains the rest. Given the increased school spending per pupil, U.S. labor quality growth has been fairly modest. Controlling for the rise in skill premium is important-failing to do so would double the estimated importance of the increased expenditure to growth in human capital.

There is a vast literature that seeks to quantify the role of human capital in economic growth and development. The most widely used methodology to measure country-level human capital stocks in the literature is to multiply the mean years of schooling of the population by the estimated Mincer return to schooling as in Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999). Since this method does not allow for differences in education quality across countries, however, Bils and Klenow (2000) add teacher human capital to the standard Mincer-type human capital specification. Bils and Klenow (2000) consider only time inputs for human capital production and ignore goods inputs, which can potentially generate remarkable differences in education quality. Manuelli and Seshadri (2005) and Erosa, Koreshkova, and Restuccia (2006) explicitly incorporate education goods as well as time as inputs for human capital production and attempt to quantify the role of human capital in explaining cross-country income differences. Their approaches are not applicable to the growth accounting exercise this paper is up to, however, because they ignore the possibility that different cohorts may face different quality of education.

This paper most closely relates to Rangazas (2002) by attempting to quantify the impact of quantity and quality of schooling on U.S. labor productivity growth. It differs from Rangazas (2002), however, in that it estimates the productivity of school spending at increasing human capital instead of taking it from micro-study estimates in the literature. An important contribution of this paper is proposing a new way of estimating the elasticity of human capital production with respect to expenditures, which is key to quantifying the impact of rising school spending on labor quality growth. I also control for the rise in skill premium and unobserved heterogeneity correlated with schooling choice-ignoring these may overestimate the role of human capital growth in income growth.

The remainder of this paper is organized as follows. Section 2 describes the BLS measure of labor quality growth and discusses the relation between the estimated return to schooling and school quality. In section 3, I introduce a simple schooling model in which individual human capital depends on expenditures as well as time spent in school, and extend it by considering skill premium and heterogeneous learning ability. I describe the identification scheme and the estimation procedure for relevant parameters in section 4 and report the estimation results and main findings in section 5. Section 6 concludes the paper.

II. Measuring Labor Quality Growth

1. The BLS Measure

Since 1983, the Bureau of Labor Statistics (BLS) has extended the traditional growth accounting framework[1)] by incorporating labor quality growth into U.S. economic growth accounting following Denison (1962). The BLS considers a production function, in which economic output Y depends on m types of physical capital inputs k_1 , k_2, ..., km and raw hours provided by n types of workers l_1, l_2, ..., l_n.

---

1) The well-known Solow residual is income growth unexplained by physical capital growth only.

$$Y = f(k_1, ...k_m, l_1, ..., l_n, t)$$

Assuming constant returns to scale technology, perfectly competitive factor markets and cost-minimizing behavior of firms, labor productivity growth denoted as $\frac{\dot{\overline{Y/L}}}{Y/L}$ is attributed to growth in physical and human capital of the economy and the residual total factor productivity growth as follows:

$$\frac{\dot{\overline{Y/L}}}{Y/L} = \frac{\dot{\overline{TFP}}}{TFP} + s_K \left[\sum_{i=1}^{m} s_{k_i} \frac{\dot{k_i}}{k_i} - \frac{\dot{L}}{L} \right] + s_L \left[\sum_{j=1}^{n} s_{l_j} \frac{\dot{l_j}}{l_j} - \frac{\dot{L}}{L} \right]$$

where

$$L = \sum\nolimits_{j=1}^{n} l_j$$

$$s_{k_i} = \frac{P_{k_i} k_i}{\sum_{i=1}^{m} P_{k_i} k_i} \text{ and } s_{l_j} = \frac{P_{l_j} l_j}{\sum_{j=1}^{n} P_{l_j} l_j},$$

$$s_K = \frac{\sum_{i=1}^{m} P_{k_i} k_i}{\sum_{i=1}^{m} P_{k_i} k_i + \sum_{j=1}^{n} P_{l_j} l_j} \text{ and } s_L = \frac{\sum_{j=1}^{n} P_{l_j} l_j}{\sum_{i=1}^{m} P_{k_i} k_i + \sum_{j=1}^{n} P_{l_j} l_j}$$

Every variable with an upper dot stands for the derivative of the variable with respect to time and P_{ki} and P_{hj} are the unit prices of the ith type of physical capital input and the jth type of labor input, respectively. The growth rate $\frac{\dot{k_i}}{k_i}$ by its cost share s_{kj} in total physical capital input costs and the weighted average of different capital input growth rates is itself weighted by the share s_K of total capital inputs in total factor input costs. The growth rate of type j labor input is weighted by its cost share s_{lj} in the total cost of labor inputs. As in the case of capital inputs, the weighted average of different labor input growth is multiplied by the cost share s_L of total labor inputs in total factor input costs before accounting for its contribution to output growth.

The BLS cross-classifies workers according to their education, experience and sex and considers each cell a different labor input. The BLS then runs Mincer-type regressions that include dummies for a few education windows, work experience, and other individual traits as regressors and exploits the predicted wages from the regression to compute cost shares to different labor inputs. The BLS measure $s_L \left[\sum_{j=1}^{n} s_{l_j} \frac{\dot{l_j}}{l_j} - \frac{\dot{L}}{L} \right]$ of labor quality growth, obtained in this manner, is mainly determined by the increases in years of schooling, but fails to capture the impact of changes in education quality on human capital of the workforce.

A simple example makes a point. Suppose there are two types of workers, high school and college graduates, and they work the same hours in the market. If the fraction of college graduates increased from one period to the next, the BLS reflects that in its measure of labor quality growth by multiplying the change by the wage differences between the two groups of workers. Suppose instead that school quality improved from one period to another while labor composition stayed the same. We would then expect some growth in labor quality because workers in the second period on average acquired better quality education. The BLS approach, however, yields no labor quality growth between the two periods because labor composition stayed the same.

The BLS reports that U.S. labor quality grew by 0.22% per year and this explains about 13% of the growth in U.S. labor productivity between 1967 and 2000. Data on public educational expenditures, however, suggests that the BLS measure of human capital may miss out on a significant part of labor quality growth. As shown in Figure 1, real public educational expenditures per pupil in elementary and secondary schools increased drastically during the 20th century, which led the average spending per pupil to more than triple for the cohorts appearing in 2000, compared to the cohorts working in 1967. To avoid overstating the expenditures growth, I deflate the time series using an education sector price index, which increases more rapidly than an overall price index.2)

Considering that increased expenditures tend to improve school quality by reducing the pupil-teacher ratio, raising teacher quality, or upgrading to state-of-the-art educational equipment,3) it is conceivable that newer cohorts have accumulated more human capital stocks through rising school spending as well as increasing educational attainment than older cohorts.

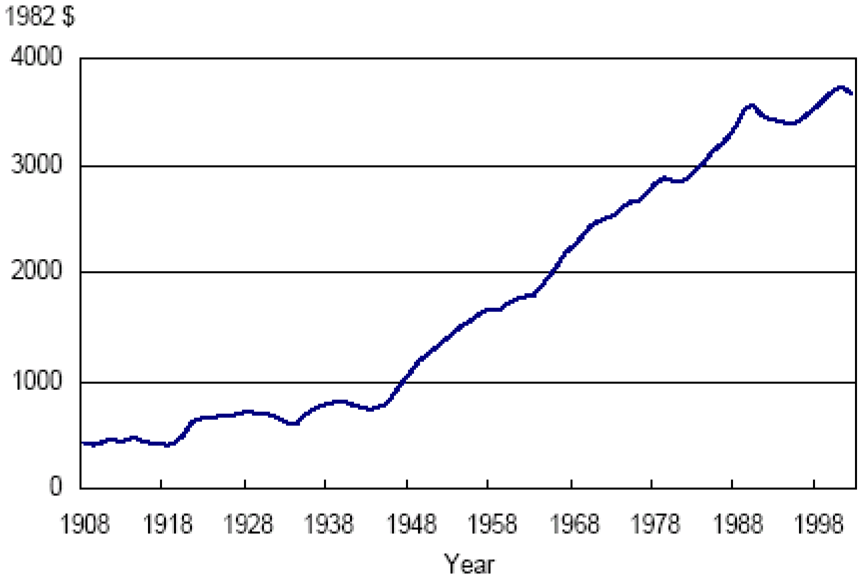
In this study, I suggest that labor input is expressed as a product of raw hours and its quality.

$$Y = f(k_1, ...k_m, h_1 l_1, ..., h_n l_n, t)$$

2) The price index for Personal Consumption Expenditures (PCE) on education is used to deflate educational expenditures. Using an overall price index as a deflator, the factor by which those data increased almost triples.

3) Hanushek and Rivkin (1997) decomposed the rise in school spending over the 20th century and found that it resulted from declining pupil-teacher ratio, increasing real wages for intructional staffs, and rising expenditures outside of the classroom.

Figure 1. U.S. Real Expenditures Per Pupil in Public elementary and Secondary Schools



where l_j is raw hours provided by type j labor input and h_j is its quality per hour. This approach decomposes the changes in the price for the hours worked by j worker types into changes in hour quality h_j provided by j type worker and the price P_{hj} per quality where $P_{l_j} = P_{h_j} h_j$. Labor productivity growth accounting is then modified as follows.

$$\frac{\dot{\overline{Y/L}}}{Y/L} = \frac{\dot{TFP}}{TFP} + s_K \left[\sum_{i=1}^{m} s_{k_i} \frac{\dot{k}_i}{k_i} - \frac{\dot{L}}{L} \right] + s_L \left[\sum_{j=1}^{n} s_{l_j} \frac{\dot{h}_j}{h_j} + \left(\sum_{j=1}^{n} s_{l_j} \frac{\dot{l}_j}{l_j} - \frac{\dot{L}}{L} \right) \right]$$

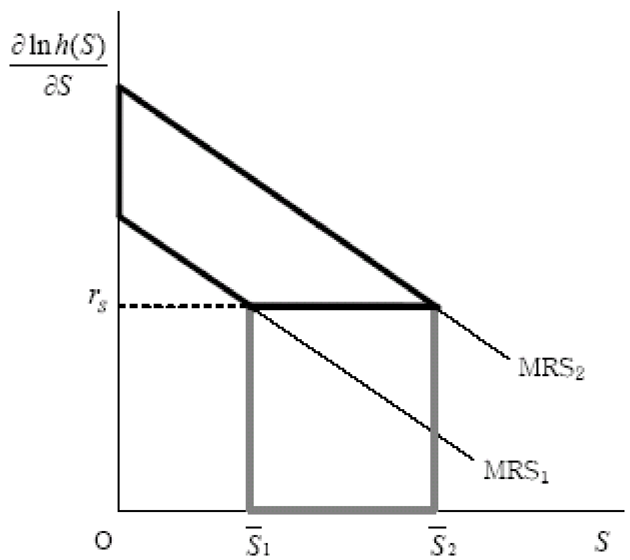
Labor quality growth now has an additional component $s_L \sum_{j=1}^{n} s_{l_j} \frac{\dot{h}_j}{h_j}$ representing the weighted average of quality growth of different labor inputs. If school quality indeed improved due to rising school spending, this term should capture its impact. This paper quantifies this component, which the BLS has not treated.

2. Rising School Quality and Return to Schooling

Economists have long used the well-known Mincer specification[4] to estimate the impact of schooling on individual earnings. If school quality indeed improved due to rising school expenditures, it should also be reflected in the estimated Mincer return to schooling. One might then argue that accounting for the increases in the estimated Mincer return to schooling over time as presented in Table 3 should be enough to quantify labor quality growth.

Although the estimated Mincer return to schooling contains important information about cross-sectional returns to schooling, it is not well-suited for cohort analysis unless the strict assumptions implicit in the specification-a constant return to schooling and the absence of cohort effects-are true. For illustration, consider cross-sectional data where younger cohorts on average obtained better quality of education as well as more years of schooling than older cohorts. Figure 2 plots marginal returns to schooling for two

Figure 2. Diminishing Returns to Schooling and Rising School Quality



4) Mincer (1974) derived an earnings specification, building on life-cycle earnings models developed in Becker (1964) and Ben-Porath (1967) with a few simplifying assumptions. The key assumptions include constant returns to years of schooling and linearly declining post-school investments in human capital. See Heckman, Lochner, and Todd (2003) for more details.

cohorts in this case, where mean years of schooling for older and younger cohorts are denoted by $\overline{S}_1$ and $\overline{S}_2$. Even though the marginal return to schooling diminishes with the level of schooling, rising school quality shifts up the marginal return to schooling of the younger cohort over all education levels. This is captured by the curve for the younger cohort (MRS_2), which resides above the curve for the older cohort (MRS_1). The more school quality rises, the more the MRS_2 curve shifts upward from the MRS_1 curve. As a result, the estimated Mincer return to schooling, γ s, approximates the marginal return to schooling for both cohorts fairly well.

Noting that the human capital stock accumulated for each cohort is obtained by integrating the area below the corresponding marginal return to schooling curve up to the mean schooling level, the difference between the resulting two areas measures the true growth in human capital between the two cohorts. If human capital growth between the two cohorts is instead computed by multiplying the estimated Mincer return to schooling by the difference between cohort mean years of schooling, the resulting measure is represented by the grey-lined rectangle. This measure of labor quality growth understates true growth in human capital by the amount indicated by the black-lined parallelogram,[5] which is greater, the more the rising school spending shifts up the marginal return to schooling curve for the younger cohort.

Rising school quality is, however, not the only factor that increases the marginal returns to schooling. If different education groups are imperfectly substitutable in labor market, the market pays different wage rates to different education groups depending on the demand for and the supply of corresponding education groups. When more educated workers get paid higher wage rates per unit of human capital than less-educated workers, the MRS_2 curve shifts upward from the MRS_1 curve as is shown in Figure 2, without much rise in school quality across cohorts. Ignoring the presence of this skill premium, the higher return to schooling for more educated workers that is due to the skill premium is attributed instead to rising school quality, overstating the impact of rising school quality on growth in human capital growth for a given diminishing return to schooling. Since empirical evidence indeed supports the notion that the skill premium rose drastically from 1980's on, controlling for this seems to be quantitatively important.

Within-cohort heterogeneity that is positively associated with schooling choice also affects the estimated return to schooling. Card (1994) argues that individuals with a

5) Even if we add higher-order polynomials of schooling in the Mincer regression to improve the model fit, the reasoning still goes through because the specification mistakes the shift of marginal return to schooling curve due to school quality rise as a small degree of diminishing returns.

higher return to schooling tend to obtain more education because of their comparative advantage. Assuming that ability distribution staysthe same across cohorts, to be consistent with the increases in mean years of schooling across cohorts, it must be that average ability level is lower for younger cohorts than for older cohorts at a given number of years of schooling. This implies that a unit of school spending is relatively less productive for younger cohorts than for older cohort. Failing to control for heterogeneity correlated with schooling choice then overstates labor quality growth due to increases in school spending.

The discussion in this section confirms that the estimated cross-sectional Mincer return to schooling itself does not provide us with a correct measure for labor quality growth when school spending has risen. In this study, I free up the assumptions behind the Mincer specification by considering such factors that affect the schooling-log earnings relation in cross-sectional data. This includes changes in education quality across cohorts, the rise in skill premium, and heterogeneous ability associated with individual schooling choice. I then use the estimated Mincer return to schooling as a guide to pin down the combination of parameters governing each factor along with other data moments.

III. The Model

In this section, I first introduce the baseline model in which human capital production depends on expenditures as well as time inputs. I then extend the model in two directions by introducing a skill premium and heterogeneous learning ability.

1. The Baseline Model

1.1. Human Capital Production Function

Individual human capital stock h(a) at age a, accumulates according to two separate processes during schooling and on-the-job as follows.

$$\dot{h}(a) = \gamma_0 h(a)^{\gamma_1} D(a)^{\gamma_2} \text{ for } a < S+6$$

$$\dot{h}(a) = \phi'(a-S-6)h(a) \quad \text{for } a \geq S+6$$

$$\phi(a-S-6) = \phi_0(a-S-6) + \phi_1(a-S-6)^2 \quad \forall a > S+6$$

$$0 < \gamma_1, \gamma_2 < 1 \text{ and } h(6) \text{ is given}$$

where $\dot{h}(a)$) is the time derivative of human capital at age a, D(a) is education goods investment at age a and S is years of schooling. An individual accumulates his human capital beginning at the age of 6 when he starts schooling. While in school, he produces human capital using his entire stock of human capital and education goods, and his human capital stock does not depreciate. This corresponds to the human capital production function described in Ben-Porath (1967). While in school, an individual is a full-time student and cannot take part in market work. Goods investment in the production function captures school quality for a given year of schooling. T restrict each input in the human capital production function to exhibit diminishing returns by assuming human capital elasticities γ_1 and γ_2 with respect to each input to be between 0 and 1, but do not impose a restriction on the return to scale. Tn Ben-Porath (1967), diminishing return to scale, or $\gamma_1 + \gamma_2 < 1$ is required because the assumption guarantees partial engagement of individuals in human capital investment after leaving school[6]. Since *T* assume a separate human capital accumulation process on-the-job from during schooling, such a restriction on the return to scale is not necessary. The parameter γ_0 governs the scale of human capital stocks and is allowed to vary across individuals in an extended model with heterogeneity, in which it is interpreted as individual learning ability. With this specification, *T* can compute individual human capital stock accumulated through schooling if *T* know an individual's years of schooling and a stream of educational expenditures he made while in school, for a given set of parameters. If γ_1 = and $\gamma_2 = 0$, then human capital grows exogenously throughout schooling period at the rate of γ_0, which collapses to the usual Mincer specification.

6) In Ben-Porath(1967), the law of motion of individual human capital follows $\dot{h}(a) = \pi[sh(a)]^{\gamma_1} D(a)^{\gamma_2}$ where $\gamma_1 + \gamma_2 < 1$. Diminishing returns to scale guarantees that the marginal cost of producing one unit of human capital increases such that there appears a period during which an individual works in the market and produces human capital at the same time, or $0 < s < 1$. If $\gamma_1 + \gamma_2 = 1$, the fractions of one's time spent in human capital production is either 0 or 1.

Once an individual leaves school, his human capital is assumed to grow exogenously through learning by doing on-the-job. More specifically, log human capital on-the-job accumulates as a quadratic function of experience. I made this assumption because we do not have good data for individual time allocation to human capital production and to the market and for goods investment after completion of schooling. When staying one more year in school, an individual incurs the same cost by delaying the return to post-schooling experience, whether human capital accumulates through learning by doing or through Ben-Porath type investments after completion of schooling. Since what matters to identify the productivity of school spending in increasing human capital is only the quantity of this cost, the learning by doing assumption for on-the-job human capital accumulation is innocuous. If younger cohorts invest more quality goods to increase human capital after completion of schooling as well as while in school than older cohorts, however, I may miss its impact on labor quality growth[7].

According to the human capital production function described above, an individual's human capital stock when he leaves school is written, given $h(6)$, as

$$h(S+6) = \left[h(6)^{1-\gamma_1} + \gamma_0(1-\gamma_1) \int_6^{S+6} D(a)^{\gamma_2} da \right]^{\frac{1}{1-\gamma_1}}$$

An efficiency unit assumption that differently skilled workers are unequal, but perfect substitutes implies that each individual is paid in proportion to his human capital. Therefore, the logarithm of the wage bill of an individual i at time t, denoted by WB_{it} satisfies

$$\ln WB_{it} = \ln w_t + \frac{1}{1-\gamma_1} \ln \left[h(6)^{1-\gamma_1} + \gamma_0(1-\gamma_1) \int_6^{S_i+6} D(a)^{\gamma_2} da \right] + \phi(Exp_{it}) + \varepsilon_{it} \quad (1)$$

The aggregate wage at time t common to every worker, and an individual shock component at time t are denoted by w_t and ε_{it}, respectively. In an extended model, individuals with different levels of education are assumed to be imperfectly substitutable and get paid different wages from each other. I assume strong exogeneity of ε_{it}, such that:

$$E(\varepsilon_{it}|Z_{it}) = 0$$

where Z_{it} stands for any known individual characteristics at time t.

7) If younger cohorts indeed invested more quality goods on-the-job than older cohorts, we should observe a rise in experience premium for more recent cohorts, but Kambourov and Manovskii (2005) provides an evidence against it.

1.2. A Simple Schooling Model

I now introduce a simple schooling model to add a restriction on the relationship between human capital production technology and schooling investment.

An individual born at time 0 chooses the optimal level of schooling and goods investment associated with each year of schooling to maximize the present value of his lifetime income stream.[8)]

$$\max_{D(a),\,S} \int_{S+6}^{R} e^{-ra} w(a)h(a)da - \int_{6}^{S+6} e^{-ra} P(a)D(a)da$$

$$s.t.\;\; h(a) = \left[h(6)^{1-\gamma_1} + \gamma_0(1-\gamma_1)\int_{6}^{S+6} D(t)^{\gamma_2}dt\right]^{\frac{1}{1-\gamma_1}} e^{\phi(a-S-6)}$$

The individual goes to school for S years, beginning at age 6, and enters the market with a human capital stock accumulated through schooling at the age of $S + 6$. Once he leaves school, he never goes back to school and works till he retires at age R. He discounts his income using the market interest rate r. Human capital production technology is the same as described in the previous section. Prices of education goods relative to consumption goods are denoted by $P(a)$.[9)]

Assuming interior solutions, first-order conditions with respect to the two choice variables are sufficient to characterize optimal levels S^* and $D^*(a)$ of schooling and education goods investments for $6 \leq a \leq S^* + 6$. For notational convenience, I define $\widetilde{S}^* = S^* + 6$.

The equation (2) and (3), two first-order conditions represent two margins on which an individual is optimizing: the quality and quantity margins of schooling. Equation (2) implies that at the optimal point, the marginal benefit of such investment, which is a human capital increment promising higher income throughout his working life, equals the marginal cost of investing one more unit of market goods at the age of a. An

8) In the presence of perfect credit markets, the individual optimization problem described here is equivalent to the standard utility maximization problem.

9) In the data, education goods prices grow more rapidly than overall price levels. Between 1929 and 2005, inflation rates based on the Consumer Price Index (CPI) city average and the Personal Consumption Expenditures (PCE) price index are 3.3% and 3.1% per annum while PCE on the education price index increased by 4.3% per year.

$$\gamma_0\gamma_2 D^*(a)^{\gamma_2-1}h(\widetilde{S}^*)^{\gamma_1}\int_{\widetilde{S}^*}^{R} e^{-rt+\phi(t-\widetilde{S}^*)}w(t)dt = e^{-ra}P(a),\ \forall a \le \widetilde{S}^* \tag{2}$$

$$\gamma_0 h(\widetilde{S}^*)^{\gamma_1-1}D^*(\widetilde{S}^*)^{\gamma_2}\int_0^{R-\widetilde{S}^*} e^{-r\tau+\phi(\tau)}h(\widetilde{S}^*)w(\tau+\widetilde{S}^*)d\tau \tag{3}$$
$$= w(\widetilde{S}^*)h(\widetilde{S}^*) + P(\widetilde{S}^*)D^*(\widetilde{S}^*) + \int_0^{R-\widetilde{S}^*} e^{-r\tau+\phi(\tau)}w(\tau+\widetilde{S}^*)h(\widetilde{S}^*)\phi'(\tau)d\tau$$

individual spends more in higher grades because it is a cheaper way to achieve the optimal human capital stock when leaving school, given the optimal number of years of schooling. More specifically, the model predicts that spending for each grade is increasing at the rate of $\frac{g_p - r}{\gamma_2 - 1}$ where g_p is growth rate of the relative price of education goods. Equation (3) relates the marginal cost of staying one more year in school to its marginal benefit. If an individual decides to stay in school for one more year, he incurs a cost in delaying the returns to post-schooling experience as well as foregone earnings and educational expenditures for that year while he expects a permanent increase in his lifetime income.

Plugging equation (2) evaluated at $a = \widetilde{S}^*$ into equation (3) yields

$$\gamma_2 = \frac{P(\widetilde{S}^*)D^*(\widetilde{S}^*)}{w(\widetilde{S}^*)h(\widetilde{S}^*) + P(\widetilde{S}^*)D^*(\widetilde{S}^*) + \int_0^{R-\widetilde{S}^*} e^{-r\tau+\phi(\tau)}w(\tau+\widetilde{S}^*)h(\widetilde{S}^*)\phi'(\tau)\}d\tau} \tag{4}$$

Equation (4) indicates that the elasticity of human capital with respect to expenditures is equal to the share of expenditures in the marginal cost of obtaining the last year of schooling by the optimizing individuals. It implies that γ_2 can be estimated by uncovering the fraction of expenditure cost out of marginal cost of staying one more year in school at the optimal schooling level. I exploit this expenditure share in the marginal cost of schooling represented by equation (4) as an important moment to estimate the impact of rising school spending on growth in the human capital of the workforce.

2. Extensions

In this section, I extend the baseline model in two directions. First, I introduce skill-specific wages, of which changes affect the estimated return to schooling without changing the marginal product of schooling, to the baseline model. Second, I allow learning ability to vary across individuals. Learning ability affects individual schooling decisions.

2.1. Skill Premium

Beginning in the late 70's, the skill premium represented by the wage gap between college and high school graduates has risen consistently. Autor, Katz, and Kearney (2005) presents evidence from the CPS March Supplement that logged wage gap between college and high school graduates increased from 0.4 in 1979 to about 0.65 in 2000. In light of the increased supply of college graduates, economists have concluded that demand for high-skilled workers has been rising even more rapidly, thereby raising the skill premium during that period. Since a rising skill premium increases empirical returns to schooling for later cohorts, we may overstate the role of rising school quality if we let it explain the entire increase in the cohort-based return to schooling.

To avoid mistaking a skill premium rise as labor quality growth, I introduce different skill prices associated with each level of schooling. I assume that when individuals decide how many years to stay in school, they do not recognize the presence of skill premium[10]. Under this assumption, equation (4) for the expenditure share in the marginal cost of schooling is still valid. I denote by w_S the wage rate per unit of human capital of an individual with S years of schooling. The observed wage bill of an individual i at time t depends on the skill-specific wage instead of the aggregate wage. The logarithm of his wage bill is then expressed as:

$$\ln WB_{it} = \ln w_{St} + \frac{1}{1-\gamma_1} \ln \left[h(6)^{1-\gamma_1} + \gamma_0 (1-\gamma_1) \int_6^{S_i+6} D(a)^{\gamma_2} da \right] + \phi(Exp_{it}) + \varepsilon_{it}$$

10) Even if individuals recognize the skill premium when they make schooling decisions but do not anticipate it to rise or fall over time, the results do not change much.

When determining skill-specific wages, I follow Katz and Murphy (1992)'s work on changes in the U.S. college premium[11]. I categorize workers into four education groups: i) workers with less than 12 years of schooling, ii) high school graduates, iii) workers with some college, and iv) college graduates and obtain average skill-specific wages for the four groups using CPS data and the parameterized on-the-job human capital production function.[12] For workers with less than 12 years of schooling and workers with some college, I use the linear projections of the time series of their average wages on the wages of high school graduates and college graduates to extract the extent to which their wages move with the wages of high school and college graduates. I then allocate the resulting wages to workers with 0, 12, 14, and 17 years of schooling and linearly interpolate wages for in-between education levels.

2.2. Heterogeneous Learning Ability

Labor economists have paid attention to the impact of unobserved heterogeneity among individuals, such as innate ability on the estimated return to schooling. More able individuals tend to obtain more education because of comparative advantage, and this systematically biases the OLS estimate for the marginal return to schooling upward. Assuming that the ability distribution stays constant across cohorts, the increases in cohort mean years of schooling imply that the average ability level of younger cohorts is lower than that of older cohorts for any given years of schooling. Without adjusting for this, I may overestimate labor quality growth given rising school spending. In this extension, I introduce individual heterogeneity in learning ability γ_0.[13] This type of

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11) When creating a measure of labor supply, Katz and Murphy (1992) allocate workers to two aggregate groups, high school equivalents and college equivalents. High school graduates and college graduates are treated as pure high school equivalents and college equivalents, respectively. For workers with all other education levels, they allocate them based on the extent to which their wages move with the wages of high school and college graduates. For example, they regress the average series for workers with some college on the wages of high school and college graduates and use the estimated coefficients to allocate them to the two aggregate groups. See Katz and Murphy (1992) for more details.

12) See section 4 for more details.

13) Although individual human capital stock $h(6)$ at the age of 6 is also a potential source of individual heterogeneity, I only consider heterogeneity in learning ability r_1 in this paper. This is sufficient for the purpose of demonstrating how the correlation between unobserved heterogeneity and schooling affects the estimated labor quality growth. In addition, empirical evidence supports that heterogeneity in the return to schooling may be more important. Many studies that attempt to measure the true return to schooling using instruments find that the ability bias is negative. Card (2001) argues that heterogeneous return to schooling may drive these results because treatment groups affected by those instruments have higher returns to schooling.

heterogeneity affects the individual return to schooling, inducing individuals with higher ability to choose more years of schooling.

Specifically, I assume that individual learning ability is log-normally distributed for every cohort, where the distribution stays the same across cohorts. I set the number of discrete levels of learning ability equal to the number of education levels we observe in the data for each cohort, where higher ability is associated with higher levels of schooling. Given the log-normal learning ability distribution characterized by its mean μ_{γ_0} and standard deviation σ_{γ_0}, I assign learning ability to each schooling level as follows. For instance, if 12 years of schooling covers 50th to 70th percentiles of the schooling distribution for a certain cohort in the data, I assign the learning ability for the 60th (60 = (50 + 70)/2) percentile to high school graduates.

IV. Identification and Estimation

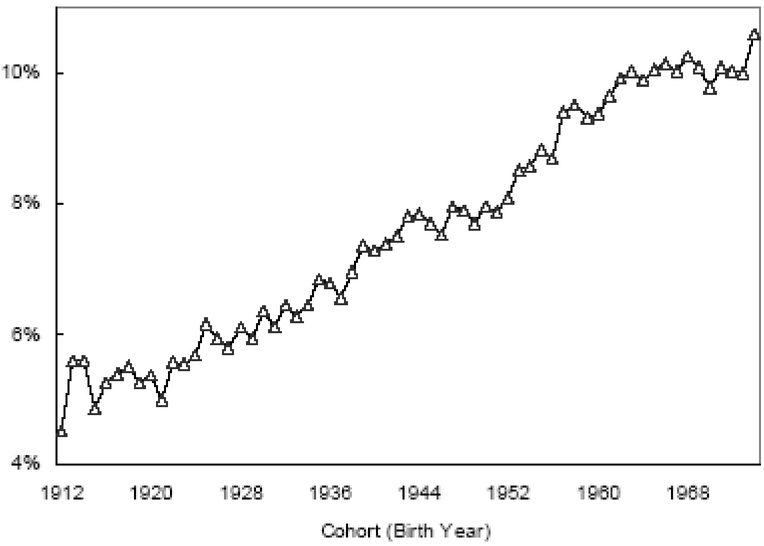
In this section, I provide insights on how to identify the productivity of school spending in increasing the human capital stocks of the workforce and describe the estimation procedure.

1. Identification

As is shown in Figure 3, the estimated Mincer return to schooling rose from about 4.5% for 1912 birth cohort to about 10% for the early 70's birth cohorts, while the cohort mean years of schooling increased. If we allow the marginal return to additional years of schooling to decline with the level of schooling, this increase in the return to schooling requires a rise either in school quality across cohorts or in skill premiums.

To estimate the impact of rising school spending on the growth in labor quality, I examine how earnings of younger cohorts compare to those of older cohorts who acquired schooling at earlier dates in cross-sectional data. To illustrate, suppose that individual human capital does not accumulate with work experience at all. If rising school spending increased school quality, in cross-sectional data, we should observe that younger cohorts earn more than older cohorts for given years of schooling. Since work experience does not increase human capital at all, the earnings differential between younger and older cohorts provides a measure of the growth in human capital due to rising school spending. The increase in the estimated return to schooling

Figure 3. Cohort-Based Mincer Return to Schooling

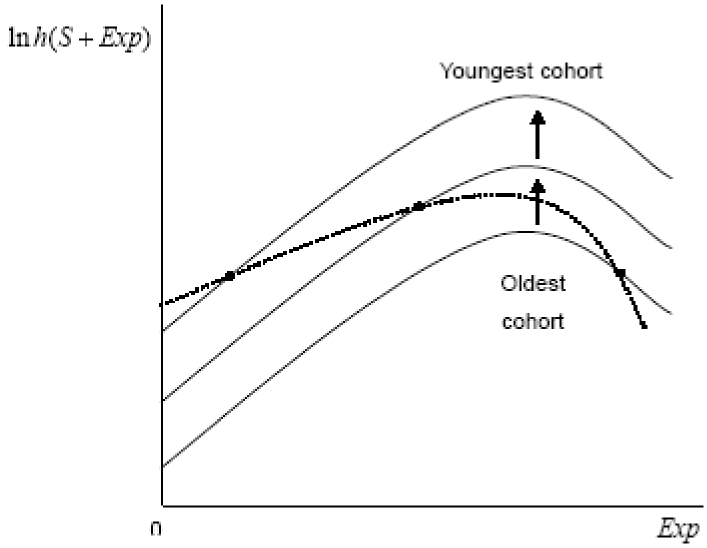


unexplained by the rise in school quality can then be attributed to a skill premium rise over time.

Earnings do increase in cross-sectional data because individuals accumulate human capital through work experience as well as through schooling, but the above logic is still valid. To be consistent both with sharply rising school quality and with increasing experience-earnings profiles in cross-sectional data would require that individual human capital stocks increase very rapidly with work experience. Figure 4 contrasts the cross-sectional experience-earnings profile with individual post-schooling human capital profiles when rising school spending indeed improves school quality. The dotted curve indicates the usual hump-shaped cross- sectional experience-earnings profile, while the black solid curves represent how individual human capital evolves with work experience for different cohorts. Even though the shape of the post-schooling human capital profile is the same for every cohort, rising school quality shifts the profile for younger cohorts upward. Since cross-sectional cohort earnings differences are determined by rising school quality and differences in work experience across cohorts, I can estimate the proportion of labor quality growth that is due to rising school expenditures by understanding how individual human capital increases with work experience.

Data on school expenditures and years of schooling are informative in unveiling the effect of work experience on human capital accumulation. Individuals take into account how their human capital stocks evolve after completion of schooling, when they decide

Figure 4. Rising School Quality and Experience-Earnings Profile



on their education levels and school expenditures. If individual human capital profiles are too steep after leaving schooling, staying in school is very costly for individuals, inducing them to substitute expenditures on schooling for time in school. We should then have observed more school expenditures than we observe in the data. If individual human capital profiles are too flat instead, individuals would not have spent as much money while in school as we see in the data. This way, I identify individual post-schooling human capital profiles using data on expenditures and years of schooling, and back out the impact of rising school quality on growth in the human capital of the workforce from the cross-sectional relationship of experience and earnings.

One thing to note is that with the models without heterogeneous ability, I do not attempt to estimate γ_1 governing the curvature of the human capital production function while in school. Not only do those models not provide a proper moment to estimate γ_1 , but the value of γ_1 also hardly affects the estimated labor quality growth due to rising expenditures on schooling. In a model with heterogeneity, however, mean years of schooling over all sample and mean schooling dispersion within cohorts are used for identifying the variance of the ability distribution and the curvature parameter γ_1. When more able individuals stay in school longer, the estimated Mincer return to schooling is higher than the mean of individual marginal return to schooling, by the magnitude of ability bias. The larger the variance of the ability distribution is, the further the mean of individual marginal return to schooling is below the estimated return to schooling. Mean years of schooling, given the curvature of the human capital production function, then determines the mean of individual marginal return to schooling, thereby identifying the variance of the ability distribution. On the other hand, given the variance of ability distribution, a higher curvature of the human capital production function generates more schooling dispersion within cohorts. The degree of curvature of the human capital production function is then identified by the mean dispersion of schooling within cohorts. The basic identification scheme of the impact of rising school quality on labor quality growth described above is still valid with the introduction of unobserved heterogeneity.

2. Estimation

Before discussing the estimation procedure, I pre-set the values of a few variables. I set the retirement age R and the interest rate r to 65 and 0.05, respectively. Education good prices are assumed to grow at the constant rate 0.115, which is the average growth rate of the PCE on the education price index between 1908 and 2000. I normalize the price of education goods in 1982 to one. I also normalize the initial human capital stock $h(6)$ of an individual at age 6 to one, which is the same for any individual in any cohort. Neither normalization affects anything other than the scale parameter γ_0. I vary the value of the curvature parameter γ_1 from 0.3 to 0.7. Values are summarized in Table 4.

Given those variables, I estimate the parameters characterizing the human capital production technology both during schooling and on-the-job using the Generalized Method of Moments (GMM), minimizing the weighted distance between the model moments and data counterparts. I start with a model with an efficiency unit assumption and then introduce the skill premium to investigate its impact on the estimated labor quality growth due to increased school expenditures. Moments I use include the estimated Mincer return to schooling over all sample and across cohorts and the estimated cross-sectional return to experience (modelled as a quadratic function of potential experience in the pooled sample Mincer regression), and the expenditure share of the marginal cost of schooling represented by equation (4).

In order to obtain the Mincer regression coefficients from the model, I need to construct individual wage bills as shown in equation (1). Since the aggregate wage is common to every individual and the error terms are assumed to be strongly exogenous, regressing logged human capital stocks of individuals on years of schooling and potential experience and its square should yield the same estimates for the return to schooling and to potential experience as the regression with individual wage bills as the dependent variable. Since individual human capital stocks vary in the model only by cohort, years of schooling and work experience, I take the joint empirical distribution of schooling and potential experience from the CPS March Supplement for the period of 1968 and 2001 and use equation (1) to construct human capital stocks for each schooling-potential experience cell for a given set of parameters. Since school spending per pupil is available only as a time series, I infer school spending for each cohort as follows. Note that school spending per pupil at any point in time is the average spending for different cohorts enrolled in different grades, and the growth rate of spending as one proceeds to a higher grade equals $\frac{g_p - r}{\gamma_2 - 1}$, as mentioned in section 3. I assume that the expenditures for the first year of schooling increase at a constant rate across cohorts and parameterize this growth rate and the level of expenditures for the first year of schooling of the earliest cohort. I then construct the time series of school spending per pupil and pick the parameters that enable this constructed time series of school spending per pupil to match the level of public expenditures per pupil in elementary and secondary schools in the 1908 data as well as its average growth rate between 1908 and 2000.

Constructed this way, cell-specific human capital stocks are then logged, and regressed on years of schooling, potential experience and its square, and time dummies, using cell sizes as weights. Later, when I consider the skill premium, I regress the sum of log human capital stocks and log skill-specific wages on the variables listed above. Changes in skill-specific wages for the sample period are estimated non-parametrically as follows. For cohort *c* with a certain number of years of schooling, changes in mean wage bills of cohort *c* with *s* years of schooling between the two consecutive years, *t* and *t* + 1, include skill-specific wage changes instead of aggregate wage changes, experience effect, and mean errors (because their human capital stocks accumulated from schooling cancel out) as follows:

$$\ln \overline{WB}_{cst+1} - \ln \overline{WB}_{cst} = \ln w_{st+1} - \ln w_{st} + \phi(Exp_{cst+1}) - \phi(Exp_{cst}) + \overline{\varepsilon}_{cst+1} - \overline{\varepsilon}_{cst}$$

Here variables with an upper bar are group means. Assuming that the error term ε_{icst} in the wage bill of an individual *i* with s years of schooling in cohort *c* at time *t* is *i.i.d.*, differences in mean errors approach 0 for a large sample. For given parameters governing the experience function ∅, taking the average of log changes in mean group wage bills over all cohorts and education levels determines skill-specific wage changes as residuals.

I also compute the expenditure share in the marginal cost of schooling for each cohort, as represented by equation 4, using the cohort mean years of schooling, and require γ_2 to be as close to the mean expenditure share in the marginal cost of schooling across cohorts as possible in the estimation. Computing the expenditure share in the marginal cost of schooling requires the evolution of aggregate wages for the entire period during which any of the cohorts was working in the market. Since I assume that individuals do not recognize the skill premium when they decide on schooling, I use the mean of the skill-specific wages obtained above, between 1967 and 2000. I assume that wage growth rates before 1967 and after 2000 are the same as the growth rates for the first and last decades of the sample period (1967－2000), respectively.

For the extended model with heterogeneous learning ability, I have two more parameters to estimate: the curvature parameter γ_1 and the variance σ_{γ_0} of the ability distribution. I solve the income maximization problem to obtain the optimal years of schooling for each level of ability and cohort. I then compute the mean years of schooling over all cohorts and the mean dispersion in schooling attainment within cohorts, to match data counterparts.

The parameter estimates denoted by $\widehat{\theta}$ minimize the weighted distance between the model moments and data counterparts, represented by the following objective function.

$$\widehat{\theta} = \arg\min_{\theta} g(\theta)' W g(\theta)$$

where $\theta = (\gamma_0, \gamma_2, \phi_0, \phi_1)$ or $\theta = (\mu_{\gamma_0}, \gamma_1, \gamma_2, \phi_0, \phi_1, \sigma_{\gamma_0})$.

The vector of moment conditions and the weighting matrix are denoted by $g(\theta)$ and *W*, respectively. It is well-known that the optimal weighting matrix is determined by the inverse of the variance-covariance matrix of data moments. For Mincer regression coefficients, estimated variances are used where covariances between moment conditions are ignored, except that covariances between coefficients of the pooled sample regressions are allowed. Since the variance of the expenditure share in the marginal cost of schooling depends on parameters, I implement a two-step estimation. The optimal weighting matrix is the inverse of the variance-covariance matrix estimated in the first-stage. I present standard errors for the estimates using numerical differentiation.

V. Results

In this section, I report parameter estimates and, using those estimates, the estimated impact of rising school spending on labor quality growth.

1. Parameter Estimates and Growth Accounting

I report parameter estimates for all three model specifications in Table 5. For all three models, the elasticity γ_2 of human capital production with respect to expenditures is estimated to be between 0.12 and 0.13. This means that school expenditures explain between 12% and 13% of the marginal cost of schooling[14] as represented by equation (4). For the models without heterogeneity, the estimated value of this share is insensitive to the curvature γ_1 of the human capital production function for the schooling period. The model with heterogeneous learning ability estimates the return to scale $\gamma_1 + \gamma_2$ of the schooling human capital production function to be about 0.87. Parameter estimates for ϕ_0 and ϕ_1 governing individual post-schooling human capital profiles confirm that the evolution of individual human capital with work experience is steeper than the cross-sectional relationship between experience and earnings, when school quality rises over time. When I consider the skill premium or heterogeneous learning ability, however, the post-schooling human capital profile is estimated to be flatter than in the baseline model, which implies that ignoring a skill premium and the heterogeneity associated with schooling choice may overstate the impact of rising school quality on labor quality growth.

Table 6 presents growth accounting for U.S. labor productivity between 1967 and 2000 using the estimated parameters. The growth rates of labor productivity and physical capital inputs are taken from the BLS. I estimate the two components of labor quality growth pure quality growth H_q and labor composition growth H_c-using the model, and obtain the TFP growth as a residual. Pure quality growth and labor composition growth measure labor quality growth due to increases in school quality and in mean years of schooling, respectively, where the latter corresponds to the BLS measure of labor quality growth. Physical capital growth and labor quality growth presented in Table 6 are adjusted for their cost shares. For comparison purposes, the BLS measure of labor quality growth is reported in the first panel.

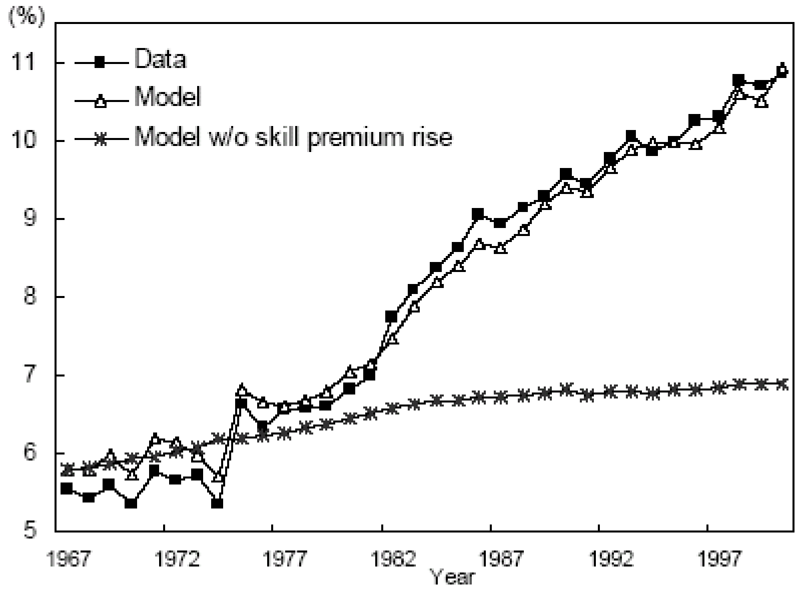
14) Foregone earnings form about 60% of the marginal cost of schooling, and the rest is attributed to the cost one incurs by delaying the return to work experience.

As a starting point to examine the role of rising school spending in labor quality growth, I proceed with an assumption that the skill premium does not exist and hence the increases in cohort-based Mincer return to schooling are solely driven by rising school quality across cohorts. The second panel of Table 6 presents the estimated labor quality growth under this assumption. I find that human capital of U.S. workforce increased by 0.5% per year between 1967 and 2000, with about two fifth of this explained by the growth in school quality. Labor composition growth in this model differs from what the BLS reports because this component reflects the impacts not only of the increases in mean years of schooling but also of changes in experience and sex composition. The mean years of work experience of the U.S. workforce declined for the first subperiod and then started to increase again for the second subperiod. Assuming that return to experience stays constant over time, these trends in mean years of experience of the workforce rarely affects the average labor composition growth over all sample period. The year-by-year Mincer regressions, however, imply that cross-sectional return to experience increased for the firstsub period and then declined for the second subperiod. By using predicted wages from those regressions to compute cost shares of different labor groups, the BLS amplifies the negative impact of declining mean years of experience on human capital growth in the first-subperiod, reducing the average labor composition growth over all sample period. The BLS also takes into account sex composition for their measure of labor composition growth while I do not consider that. Increasing share of female labor force over the sample period reduces labor composition growth by the BLS. The estimated labor quality growth due to the rise both in school spending and in educational attainment explains about 30% of the U.S. labor productivity growth between 1967 and 2000.

With this new measure of labor quality growth, the growth rate of total factor productivity declines. The contribution of the growth in total factor productivity to U.S. labor productivity growth is a little less than aquarter, instead of 40% as the BLS reports. For the first subperiod(1967−1984), during which a recession hit the U.S. economy, total factor productivity is estimated to have been fairly small.

The assumption that the skill premium does not affect the estimated Mincer return to schooling is, however, too restrictive. A vast literature on the rise of U.S. college premiums for the last two decades of the 20th century suggests that later cohorts work while the skill premium is higher, and hence some part of their higher return to schooling is due to the rise in skill premium, instead of rising school quality. Without considering a skill premium, we may incorrectly attribute the increases in the Mincer return to schooling across cohorts resulting from the rise in school premium to rising

Figure 5. Trends in Mincer Return to Schooling



school quality. The third panel in Table 6 indeed confirms this argument. Controlling for a skill premium reduces the estimated pure quality growth almost by half from the estimate in the model without a skill premium.

The importance of considering the rise in skill premium is reinforced by Figure 5. It decomposes the driving forces behind the rise in the estimated Mincer return to schooling over time. I plot the trends in the Mincer return to schooling from the model, and compare them with the trajectory of the Mincer return to schooling, holding the skill premium fixed at its 1967 level. Without the rise in skill premium, the model explains only about a quarter of the total increase in the Mincer return to schooling between 1967 and 2000. This confirms that a significant part of higher returns to schooling for more recent cohorts results from the fact that they work in the market when the skill premium is higher, not from better quality schooling. Ignoring the rise in skill premium and letting the rise in school quality take all the credit for higher return to schooling for later cohorts substantially overstates the impact of rising school spending on labor quality growth. Accordingly, I use this model with a skill premium as a benchmark for the counterfactual exercises and for the comparison with related literature later in this paper.

Even though controlling for the skill premium is important for correctly measuring the impact of rising school spending on labor quality growth, it rarely affects the estimated labor composition growth. Weights used to compute labor composition growth do not require distinguishing skill prices from quality (both reflected in individual wages). Examining labor composition growth for two subperiods divided at 1984, however, reveals that failing to control for the skill premium overstates labor composition growth for the first subperiod and understates it for the second. The skill premium is estimated to have risen more rapidly in the early 1980s, and this is not fully captured by the baseline model.[15)]

Adjusting for the skill premium, the contribution of labor quality growth and total factor productivity growth to U.S. labor productivity growth is estimated equally to be 27%. I report sensitivity analysis results for the baseline and skill premium models in which I preset the value of γ_1 in Table 7. The estimated labor quality growth changes little as the value of γ_1 varies.

The last panel of Table 6 presents the growth accounting for the heterogeneous agent model. Controlling for heterogeneous learning ability (holding the distribution constant across cohorts), decreases the estimated impact of rising school spending on labor quality growth. A single value of γ_0 in the models without heterogeneity implicitly assumes that schooling is as productive for younger cohorts as for older cohorts, for given investments of time and goods. Considering that more able individuals tend to stay in school longer, to be consistent both with the constant ability distribution across cohorts and the increases in cohort mean years of schooling requires that the average ability for younger cohorts is lower than for older cohorts, for any given level of education. This implies that schooling is less productive for younger cohorts than for older cohorts when the same amount of time and goods are invested. Adjusting for this effect reduces the baseline estimate of pure quality growth, particularly for the first subperiod while the mean years of schooling increased more rapidly. The impact of heterogeneity on the estimated labor quality growth should, however, be interpreted with caution. Without considering the skill premium at the same time, the variance of heterogeneous learnings ability may be overstated to match the mean years of schooling in data. If agents anticipate a fraction of the rise in skill premium in advance, the ex-ante return to schooling agents take into account when making schooling decisions is on average lower than the cohort-based Mincer return to schooling. If this is the case, the mean years of schooling over all sample can be matched without a large ability bias. I interpret the quantitative result for this specification to be suggestive, rather than conclusive.

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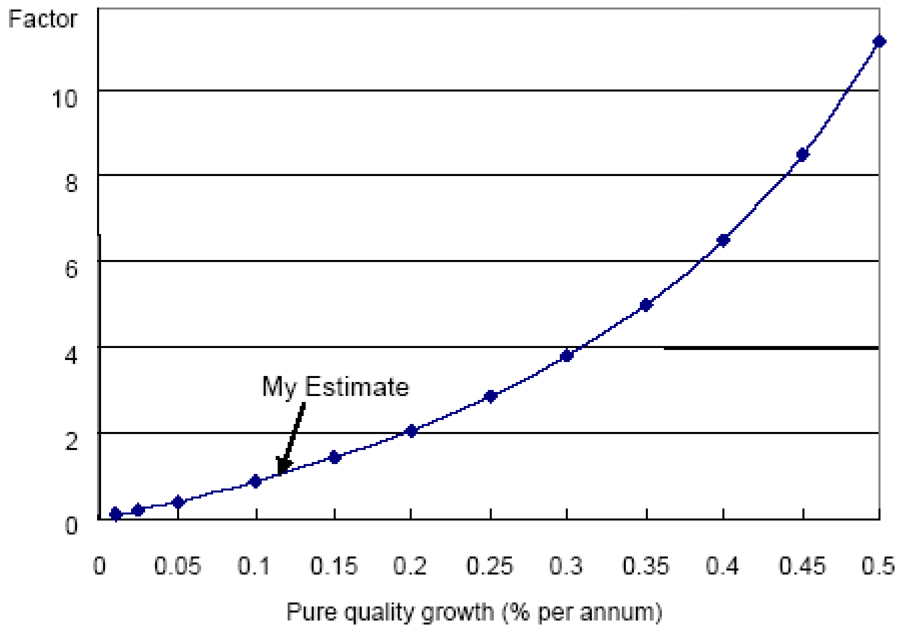
15) Holding the skill premium fixed at its 1967 level reduces labor composition growth in the latter subperiod by a quarter.

2. Counterfactual Exercises

In this subsection, I implement two counterfactual exercises to provide some insights on the identification of labor quality growth due to rising school spending. First, I examine how robust the estimated proportion of labor quality growth that is due to rising school expenditures is, using the consistency of the estimate with observed school spending per pupil. For illustration, suppose labor quality has actually grown more rapidly due to rising school spending than my estimate, 0.12% per year. Higher labor quality growth requires higher productivity of school spending in human capital production, inducing individuals to spend more while in school on average than we observe in the data, expecting a higher return on spending. In addition, more rapid labor quality growth also implies that human capital increases very steeply with experience after completion of schooling, to be consistent with the fact that earnings increase with work experience in cross-sectional data. Since a very steep return to post-schooling experience makes staying in school too costly for individuals, this would have individuals spend more per year of schooling while leaving school early, compared to what we see in the data.

In the following exercise, I examine what would have been the level of school spending per pupil, relative to what we observe in data, if labor quality growth due to rising school spending had actually been higher or lower than my estimate, holding the growth rate of expenditures per pupil and the distribution of schooling as they are in the data. Figure 6 plots the results. If labor quality indeed grew by 0.25% per year-about twice my estimate over the sample period, the level of school spending per pupil would have to have been about 3 times as high as we actually see in the data. If the increased school spending per pupil instead induced labor quality growth of only 0.05% per year, we should have observed only one third of school spending per pupil we observe in the data. This confirms that the estimated labor quality growth due to rising school spending is fairly robust.

Figure 6. Level of Spending per Pupil relative to Data Required for Pure Quality Growth



The key to estimating the impact of increased school expenditures on labor quality growth is obtaining a precise estimate for the elasticity γ_2 of school quality with respect to school expenditures. In order to provide intuition about how the productivity of school spending in human capital production is identified, I present the responses of each moment exploited for the estimation the estimated Mincer return to schooling, the cross-sectional return to experience, and the expenditure share in the marginal cost of schooling-to changes in γ_2, holding other parameters fixed at their estimates from the model with a skill premium. Figure 7 plots the percentage deviation of three model moments from data counterparts for various values of γ_2. As school spending becomes more productive in improving school quality than I estimate γ_2 to be, any given number of years of schooling generates higher earnings, with this effect more prominent for younger cohorts due to increased school expenditures. This raises the level of the Mincer return to schooling from the model above what we actually see in the data. A value of γ_2 double my estimate generates about 10% of the Mincer return to schooling, where its estimate from the data is 8%. This higher elasticity of school quality with respect to school spending also flattens the cross-sectional experience-earnings profile compared to what we observe in the data. If spending is more productive, earnings differentials between younger and older cohorts, attributable to schooling become larger. Holding the evolution of individual earnings with experience fixed, this offsets the experience premium older cohorts have compared to younger cohorts in cross-sectional data, thereby decreasing the cross-sectional return to experience below what data suggest. In this exercise, I define the cross-sectional return to experience as the log wage differential between cohorts with no experience and with 20 years of experience based on Mincer regression coefficients. Doubling my estimate for γ_2 reduces the cross-sectional return to experience by 20% below the estimate using the data.

Figure 7 shows that the expenditure share in the marginal cost of schooling is even more sensitive to γ_2 than other two moments. If school spending becomes more productive in increasing human capital as γ_2 increases, the marginal cost of schooling increases because of higher foregone earnings, and hence the expenditure share in the marginal cost of schooling declines. Unless individuals had spent more while in school than we actually observe, the higher the value of γ_2 is, the farther it moves away from the expenditure share of the marginal cost of schooling. As Figure 7 implies, this channel is quantitatively very powerful in estimating γ_2.

3. Literature Discussion

In this subsection, I relate my results to those in Manuelli and Seshadri (2005) and Erosa, Koreshkova, and Restuccia (2006), which explore the role of human capital in explaining income differences across countries. Both studies consider not only time but also market goods as inputs for human capital production as I do in this paper and analyze how much of cross-country income differences can be attributed to differences in human capital stocks, using a structural model.

The key difference between their studies and this paper is that they consider no quality differences in schooling across cohorts. If younger cohorts face better quality of schooling, the cross-sectional experience-earnings profiles fall apart from how individual human capital evolves with work experience. Relatively higher human capital stocks held by younger cohorts crowd out earnings differentials across cohorts due to their differences in work experience in cross-sectional data. They, however, ignore this possibility and use the cross-sectional relationship between experience and earnings as the evolution of individual human capital stock after completion of schooling.

I analyze how the estimated growth in the pure quality component of U.S. workforce between 1967 and 2000 would change if I consider the cross-sectional relationship between experience and earnings as the individual return to experience. I re-estimate the human capital production technology while in school with individual return to experience fixed at the coefficient estimates for experience and its square from the cross-sectional Mincer regression. This experiment implies that rising school spending increased human capital of U.S. workforce by 0.16%, which is 30% higher than my estimate. The counterfactual exercise in the previous subsection implies that labor quality growth of 0.16% per year requires 50% more school expenditures per pupil as we observe in the data.

VI. Conclusion

Building upon Denison (1962), the Bureau of Labor Statistics incorporates labor quality growth as a source of U.S. labor productivity growth and attributes a little more than 10 percent of U.S. labor productivity growth to labor quality growth between 1967 and 2000. Although the BLS measure of labor quality growth adjusts for the increases in mean years of schooling of the workforce during that period, it fails to capture the impact of changes in school quality on the human capital of the workforce. The mean school spending pupil in the U.S. more than tripled for that period, which suggests that the BLS measure of labor quality growth may miss a significant part of labor quality growth.

This paper attempts to measure how much U.S. labor quality has risen in response to the increase in public school spending per pupil, and how much U.S. labor productivity growth is due to labor quality growth. To approach the question, it is critical to identify the productivity of school spending in human capital production. In this paper, I propose a new way of estimating this productivity by comparing earnings of different cohorts that appear in the same market, beyond the estimated Mincer return to schooling.

If the human capital of the workforce increased due to rising school spending, we should observe higher earnings for younger cohorts than older cohorts for given years of schooling, after controlling for years of schooling and work experience. Accordingly, the profile of experience and log earnings in cross-sectional data should be flatter than the actual post schooling human capital profile. The more labor quality growth generated by increased school spending, the steeper the post-schooling human capital profile relative to the cross-sectional experience-log earnings profile. Since a steeper post-schooling human capital profile induces individuals to spend more money on schooling, it cannot be too steep to be consistent with school expenditures we observe in the data. Conversely, it cannot be too flat, either, or else individuals would not spend as much as we see in data. In this way, I simultaneously identify a post-schooling human capital profile that is consistent with data on school spending, and the impact of rising school spending on labor quality growth.

I find that rising school spending is about half as important as the increases in mean years of schooling for U.S. labor quality growth and that about a quarter of U.S. labor productivity growth can be attributed to labor quality growth between 1967 and 2000. Despite a remark- able increase in school spending, U.S. labor quality growth has been surprisingly modest. Controlling for a skill premium is important∃ignoring the rise in skill premium would double the estimated importance of increased expenditure to growth in human capital. The growth of human capital of the workforce due to rising school spending explains only a quarter of the increases in the estimated Mincer return to schooling over that period, and the rest is ascribable to a rise in the skill premium.

In this study, I abstract from the causes of the increase in school spending and focus on its consequences in terms of labor quality growth. The finding that the drastic rise in school spending contributed only modestly to growth in labor quality raises a question of what has driven such a rise in school expenditures. Exploring this may help us better understand the role of education in economic growth.

Table 1. BLS Growth Accounting for private business sector between 1967 and 2000

	Y/L	TFP	$s_K \times K/L$	$s_L \times H$
Annual growth rate	1.66	0.66	0.77	0.22
Contribution (%)	100.0	39.8	46.4	13.3

Table 2. Pooled Sample Mincer Regression Results for 1968-2001 Surveys

S	Exp	Exp^2	R-squared	obs.
0.080038 (0.0002)	0.031478 (0.0001)	−0.0000525 (0.0000)	0.31	1, 343, 830

Note : Numbers in parentheses stand for standard errors.

Table 3. Mean Years of Schooling ($\overline{S}$) and Estimated Returns to Schooling ($\boldsymbol{\beta}_1$)

year	$\overline{S}$	β_1	year	$\overline{S}$	β_1
1968	11.22	0.056	1985	12.63	0.082
1969	11.28	0.054	1986	12.68	0.085
1970	11.39	0.056	1987	12.71	0.088
1971	11.49	0.054	1988	12.73	0.088
1972	11.57	0.058	1989	12.76	0.089
1973	11.68	0.057	1990	12.79	0.091
1974	11.79	0.057	1991	12.85	0.093
1975	11.97	0.054	1992	13.01	0.091
1976	11.97	0.066	1993	13.08	0.096
1977	12.02	0.063	1994	13.13	0.099
1978	12.07	0.065	1995	13.13	0.096
1979	12.20	0.065	1996	13.17	0.097
1980	12.26	0.065	1997	13.15	0.101
1981	12.32	0.067	1998	13.18	0.100
1982	12.43	0.069	1999	13.22	0.104
1983	12.56	0.076	2000	13.24	0.101
1984	12.58	0.079	2001	13.27	0.103

Table 4. Pre-Set Values

Variable	R	r	g_p	P_{1982}	$h(6)$	γ_1
Value	65	0.05	0.0115	1	1	$0.3 \sim 0.7$

Table 5. Parameter Estimates

γ_0	γ_1	γ_2	ϕ_0	ϕ_1	σ_{γ_0}
		Baseline model			
0.0811	0.30	0.1263	0.0345	−0.0005	
(0.0334)	(..)	(0.0510)	(0.0012)	(0.0000)	
0.0559	0.50	0.1299	0.0347	−0.0005	
(0.0235)	(..)	(0.0510)	(0.0013)	(0.0000)	
0.0417	0.70	0.1332	0.0349	−0.0005	
(0.0179)	(..)	(0.0511)	(0.0013)	(0.0000)	
		Skill premium model			
0.0312	0.30	0.1235	0.0332	−0.0005	
(0.0135)	(..)	(0.0569)	(0.0008)	(0.0000)	
0.0272	0.50	0.1236	0.0333	−0.0005	
(0.0118)	(..)	(0.0568)	(0.0009)	(0.0000)	
0.0241	0.70	0.1237	0.0334	−0.0005	
(0.0105)	(..)	(0.0567)	(0.0009)	(0.0000)	
μ_{γ_0}	γ_1	γ_2	ϕ_0	ϕ_1	σ_{γ_0}
		Heterogeneous agent model			
−3.5382	0.7457	0.1307	0.0343	−0.0006	0.0600
(0.0615)	(0.0679)	(0.0123)	(0.0006)	(0.0000)	(0.0047)

Note: Numbers in parentheses stand for standard errors.

Table 6. growth Accounting

Year	Y/L	TFP	$s_K \times K/L$	$s_L \times H$	
				$s_L \times H_q$	$s_L \times H_c$
BLS					
$1967-2000$	1.66	0.67	0.77	..	0.22
$1967-1984$	1.43	0.50	0.81	..	0.12
$1984-2000$	1.90	0.85	0.72	..	0.32
Baseline Model					
$1967-2000$	1.66	0.39	0.77	0.19	0.31
				(0.08)	(0.00)
$1967-1984$	1.43	0.14	0.81	0.19	0.29
$1984-2000$	1.90	0.54	0.72	0.20	0.34
Skill Premium Model					
$1967-2000$	1.66	0.46	0.77	0.12	0.31
				(0.05)	(0.00)
$1967-1984$	1.43	0.28	0.81	0.11	0.23
$1984-2000$	1.90	0.66	0.72	0.12	0.40
Heterogeneous Agent Model					
$1967-2000$	1.66	0.43	0.77	0.14	0.32
				(0.02)	(0.04)
$1967-1984$	1.43	0.23	0.81	0.10	0.29
$1984-2000$	1.90	0.65	0.72	0.18	0.35

Note: Numbers in parentheses stand for standard errors.

Table 7. Sensitivity Analysis

	$s_L \times H_q$			$s_L \times H_c$		
	Baseline Model					
Year	$\gamma_1 = 0.3$	0.5	0.7	0.3	0.5	0.7
1967 – 2000	0.18	0.19	0.20	0.31	0.31	0.31
	(0.08)	(0.08)	(0.09)	(0.00)	(0.00)	(0.00)
1967 – 1984	0.18	0.19	0.20	0.28	0.29	0.29
1984 – 2000	0.18	0.20	0.21	0.33	0.34	0.34
	Skill Premium Model					
Year	$\gamma_1 = 0.3$	0.5	0.7	0.3	0.5	0.7
1967 – 2000	0.11	0.12	0.12	0.31	0.31	0.31
	(0.05)	(0.05)	(0.05)	(0.00)	(0.00)	(0.00)
1967 – 1984	0.11	0.11	0.11	0.23	0.23	0.23
1984 – 2000	0.12	0.12	0.13	0.40	0.40	0.40

Note: Numbers in parentheses stand for standard errors.

Appendix A. Data

Mincer regressions provide a set of moments to identify production function parameters. As the representative sample of the U.S. I use the Current Population Survey March Supplement from 1968 to 2001 to run Mincer regressions. Although the data set is available beginning 1964, we excluded the first four surveys because questions on earnings have changed since 1968. Sample selection criteria follow those of BLS (1993) as closely as possible. To be included in the sample, individuals should have a job when surveyed and report positive weeks and hours worked for the past year. Individuals working for the government or self-employed are excluded. Age restrictions are imposed so that individuals between the ages of 16 and 65 in the year they worked are included in the sample. Relaxing age restriction appears to affect the results little. All individuals in the sample reported their years of schooling, weeks worked in the past year, usual hours worked (or hours worked in the past week for surveys before 1976), wage or salary income in the past year and other individual characteristics such as gender, race, marital status, census division of residence and SMSA status. Since weeks worked were separated into intervals through 1975, mean weeks worked in 1976 survey were substituted for previous surveys. Annual hours are obtained by the product of weeks worked and hours worked per week. Top-coded earnings before 1996 were multiplied by 1.5, following Katz and Murphy (1992). Earnings equations are based on hourly wages obtained from annual earnings and annual hours worked. The BLS started to code years of schooling in interval since 1992. I assigned 0, 3, 6, 8, 9, 10, 11, 12, 14, 16, and 17 for categories, none, 1-4, 5-6, 7-8, 9-11 years of schooling, 12 years with no diploma 12 years, some college with no degree and other associate degrees, bachelor degree, master and Ph.D. degrees. Throughout the survey, the highest years of schooling was recoded as 17 years.

Educational expenditure data were taken from the *Digest of Education Statistics 2004* by the National Center for Education Statistics (NCES) and *120 gears of American education: A statistical Portrait* by the U.S. Department of Education. Specifically, yearly total expenditure per pupil in public elementary and secondary schools were used to capture quality improvement of elementary and secondary education. Since the data were collected biennially in the mid-20th century, I used a cubic spline to interpolate the series.

To obtain a time series of real spending per pupil, I need to be careful about what deflator to use. Since education goods prices rose much faster than the average commodity prices, deflating educational expenditures by an overall price index would overstate the growth of real expenditures on education. Therefore, I use the price index for Personal Consumption Expenditures (PCE) on education to deflate educational expenditures. Since the data are not available before 1929 yet the earliest cohort I consider in this paper starts to go to school in 1908, I use the projection of PCE on education price index on the Consumer Price Index (CPI) and splice it to the actual data since 1929. Since CPI has been published by the BLS beginning 1913, the price index in Warren and Pearson (1935) is used for years before 1913. All other goods and wages are deflated using the PCE. Using the CPI instead changes the results little.

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CHAPTER II-2

R&D Investment and Job Creation in Korea

by
Byung Woo Kim*

Abstract

If technical progresses are of a form that can be utilized by existing plant, then investors will be encouraged to create new plants. This is called "capitalization effect". However, if the technical progress is very fast, the proportion of workers released from production unit will be high. This is called "creative destruction effect".(Aghion and Howitt, 1998)

We tested some propositions of Schumpeterian growth theory by real data of Korean economy. Considering the results of estimation and testing, we can see that the evidence is strongly in favor of the capitalization effect of growth on unemployment in Korean economy. But, we can see the decreasing trend of those capitalization effect by detecting the increase of creative destruction effect of growth. Finally, recent "jobless growth" may come from the nonexistence of capitalization effect of productivity growth.

JEL Classification: O51, J63

Key Word: R&D investment, technical innovation, economic growth, creative destruction, capitalization effect

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Ⅰ. Introduction

We can ask whether technological progress by R&D create or destroy jobs in Korea. On one hand, they say that productivity growth stimulate demand and the creation of jobs, because firms want to capitalize on more rapidly growing productivity. But, there is the view that technological progress destroys jobs.[1)]

In this paper, we discuss the recent data on the input for knowledge, R&D, and unemployment in Korean economy. In particular, we explore the hypothesis that technological change represented by R&D investment increased the unemployment rate. We argue that technological change would plausibly have led to decrease in the unemployment rate in Korea.

Davis and Haltiwanger(1992) show that periods of high unemployment tend to be periods of high job turnover. Since industrial innovations raise the job-destruction rate through skill-obsolescence, there will be a positive relationship between growth and unemployment according to them.

In general, unemployment is caused by workers moving to new plant embodying technology. This is called "creative destruction effect". However, technical advances can take a form that can be utilized by existing plant or updating it. Then investors will be encouraged to create new jobs for benefiting from future technical advances. This is called "capitalization effect".(Aghion and Howitt, 1998)

The past 30 years are particularly noteworthy because we saw a change in productivity common to all industrialized countries, together with continuing structural change away from manufacturing and toward services. Meanwhile, the U.S. and other developed countries are often said as having so called "Jobless Growth". In spite of economic growth, the rate of increase in employment does not rise accordingly. "Jobless growth" has been an important concern also in Korea in the recent period.

1) In Principles, Ricardo said something about the negative effect of innovation on unemployment. In this paper, we show how modern economic tools can be used to analyze under what conditions the encouragement of more innovation will reduce unemployment. "…I have been of opinion that such an application of machinery to any branch of production as should have the effect of saving labor was a general good,………"(Ricardo, p. 269)

Table 1. The rate of Increase in Economic Growth and Unemployment in Korea (%)

	GROWTH	Unemployment
2000	8.5	4.4
2001	3.8	4
2002	7	3.3
2003	3.1	3.6
2004	4.7	3.7
2005	4.2	3.7
2006	5.1	3.5
2007	5	3.2

The question whether faster technological progress speeds up the destruction of jobs in Korea will be the main focus of the present paper. We review new endogeneous growth models of intentional industrial innovation. We deal with innovation that enhances the plant unit's productivity.(Aghion and Howitt, 1998)

II. Backgrounds: Economic Growth and Unemployment

1. New growth theory and Labor Market

Many of the early growth models treated technological progress as exogeneous. The view that innovation is driven by basic research, which is implicit in the models with exogeneous technology, was made explicit in a paper by Shell(1967). He makes knowledge the intended output of those who create it.

Aghion and Howitt(1998) introduced capital accumulation into the basic Schumpeterian (innovation) model. They extended the multisectoral model so as to include the embodiment of new technologies in new capital goods, and the use of capital in research. They also considered population growth with capital accumulation. In a Schumpeterian model, with a growing population the growth rate of output should growing, because the reward to innovation is increasing in the size of the population.[2)]

2) The steady state of their model shows the phenomena that Jones(1995) presented a refutation of R&D-based growth theory. That is, though the amount of research per person is growing, but the growth rate of output per worker is constant. These are consistent with the generalized Schumpeterian model that takes into account

Also, they constructed growth model which incorporates the unemployment, and this paper is broadly based on this Schumpeterian model.

Generally, labor markets are characterized by high rates of turnover. In the Korean manufacturing, more than 2% of workers leave their jobs in a typical month. In addition, there is high turnover of jobs themselves. In the Korean manufacturing, at least 10% of existing jobs disappear each year.(Kim, 2006) These data suggest that a large portion of unemployment is the result of the dynamics of the economy.

Constructing a friction model for the labor market requires moving a market with matching process. When workers and jobs are heterogeneous, the labor market has no characteristics of a Walrasian market. Workers and firms engage in a process of trying to match up specific needs. Since this process has some frictions, it results in unemployment.[3](Romer, 2006)

Much literature tries to characterize how equilibrium unemployment reacts to the rate of technological change. Two approaches are divided on that view.(Hornstein et al., 2005)

The first approach(Aghion and Howitt, 1998) argues that new equipment enters the economy through the creation of new matches("creative destruction effect").[4]

The second approach(Mortensen and Pissarides, 1998) proposes an alternative view that the new technologies enter into firms through a upgrading process of plant unit. For small values of the upgrading cost, unemployment falls with growth("capitalization effect").

We will turn to the analysis of how technological progress affects frictional unemployment in matching model.

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population growth (and capital accumulation).(Aghion and Howitt, 1998)

3) In addition, it may have implications for how employment respond to technological progress.

4) In this process, the increase of growth rate raises job destruction rate(=growth rate/lifetime of plant).

<Summary> Technical Progress and Unemployment (Aghion and Howitt, 1998)[5)]

Effect	Growth rate g	Job-destruction b	Job-creation p(v)	Level of vacancies v	Unemployment u
Direct Creative Destruction	↑	↑			↑*
Indirect Creative Destruction	↑		↓		↑*
Capitaliztion	↑			↑	↓*

Now, we briefly overview the situation of labor market in the Korean economy.[6)]

First, we consider the supply side of labor market. In viewpoint of economically active population, the most important problem in Korea is that of "aging society". It means that the magnitude of total population and labor force will shrink in the near future. Recently labor force participation growth also shows stationary situation. Total labor hours (per week) declined sharply to about 40 level in the 2000's. But, the level of human capital per worker shows steady increase due to the increase of persistent human investment like schooling.

Second, we consider the demand side of labor market. During 1960-2004, total employment has increased from 7.7 to 22.6 (million) persons. The elasticity of employment to production shows steady decreasing trend recently. In manufacturing sector, it shows the value of nearly "zero".

3. The 1990s in Korea

During the period of 1970~2004, the increase in real GDP came with a large increase in total employment growth and a steady decrease in unemployment. Productivity growth was unusually high during the second half of the 1970s, and 1980's.

The result of output growth in excess of productivity growth was a steady decrease in unemployment.[7)]

After the late 1990s in which financial crisis occurred, output growth was high, but firms and consumers did not have optimism. For firms, there were no factors and incentives that appeared to justify high rates of investment.

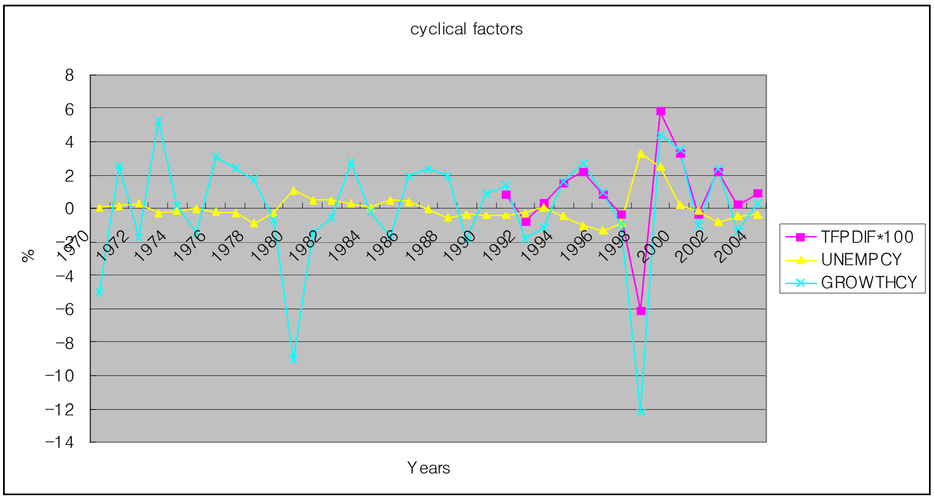
5) "Indirect creative destruction" effect decreases the job creation rate. Aghion and Howitt(1998) use this term interchangeably with "job finding rate".

6) Ahn(2005), Chung(2006).: Both are Korean textbooks.

7) We can consider the following elementary identity.(Blanchard et al. 1996, Blanchard 2006) Employment= (output) / (productivity).

In 2001, the Korean economy went into recessions. But, output growth was positive and showed about 4.5% in 2002 and 2003. To the surprise, unemployment was yet high. The recovery was the jobless growth(recovery). Labor productivity growth(averaging 5%, BOK) and total factor productivity grow(1~3%, OECD) was high. So, the plants seemed to have a short lifetime and hence the proportion of workers released would be high.("direct creative destruction").[8] This was due to the pessimism (or skeptism) of firms about the effect of productivity growth on the economy.

Figure 1. Cyclical Factors in GDP and Unemployment Rate in Korea



Source: BOK

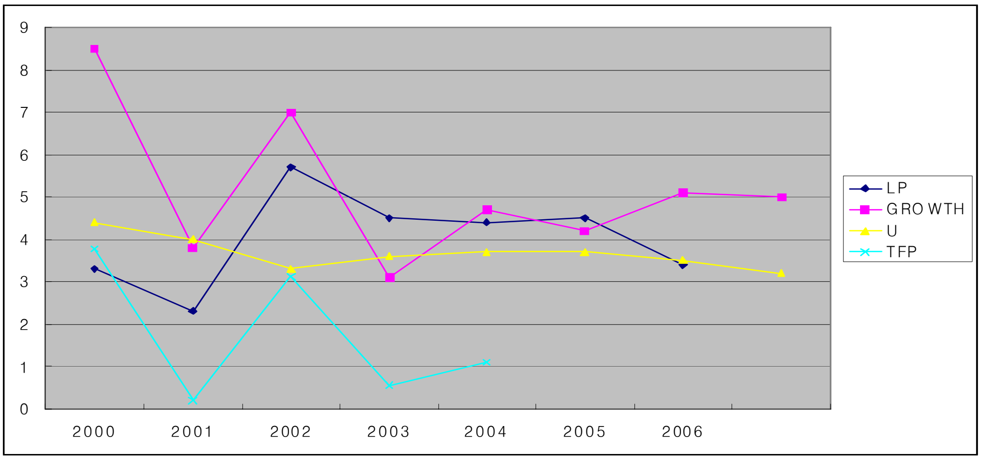
We extracted the cyclical factors for growth and unemployment through this HP filter.(<Fig.1>)

From this, we can find, after the late 1990s, output growth was relatively high. And the increase in productivity growth compared to GDP growth did not come with a steady decrease in unemployment.

After, in 2001, the Korean economy went into recessions, output growth was somewhat high in 2002 and 2004. But, unemployment was also high in 2004-2005.

8) Generally, in macroeconomics, the labor productivity is known as procyclical variable.

Figure 2. The Growth Rate of TFP and Unemployment Rate in Korea(2000's)



Source: BOK

Table 2. The Growth Rate of TFP, GDP and Unemployment Rate in Korea

	Labor Productivity	GDP GROWTH	U	TFP Growth
2000	3.3	8.5	4.4	3.786
2001	2.3	3.8	4	0.212
2002	5.7	7	3.3	3.127
2003	4.5	3.1	3.6	0.547
2004	4.4	4.7	3.7	1.111
2005	4.5	4.2	3.7	*
2006	3.4	5.1	3.5	*
2007	*	5	3.2	*

Source: BOK

III. Model: The 2nd Generation Endogeneous Gowth Models[9)]

1. An Augmented Schumpeterian Model: Growth and Demand for Labor

The Schumpeterian 2nd generation endogeneous theory of growth [Young(1998), Aghion-Howitt(1998)] provides a way of deleting the scale effect.[10)] But, in this paper, we yet retain the characteristic of "scale effect" in these Schumpeterian models. Young(1998) argues, as population increases, the variety of goods also grow over which R&D is spread.

A single final-good (or aggregate consumption) sector produces a homogeneous output good C, according to the CES technology

$$C= \left[\int_0^B Y(i)^{\upsilon} di\right]^{(1/\upsilon)}$$

where B is the variety of goods, Y(i) is the consumption. And $\upsilon<1$ is related to the elasticity of substitution.

Let each variety Y(i) be produced according to the following equations:

$$Y_i= (A_i L_{Y i})^{(1-\alpha)} K_i^{\alpha} ,$$

where Ki is physical capital in each variety sector.

$$\Delta A_i/A_i = \delta L_{A i}$$

To complete the model, we need to explain how B changes over time. We assume that $B=L^{\beta}$

In the 2nd generation growth models, $\beta=1$ holds. So the variety of consumption goods is proportional to the population.[11)]

The growth of productivity comes from R&D that uses final output(GDP) as the

9) This summarized model comes from Jones(1999).

10) "Scale effect" means that the same R&D effort can lead to sustained growth of productivity.

11) These implications of growth model mainly come from Jones(1999).

input. The rate of innovation g_A in a sector to which N_t units of output in R&D is given:[12)]

$g_{At}= \lambda g(N_t/A_t)$

Growth in productivity parameter A comes from the knowledge spillovers. The measure of the marginal impact of R&D on the public knowledge is equal to 1/B.

The rate of technological progress is

$g_A= \Delta A_i/A_i= \lambda g(N/A)$

We consider the relationships between there variables and labor market variables. We introduce hiring costs ($=cA_t$), and assume the wage is wanted at the level that is proportional to the technology ($w_t=aA_t$). There also is quit rate b of worker.

In steady-state, the cost of labor for the each variety firm is

$w_t^*=A_t^*a^*= A_t^* [a+(b+g_t+r-g_A) c]$ (1)

The demand for labor by variety firms will be

$L_{Dt} =\Sigma L_{Yi} = l^*(r^*, a^*e^{g(s-t)})$

The value of innovation (or the price of patent) is:

$V_t =A_t v(r+g, a^*, g_A)$ (2)

When consumption grows at the rate g, the rate of interest is:

$r=p+ \varepsilon g_A$ (3)

We have the following arbitrage equation.

$1= \lambda v(p+(\varepsilon+1) g_A, w+(p+(\varepsilon g_A +b) c, g_A)$

Once again, the steady-state growth rate is

$g_A= \lambda g(N/A)$

12) The following (augmented) Schumpeterian model comes from Aghion and Howitt(1998).

Therefore, the demand for labor by monopolistic firms is

$L_D = \Sigma L_{Yi} = l^*(r^*, a^*)$
$= l^* [\rho + (\varepsilon+1) g_A, w+(\rho+\varepsilon g_A + b) c]$

2. The Hypothesis Being Tested

From these analyses, we can choose some hypothesis for empirical testing research.(Aghion and Howitt, 1988)

· Growth Rate

The growth rate of output g_A is an increasing function of R&D fertility λ and decreasing function of the level of real wages w, the hiring cost c, the (real) interest rate and the quit rate of worker b.

· Job Separation Rate

The growth rate of output g_A affect the job separation rate positively.

· Unemployment Rate

The employment level(or the unemployment rate) is an decreasing(increasing) function of the growth rate of output g_A, the hiring cost c, and the quit rate of worker b.

· Job Creation

The rate of job creation is an decreasing function of the growth rate of output g_A, the hiring cost c, and the quit rate of worker b.

3. Implication of the Simple model for Economic Growth[13)]

We can modify the above anlysis by assuming R&D uses only labor as the input. We assume there is no horizontal innovations, B=1 and β=0. Since each intermediate good Y_i is used in the same amount($Y= Y_i$), C is equal to Y. Per capita output growth is: $g_c = g_A$

With the Romer(1990) production function for new knowledge, the growth rate of A now depends on R&D effort per variety L_A: $g_A = \Delta A/A = \delta s_R L$

Substituting this results yields the growth rate of output per capita in the

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13) This sub-section may be irrelevant in this paper. But, it's useful to understand Schumpeterian growth model.

model(Jones, 1999)

$g_c = \delta s_R L$

With β=0, one derives the following results. 1) The scale effect exists. 2) s_R also affects long-run growth.

Ⅳ. Economic Growth and Labor Market: Empirical Analysis

1. Data and empirical analysis: Growth and unemployment

The data set consists of some macro-economic variables like rate of unemployment, GDP, wage, etc. observed for 35 years(1970~2004) in Korea. They were obtained from OECD, BOK, KOSIS, Ministry of Labor and IFS.

In this section 4.1, we mainly test the prediction for growth and unemployment by Aghion and Howitt(1998).

1.1 Capitalization Effects

We extracted the series for (unobservable) natural rate of unemployment(u*) through this HP filter. From regression result, we can find that R&D investment significantly lower the trend of unemployment rate(natural unemployment rate).

In regression of the number of job vacancy(VACAN) on the growth rate(log difference of GDP), there seem to exist the "capitalization effect." That is, the increase of in growth rate causes to significantly increase the magnitude of vacancy.<Table 3>[14)]

14) AR(1) denotes first-order autocorrelation coefficient, hereafter.

Table 3. Capitalization Effect

Dependent Variable: LOG(VACAN)				
Sample (adjusted): 1995 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	11.33133	0.542138	20.90118	0
LOG (GDP/GDP(-1))	6.645673	1.987942	3.342991	0.0124**
AR(1)	0.780884	0.288059	2.71085	0.0302

From this estimation results, we can see that the increasing effect of the level of vacancies υ and hence job-finding rate $p(\upsilon)$[capitalization effect] dominates both the increasing effect of job-separation rate(1/S)[creative destruction effect] and decreasing effect of the job-creation rate p( ) [indirect creative destruction effect].

Considering the goodness of fit, we can see that the evidence is strongly in favor of the capitalization effect of growth on unemployment except in the early 1990's and the early 2000's.

We can say that the increase of the estimated random coefficient in the early 1990's and the early 2000's shows the offset effect of creative destruction. That is, we can see the decreasing trend of those capitalization effect by detecting the decrease of absolute value for the state variable(regression coefficient) that means the increase of creative destruction effect of growth.(Kim, 2007)

1.2 Long-run Relationship

Meanwhile, there is a danger of obtaining apparently significant regression results from unrelated data when using non stationary series in regression analysis. Such regressions are said to be spurious.[15]

15) In a seminal paper, Granger and Newbold(1974) argued that researchers had not paid sufficient attention to the warning of very high autocorrelation in the residuals from conventional regression models. Among their extreme conclusions, they suggested that researchers use a critical t value of 11.2 rather than the standard normal value of 1.96 to assess the significance of a coefficient estimate. The pure random walk, the random walk with drift and the trend stationary process are characterized by a unit root.

So, we performed two widely used unit root tests: the augmented Dickey-Fuller(ADF) test, and the Phillips-Perron test.16) For unit root tests, consider first an AR(1) process.

$$x_t = \alpha + \rho\ x_{t-1} + \varepsilon$$

Both the ADF and the PP tests the unit root as the null hypothesis H: ρ=1.

Test results report the test statistic as follows.(<Table 4>). Since two variables are non stationary series, we perform cointegration test to see whether there exist long-run relationship between them.

Table 4. Unit root test statistics

Null Hypothesis: LOG(RD) has a unit root				
Lag Length: 1 (Automatic based on SIC, MAXLAG=5)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.053844	0.7165
Null Hypothesis: UNEMP has a unit root				
Lag Length: 2 (Automatic based on SIC, MAXLAG=5)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2.256924	0.1933

The Johansen(1988) cointegration test method is used for finding long-run equilibrium relationship between R&D input(RD) and the rate of unemployment(u).17) In the case where there are only two variables in an equation, there can be at most only one linear combination of the two variables that is stationary. Test result shows that there is long-run equilibrium relationship between u and R&D. And, cointegrating coefficient is estimated significantly as negative.

16) Strictly speaking, the previous estimation results in <Table 4> can be thought of Engle and Granger(1987)' cointegration test results, because the relevant variables are all non stationary and the residual series is stationary.

17) Studies in empirical macroeconomics related growth almost always involve non stationary and trending variables, such as income, productivity(TFP) and R&D personnel. Recent research and a growing literature has shown that there are appropriate ways to analyze trending variables, cointegration anlaysis.

Table 5. Johansen Cointegration test statistics

Sample (adjusted): 1983 2006				
Trend assumption: Linear deterministic trend				
Series: LOG(RD) UNEMP				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.518993	17.99409	15.49471	0.0206**
At most 1	0.017722	0.429133	3.841466	0.5124
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
Normalized cointegrating coefficients (standard error in parentheses)				
LOG(RD)	UNEMP			
1	0.585445			
	-0.08834			

2. Empirical Tests

In this section 3.2, we test the prediction for growth and labor market variables(unemployment) by Aghion and Howitt(1998).

(1) Growth Rate

The growth rate of output g_A is an increasing function of R&D fertility and decreasing function of w, c, r and b. The steady-state growth rate is

$g_A = \lambda g(N/A)$

which is increasing function of level of R&D, N.

First, we estimate the R&D(LNRD) elasticity of productivity (LNTFP) by using annual data from 1970-2004. It was estimated significantly as 0.136.

Table 6. Estimation Results for Total Factor Productivity on R&D

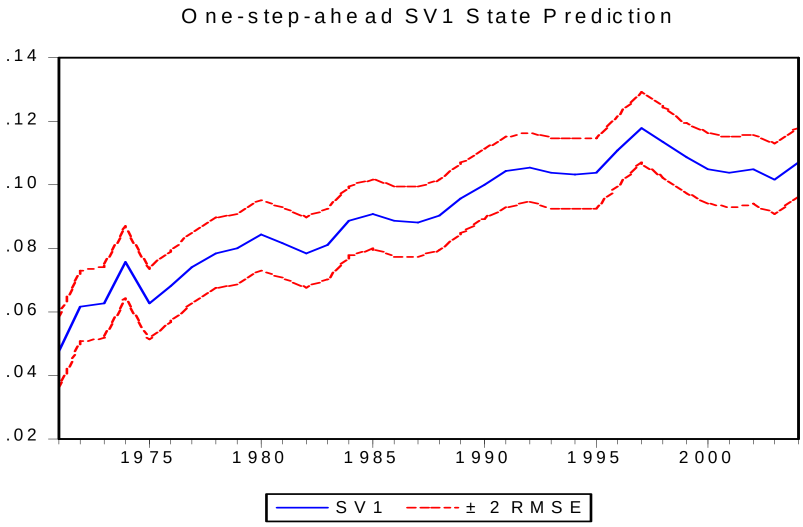
Dependent Variable: LNTFP				
Sample (adjusted): 1971 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003813	0.114741	0.033234	0.9737
LNRD	0.136053	0.011348	11.98959	0.0000**
AR(1)	0.694272	0.134503	5.161757	0

We also regress the level of productivity(LNTFP)on the efficiency of R&D, λ(SV1). It was significantly estimated and was of expected sign. The efficiency of R&D was estimated by random coefficient model(state-space model).<Figure 3>

Table 7. Estimation Results for Total Factor Productivity on R&D Efficiency

Dependent Variable: LNTFP				
Sample (adjusted): 1971 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.528124	0.107101	-4.931099	0
SV1F	19.90942	1.148753	17.33134	0.0000**
AR(1)	0.217192	0.069017	3.146938	0.0036

Figure 3. Estimation Results for R&D Efficiency



(2) Job Separation Rate

The growth rate of output g_A affect the job separation rate positively.

We regress the job separation rate(SEPAR) on the level of R&D investment(LNRD). The coefficient was estimated significantly negative. We can infer that this gives implication of the dominance of "capitalization effect" of growth.

Table 8. Estimation Results for Job Separation Rate

Dependent Variable: SEPARR				
Sample (adjusted): 1995 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	9.197851	1.307527	7.03454	0.0002
LNRD	-0.556606	0.110361	-5.043505	0.0015**
AR(1)	-0.027966	0.379196	-0.073751	0.9433

(3) Unemployment Rate

Since the rate of productivity growth and the unemployment rate are jointly determined, we consider the simultaneous equations model.

We consider the SUR(seemingly unrelated regression) estimator. It is based on the assumption that there is contemporaneous correlation in the errors across equations.

$g_A = \alpha + \beta \log(RD)_t + \varepsilon_t,$

$u_t = \gamma + \delta g_{At} + \eta \log(w) + \varepsilon_t,$

Except for γ and δ, all coefficents were estimated significantly as positive. This means the growth of productivity reduces the rate of unemployment(u; "capitalization effect") and u is increasing function of wage.

Table 9. SUR Estimation Results

Estimation Method: Seemingly Unrelated Regression				
Sample: 1970 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.057755	0.035871	-1.610087	0.1127
C(2)	0.142565	0.003758	37.93995	0.0000**
C(3)	-18.61631	7.477737	-2.489564	0.0156**
C(4)	-10.9819	3.15332	-3.482646	0.0009**
C(5)	2.860569	0.895929	3.192854	0.0023**
Equation: LNTFP = C(1)+C(2)*LNRD				
Equation: UNEMP = C(3)+C(4)*LNTFP+C(5)*LOG(WAGE)				

Next, since the rate of growth is determined by R&D productivity(SV1), we estimated how the latter affects the rate of unemployment(UNEMP). It is estimated significantly as positive at 10% significance level. Among estimation results in this paper, only this regression supports "creative destruction". Generally, the effect of the increase in the frequency(efficiency) parameter in R&D equation on unemployment is known to be neutral.(Aghion and Howitt, 1998)[18]

18) But, they also admit that if growth depend partly on an exogeneous process, then this neutrality may be no longer hold.(Aghion and Howitt, 1998)

Table 10. Estimation Results for the Rate of Unemployment on R&D Efficiency

Dependent Variable: UNEMP				
Sample (adjusted): 1982 2006				
	Coefficient	Std. Error	t-Statistic	Prob.
C	3.198633	2.054459	1.556922	0.1338
SV1F	1.013505	0.583532	1.736846	0.0964*
AR(1)	0.885974	0.099194	8.931724	0

(4) Job Creation

The rate of job creation is an decreasing function of the growth rate of output g_A,the hiring cost c, and the quit rate of worker b.

So, we tested how the rate of growth(GROWTH) affects job finding rate(FINDR) and the number of persons who enters job. Economic growth increases job finding rate and the number of job entrance(ENTER). The latter is also increased by the increase of vacancies(VACAN).

Table 11. Estimation Results for the Job Finding Rate and The magnitude of Job Entrance

Dependent Variable: FINDR				
Sample (adjusted): 1994 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	2.141833	0.074536	28.7356	0
GROWTH	0.069489	0.010715	6.485308	0.0001*

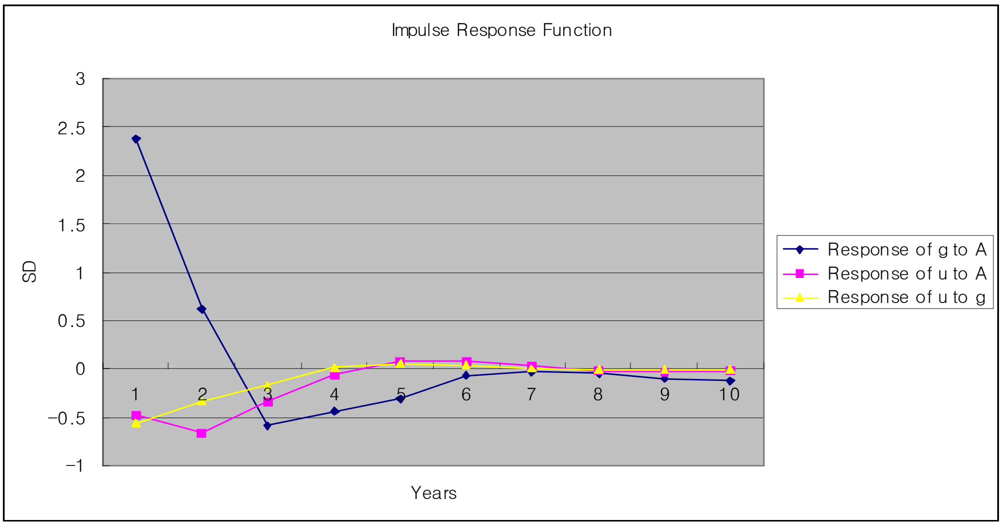
Dependent Variable: LOG(ENTER)				
Sample (adjusted): 1995 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	11.51019	0.090696	126.9093	0
GROWTH	0.039223	0.006384	6.143511	0.0005*
AR(1)	0.565798	0.265347	2.132296	0.0704

Dependent Variable: LOG(ENTER)				
Sample (adjusted): 1996 2004				
	Coefficient	Std. Error	t-Statistic	Prob.
C	2.556963	4.920537	0.519651	0.6307
LOG(UNEMPLOYED)	0.51564	0.377199	1.367021	0.2434
LOG(VACAN)	0.492226	0.229123	2.148303	0.0982*
AR(1)	0.418231	0.458437	0.912298	0.4132
AR(2)	-0.693908	0.472545	-1.468447	0.2159

(5) VAR: Impulse Response Function

Finally, we estimated 3-variable(g, A, u) VAR(vector-autoregression) model to see what the impulse response functions look like. The graph also supports the "capitalization effects". We had better recognize that the relationship between three variables simultaneously determined. So, we use VAR model.

Figure 4. Estimation Results for Impulse Response Functions



V. Summary and conclusion

Aghion and Howitt(1998) analyzed the relationship between growth and unemployment endogenizing growth. New technology is embodied in plants which are costly to build. Unemployment is caused by workers having to move from a plant embodying old technology old technology to one embodying new technology.

In this paper, we showed that direct creative destruction is not the only effect of faster productivity growth in the past of Korea.

Investors were encouraged to create new plants and vacancies by the possibility of benefiting from future technological advances. This capitalization effect could more than offset the creative destruction effect, resulting in an overall decrease in unemployment when growth rises.

We showed that considering goodness of fit of regression model, we can see that the empirical evidence is strongly in favor of the character of capitalization effect from R&D

activities and economic growth.

The magnitude of vacancy was increased by the increase of growth rate. And, there was negative long-run equilibrium relationship(cointegration) between R&D investment and unemployment rate.

R&D was negatively correlated with the job separation rate. And productivity growth has decreased the rate of unemployment. In addition job finding rate was increased by economic growth.

The empirical results that show "capitalized effects" are: state space model for unemployment rate, cointegration test for unemployment rate, SUR estimation for unemployment rate, impulse response for unemployment rate in VAR model.

In summary, we adopted the approach that the expectation of investors plays an important role in technical progress. If this expectation takes the form of optimism, technical progress affects unemployment negatively(reducing unemployment) and we call this phenomenon as "capitalization effect".

Assuming simple aggregate production function neglecting the physical capital, we can see the following relationship exists.

$$\Delta \text{ employment} = \Delta \text{ output(determined by expectation)} - \Delta \text{ productivity}$$

So, we can conclude that relatively high unemployment rate in 2002-2004 comes from skeptism for the economy (and productivity growth) of investors which cannot lead to high rate of investment.(no "capitalization effect")

Finally, in Korea, there has been a shift away of structure of production and job creation from manufacturing toward service. Davis and Haltiwanger(1992) analyze job creation and job destruction in manufacturing sector in the U.S. They find these rates are very large: about 10% in a year. But, among 10% of job destruction, about 80% is newly replaced by job creation. The omission of analysis for this job creation in Korea by technical progress may be the limit of this paper.

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CHAPTER III-1

Corporate Governance and Liquidity#

by

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Abstract

We investigate the empirical relation between corporate governance and stock market liquidity. We find that firms with better corporate governance have narrower spreads, higher market quality index, smaller price impact of trades, and lower probability of information-based trading. In addition, we show that changes in our liquidity measures are significantly related to changes in the governance index over time. These results suggest that firms may alleviate information-based trading and improve stock market liquidity by adopting corporate governance standards that mitigate informational asymmetries. Our results are remarkably robust to alternative model specifications, across exchanges, and different measures of liquidity.

JEL Classification: G10, G34

Keywords: Corporate governance, Spreads, Price impact, Information-based trading, Liquidity

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The authors are solely responsible for the content. The authors thank Institutional Shareholder Service (ISS) for providing corporate governance data. The authors thank Xin Zhao and Robert Van Ness for programming help, and Yang Cao, Pankaj Jain, Jacky Jiang, Robert Kieschnick, Diana Knyazeva, Kenneth Kim, Kaye Lee, Matthew Spiegel, Joakim Westerholm, Hao Zhang, and session participants at the 2007 FMA conference for valuable comments and discussion.

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I. Introduction

In this paper we examine how corporate governance affects stock market liquidity.[1)] Several recent studies examine the relation between external corporate governance and liquidity utilizing cross country differences in legal and regulatory environments. For example, Bacidore and Sofianos (2002) show that, among New York Stock Exchange (NYSE)-listed companies, those based in the U.S. exhibit higher stock market liquidity than those based outside the U.S. Brockman and Chung (2003) show that, among companies listed on the Stock Exchange of Hong Kong, those based in Hong Kong have narrower spreads and greater depths than those based in mainland China. They interpret this finding as evidence that poor shareholder protection results in poor liquidity. Similarly, Chung (2006) shows that American Depository Receipts of companies operating in countries with stronger shareholder protection mechanisms exhibit narrower spreads.[2)]

In contrast to the above studies that focus on differences in liquidity due to legal and regulatory environments, our study focuses on differences in liquidity due to internal corporate governance. The proposition that internal corporate governance is related to stock market liquidity is not original to our study. Coffee (1991), for example, argues that large investors have increasingly supported measures that improve internal corporate governance because such measures also improve stock market liquidity (which makes their exit less costly). Bhide (1993) holds that high stock market liquidity discourages internal monitoring (by active stockholders) and the benefits of market liquidity must be weighed against the cost of impaired shareholder activism. Bolton and von Thadden (1998) analyze this trade-off using a theoretical model and show that the optimal level of ownership concentration depends on firm characteristics and operating environment.

Faure-Grimaud and Gromb (2004) show that information generated by liquid markets increases the large shareholder's incentive to undertake value-enhancing

1) Prior research examines how internal corporate governance (e.g., board structure, managerial compensation, and charter provisions) and external corporate governance (e.g., legal/regulatory environments and markets for corporate control) affect firm value, cost of capital, and stock returns. See Shleifer and Vishny (1997), La Porta et al. (2000), Mitton (2002), Gompers, Ishii, and Metrick (2003), Bebchuk and Cohen (2005), Bebchuk, Cohen, and Ferrell (2005), Chi (2005), Ashbaugh, Collins and LaFond (2006), and Masulis, Wang, and Xie (2006). See Gillan (2006) for a recent survey of corporate governance literature.

2) Eleswarapu and Venkataraman (2006) show that companies in countries with better judicial efficiency, higher accounting standards, and higher political stability exhibit higher stock market liquidity.

activities (e.g., monitoring). Using an alternative definition of liquidity (i.e., the ability to trade anonymously) several authors also show that liquidity increases the incentive to monitor by lowering the cost of acquiring large positions [see Kahn and Winton (1998), Maug (1998), and Noe (2002)]. To our knowledge, however, the empirical relation between internal corporate governance and stock market liquidity has not yet been established.[3] The analysis of the relation between corporate governance and liquidity is important because it could shed some light on the channel through which corporate governance affects shareholder wealth.

We conjecture that corporate governance affects stock market liquidity because effective governance improves financial and operational transparency,[4] which decreases information asymmetries between insiders (e.g., mangers and large shareholders) and outside investors (e.g., outside owners and liquidity providers), as well as among outside investors. Governance provisions may improve financial transparency by mitigating management's ability and incentive to distort information disclosures (Luez et al., 2003). These provisions make it less likely that management, acting in its self-interest, does not fully disclose relevant information to shareholders or discloses information that is less than credible. For example, governance provisions related to the independence of the audit committee are intended to improve the quality of the financial statements. Similarly, Ajinkya et al. (2005) and Karamanou and Vafeas (2005) show that boards that do a more effective job of monitoring management enhance the quality and the frequency of information released by management. These studies show that companies with more effective boards issue more frequent earnings forecasts and that these forecasts are more accurate. Higher board quality, therefore, should be associated with lower information asymmetry.

Corporate governance may improve operational transparency by improving the ability of shareholders to discern the quality of management and the true value of the firm. By strengthening the disciplinary threat of removing management (Manne, 1965), governance provisions protect shareholder interests and limit the extent to which management can expropriate firm value through shirking, empire building, risk aversion, and perquisites [see Bebchuk, Cohen, and Ferrell (2005) and Bebchuck and Cohen (2005)].

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3) Attig et al. (2006) show that poor information disclosure by self-serving owners reduces stock market liquidity using a sample of Canadian stocks. They do not examine the relation between corporate governance and liquidity.

4) Transparency, as described by the OECD Principles of Corporate Governance, involves the timely disclosure of adequate information concerning a company's financial performance, as well as commercial objectives, ownership structures, remuneration, related party transactions, governance structures, and internal controls.

Diamond (1985) analyzes the consequence of voluntary information disclosure and shows that increased disclosure reduces both the precision of private information (relative to the precision of public information) and the incentive for private information search. He shows that reducing information asymmetries between management and traders tends to decrease the latter's incentive to acquire private information, leading to less heterogeneity among trader beliefs and smaller speculative positions among informed traders. Liquidity providers may therefore post wider spreads and smaller depths for stocks of poorly governed companies because they face greater adverse selection problems in these stocks (Glosten and Milgrom, 1985). For the same reason, the price impact of trades (Kyle, 1985) may tend to be greater for stocks of companies with poor governance structure.

Theory therefore suggests that poor corporate governance may impair stock market liquidity to the extent that poor governance is associated with low financial and operational transparency. In this broad context, we examine the effect of corporate governance on liquidity using an index of governance attributes that are likely to affect financial and operational transparency.[5] Our governance index, which is based on data compiled by Institutional Shareholder Services (ISS), consists of 24 such governance attributes. Our measures of liquidity include quoted spreads, effective spreads, and an index of market quality for a large sample of NYSE/AMEX and NASDAQ stocks. To examine the relation between corporate governance and information asymmetries more directly, we also estimate two measures of information-based trading, the price impact of trades and the probability of information-based trading as derived by Easley, Kiefer, O'Hara, and Paperman (1996).

Our results show that stocks of companies with better governance structure exhibit narrower quoted and effective spreads, higher market quality index, smaller price impact of trades, and lower probability of information-based trading. The estimated improvement in liquidity is economically significant, with an increase in our governance

5) In recent years many U.S. companies have adopted new standards to improve corporate governance. Some of these standards were mandated by new listing requirements (e.g., by the NYSE, AMEX, and NASDAQ), some were required by additional regulatory structure (e.g., by the SEC and the Sarbanes-Oxley Act), and others were neither mandated nor required. For example, our governance index for D.R. Horton, Inc. (DHI) increased sharply between 2002 and 2003 when it adopted several new governance standards, such as allowing shareholders to call special meetings and requiring only a majority shareholder vote (rather than supermajority) to approve mergers. Incidentally, DHI also experienced a dramatic improvement in liquidity over the same period, with a 50% increase in the market quality index (defined by the ratio of quoted depth to quoted spread). Whether such a relation between corporate governance and liquidity is systematic, of course, requires a more formal empirical analysis that, in part, controls for other relevant factors.

index from the 25th to 75th percentile decreasing quoted spreads on NASDAQ by about 4.7%. Our results are robust to different estimation methods (including fixed effects and error component model regressions), across markets, and alternative measures of liquidity. In addition, we find that changes in our liquidity measures are significantly related to changes in governance scores over time. These results suggest that firms may alleviate information-based trading and improve stock market liquidity by adopting corporate governance standards that mitigate information asymmetries.

The paper is organized as follows. Section II presents the detailed description of the measures of corporate governance and stock market liquidity and their descriptive statistics. Sections III presents our empirical findings. Section IV concludes the paper.

II. Variable Measurement, Data Sources, and Descriptive Statistics

In this section we discuss our variable measurement procedures, data sources, and descriptive statistics of the key variables used in the study.

1. Corporate Governance Metrics

An index of corporate governance that is relevant for stock market liquidity requires data on governance standards that would, in theory, improve financial/operational transparency and investor protection. Existing metrics of corporate governance are not completely adequate in this regard. For example, a well-known index of corporate governance developed by Gompers, Ishii, and Metrick (2003) (GIM) is designed primarily to capture anti-takeover provisions in a firm's charter, bylaws, and state law.

Because our application is based on a broader interpretation of corporate governance, we develop our own index using the data provided by Institutional Shareholder Service (ISS). The ISS data are very broad, consisting of 51 governance standards in eight categories. From the ISS data, we select 24 governance standards in six categories that are most closely related to financial and operational transparency. We determine whether a particular governance standard is met using the minimum standard provided in ISS Corporate Governance: Best Practices User Guide and Glossary (2003). We then create an index (Gov-Index) for each firm by awarding one point for each governance standard that is met. This method is similar to the coding method used in Brown and Caylor (2006) for their index.

Appendix A shows the 24 governance standards and their six categories. We use a governance standard related to the independence of the audit committee (Audit #1) to capture, in part, the extent to which governance may improve financial and operational transparency. The audit committee reviews the adequacy and effectiveness of internal auditing, accounting, and financial controls of the company. The committee also reviews the audit performed by the company's independent auditors and makes recommendations concerning the appointment of the independent auditor. We conjecture that a firm's financial and operational transparency would be higher if the audit committee were composed solely of independent directors. For similar reasons, we use nine governance standards that are related to the independence and effective functioning of the board, including key committees such as the nominating and compensation committees (Board #1-4, 6, 8-11).

Stock compensation and stock ownership programs are often adopted with the purpose of aligning the interests of directors and key executives with those of shareholders. For example, Duke Energy (2005 Proxy Statement, p. 19) claims their equity based compensation program serves to:[6] "link the interests of executives with shareholders," motivate executives to "achieve strong financial and operational performance" and balance "rewards for short-term and long-term results." We therefore expect stock compensation to increase the incentive for management to strategically manage the firm in shareholders' interests, and hence improve operational transparency. To capture this effect of equity based compensation, we use four governance standards that are based on executive and director compensation and ownership (Compensation #1 and Ownership #1, 2, 3).

Finally, attributes of corporate governance may also improve operational transparency to the extent that they mitigate the entrenchment of incumbent management. We therefore include nine governance standards (Board #5, 7 and Charter #1-7) that are related to provisions in the firm's charter and bylaws that, if not implemented, serve to delay or impede takeovers. These nine standards mirror those in the GIM index, including two that may be most relevant in this regard (annually elected boards and a poison pill) and four of the top five, as identified by Bebchuk and Cohen, and Ferrell (2005).

Appendix A shows the cross reference of our governance standards to the GIM standards. Nine of GIM's 22 governance standards are captured in our Gov-Index, with seven of these clustered in the ISS category charter/bylaws. Gov-Index includes all the standards in GIM's category Delay four of six standards in GIM's category Voting; and

6) See http://www.duke-energy.com/investors/publications/annual/proxy_2005/other/Duke_Energy_2005_Proxy_Statement.pdf

one standard that proxies for GIM's category State.

There are two additional reasons why we use data from ISS, rather than the GIM index, in our study. First, the ISS data are available for a much larger number of firms in recent years, for which we have liquidity data (the ISS data are available for more than 2,400 firms at the beginning of our study period in 2001 and over 5,000 firms at the end of our study period in 2004). Second, the ISS data are available annually, rather than biannually.

2. Liquidity Measures: Spreads, Price Impact, and the Probability of Information-Based Trading

We obtain data for liquidity variables from the Trade and Quote database (TAQ) provided by the NYSE. Each quote observation in the data file includes ticker symbol, the quote date, time-stamp, bid price, ask price, bid depth, ask depth, and exchange code. We then apply the following data filters to trades and quotes, which are standard in the microstructure literature (see, e.g., Huang and Stoll, 1996), to clean the data of errors and outliers: (1) delete quotes if either the bid or ask price is negative; (2) delete quotes if either the bid or ask size is negative; (3) delete quotes if the bid-ask spread is greater than \$4 or negative; (4) delete trades and quotes if they are out of time sequence or involve an error; (5) delete before-the-open and after-the-close trades and quotes; (6) delete trades if the price or volume is negative; and (7) delete trades and quotes if they changed by more than 10% compared to the last transaction price and quote. We delete unlisted stocks, stocks with average annual share prices less than \$5, and stocks not included in the NYSE's TAQ, the Center for Research in Security Prices (CRSP), Standard & Poor's COMPUSTAT, or the ISS databases.

We calculate the quoted percentage spread of stock (firm) i at time τ as

$$\text{(1)} \qquad \text{Quoted Spread}_{i,\tau} = (\text{Ask}_{i,\tau} - \text{Bid}_{i,\tau})/\text{M}_{i,\tau};$$

where $\text{Ask}_{i,\tau}$ is the ask price for stock i at time τ, $\text{Bid}_{i,\tau}$ is the bid price for stock i at time τ, and $\text{M}_{i,\tau}$ is the mean of $\text{Ask}_{i,\tau}$ and $\text{Bid}_{i,\tau}$. For each stock, we then calculate the time-weighted average quoted spread during each year from 2001 through 2004. The quoted spread is the implicit trading cost for market orders when a trade occurs at the quoted price with no price improvement.

To measure the cost of trading when it occurs at prices inside the posted bid and ask quotes, we also calculate the effective percentage spread of stock i at time τ as

$$(2) \qquad \text{Effective Spread}_{i,\tau} = 2D_{i,\tau}\,(P_{i,\tau} - M_{i,\tau})/M_{i,\tau};$$

where $P_{i\tau}$ is the transaction price for stock i at time τ, $M_{i\tau}$ is the midpoint of the most recently posted bid and ask quotes for stock i, and $D_{i\tau}$ is a binary variable which equals one for customer buy orders and negative one for customer sell orders. We estimate $D_{i\tau}$ using the algorithm in Ellis, Michaely, and O'Hara (2000). [See Bessembinder(2003) for detailed comparative analyses of different classification methods.] For each stock, we then calculate the trade-weighted average effective spread during each year.

To the extent that corporate governance can affect both the spread and depth simultaneously, a more comprehensive analysis of the effect of corporate governance on stock market liquidity requires an empirical measure that captures both dimensions of liquidity. One such measure is the market quality index originally suggested by Bollen and Whaley (1998), which is defined as the ratio of the quoted depth to quoted spread.[7)]

$$(3) \qquad \text{Market Quality Index}_{i,\tau} = \frac{(1/2)\text{Quoted Depth}_{i,\tau}}{\text{Quoted Spread}_{i,\tau}}$$

For each stock, we calculate the time-weighted average market quality index during each year. Note that the market quality index cannot be meaningfully calculated from TAQ data for NASDAQ firms because TAQ reports only the size of the first inside dealer quote for NASDAQ firms. We therefore report the market quality index for NYSE/AMEX firms only.

As noted earlier, another frequently used measure of stock market liquidity is the extent to which an asset can be bought or sold without affecting its price. We measure the price impact of trades by

$$(4) \qquad \text{Price Impact}_{i,\tau} = 100D_{i,\tau}\,[(M_{i,\tau+5} - M_{i,\tau})/M_{i,\tau}],$$

7) This measure assumes a linear liquidity supply schedule (i.e., a linear tradeoff between the spread and depth), which may not correctly capture actual preferences of liquidity providers.

where $M_{i,\tau}$ and $M_{i,\tau+5}$ are quote midpoints at time τ and $\tau + 5$ minutes, respectively. The mean value of price impact during each year is calculated by weighting each trade equally. The price of impact of trades measures the extent to which a trade alters the share price. If a trade does not carry new information on the value of the share, its price impact should be zero on average. In contrast, if the trade is information motivated, it would move the price to the direction of the trade—buyer-initiated trades raise the price (i.e., quote midpoint) and seller-initiated trades lower the price.

To estimate the probability of information-based trading (PIN), we use the sequential trade model of Easley, Kiefer, O'Hara, and Paperman (EKOP) (1996), applied to each firm over each year (see Appendix B for details). In the EKOP model, market makers observe trades, update their beliefs, and establish quotes. This process of trading, and learning from trading, results in prices converging to full information values. The EKOP model provides a structure necessary to infer information based trading from observable variables such as the number of buys and sells.

3. Control Variables

Although our main research question is whether corporate governance affects liquidity, we include a number of control variables in our empirical analyses. They are share price, return volatility, trading volume, firm size, company age, analyst following, institutional ownership, research and development (R&D) expenditure, and asset tangibility. We provide further details on these variables later in the paper.

We measure return volatility by the standard deviation of daily closing quote-midpoint returns, trading volume by the mean daily dollar trading volume, firm size by the book value of total assets, analyst following by the number of analysts following the company, institutional ownership by the percentage of shares held by institutions, and R&D expenditure by the ratio of R&D expenditure to sales. We obtain data on analyst following from the Institutional Brokers' Estimate System (I/B/E/S) database, institutional ownership from the CDA/Spectrum Institutional (13f) Holdings database, and all other data (i.e., company age, R&D expenditures, sales, and total assets) from the COMPUSTAT or CRSP databases. Following Berger et al. (1996) and Almeida and Campello (2007), we measure asset tangibility by [(0.715 * Receivables + 0.547 * Inventory + 0.535 * Capital) + Cash]/Assets, where Receivables is COMPUSTAT item #2, Inventory is item #3, Capital is item #8, Cash is the value of cash holdings (item #1), and Assets is the book value of total assets (#6).

4. Descriptive Statistics

Given the differences in both market structure and governance standards for listing, we report our results separately for NYSE/AMEX and NASDAQ firms. Table 1 shows descriptive statistics on Gov- Index, liquidity measures, and other stock attributes for our study sample of firms.[8] For the NYSE/AMEX firms in our sample, the minimum and maximum values of Gov-Index are 3 and 20. The mean (median) value of Gov-Index is 11.49 (12), indicating that, on average, our sample firms meet about half of the governance standards. The summary statistics on the governance standards for NASDAQ firms are qualitatively similar, although somewhat smaller in magnitude.

The descriptive statistics show that NYSE/AMEX firms in our sample tend to be larger in total assets, have greater trading volume, and exhibit lower return volatility than NASDAQ firms. NYSE/AMEXfirms tend to be more liquid with lower effective spreads and exhibit smaller price impact than NASDAQ firms. In addition, NYSE/AMEX firms are older, followed by more analysts, and exhibit higher institutional ownership. For example, the mean number of analysts (6.92) for the NYSE/AMEX sample is significantly greater than the corresponding figure (4.57) for the NASDAQ sample. Similarly, the mean percentage (60.33%) of shares held by institutional investors for our NYSE/AMEX sample is significantly higher than the corresponding figure (46.58%) for the NASDAQ sample. Note that R&D expenditure ratios of some NASDAQ firms are very high (the maximum value is 71.4473), indicating that these firms' R&D spending is much larger than their sales in relative terms.

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8) 8 For these descriptive statistics, we assume that a firm has no analyst following if its analyst following information is not included in the I/B/E/S database and zero R&D expenditure if its R&D expenditure is not reported in the COMPUSTAT database. See Section III.A for further details on our coding of these variables.

III. Regression Results

In this section, we examine how our liquidity measures are related to corporate governance after controlling for other possible determinants of stock market liquidity.

1. Corporate Governance, Spreads, and Market Quality Index

To examine the relation between liquidity and corporate governance, we first regress both the quoted and effective spreads on Gov-Index and a number of control variables using the pooled cross- sectional and time-series data. Prior studies show that a significant portion of cross-sectional and time-series variation in spreads can be explained by select stock attributes such as dollar trading volume, share price, and return volatility.[9] To isolate the effect of corporate governance on spreads, we include 1/price, return volatility, and trading volume (in log) in the regression model as control variables. We use the reciprocal of share price (instead of share price) because such specification captures more accurately the effect of the tick-size induced binding constraint on spreads when spreads are measured in relative terms [see Harris (1994, p. 160)].[10]

We note that Gov-Index and our measures of market liquidity could be spuriously correlated because they are related to a common set of variables. Including the variables that are related to both Gov-Index and market liquidity in the regression model reduces the possibility that any estimated relation between Gov-Index and our measures of market liquidity is spurious. For example, firms that are widely followed by analysts and/or held by institutional investors may be pressured to adopt better corporate governance and, at the same time, exhibit lower spreads due to greater trading activity. Similarly, larger firms may simultaneously exhibit better governance structure because of higher investor interest and lower spreads because of smaller adverse selection risks (e.g., more information is available on larger firms).[11] To examine whether corporate governance has an independent, direct impact on liquidity, we therefore include analyst following (i.e., the number of analysts following the

9) See, e.g., McInish and Wood (1992), Chung, Van Ness, and Van Ness (1999), and Stoll (2000).

10) We obtain qualitatively similar results when we use log(price) instead of 1/price. The results are available from the authors upon request.

11) Harris (1994) uses firm size as a proxy for the degree of public information available about the stock.

company), institutional ownership (i.e., the percentage of shares held by institutions), and firm size (i.e., the book value of total assets) in the regression model.

For the same reason, we also include company age, asset tangibility, and R&D expenditure ratio as additional control variables. Note also that asset tangibility could reduce asymmetric information problems because tangible assets' payoffs are easier to observe. In contrast, high R&D intensity may increase asymmetric information problems because payoffs from R&D are difficult to predict. Finally, we include a dummy variable for firms included in the S&P 500 index as well as dummy variables for one-digit SIC industry codes to control for any index membership and industry effects. Based on these considerations, we estimate the following regression model for our study sample of NYSE/AMEX firms, NASDAQ firms, and the combined sample of NYSE/AMEX and NASDAQ firms, respectively:

$$\begin{aligned} &\text{Quoted Spread}_{i,t} \text{ or Effective Spread}_{i,t} = \beta_0 + \beta_1 \text{Log(Gov-Index}_{i,t}) + \beta_2 (1/\text{Price}_{i,t}) \\ &+ \beta_3 \text{Return Volatility}_{i,t} + \beta_4 \text{Log(Trading Volume}_{i,t}) + \beta_5 \text{Log(Assets}_{i,t}) + \beta_6 \text{Age}_{i,t} \\ (5)\quad &+ \beta_7 \text{Number of Analysts}_{i,t} + \beta_8 \text{Institutional Ownership}_{i,t} + \beta_9 \text{Asset Tangibility}_{i,t} \\ &+ \beta_{10} \text{R\&D}_{i,t} \text{Expenditure} + \beta_{11} \text{S\&P 500 Dummy} \\ &+ \text{Dummy Variables for One-Digit SIC Industry Code} + \varepsilon_{i,t}; \end{aligned}$$

where Quoted $\text{Spread}_{i,t}$ is the time-weighted mean quoted percentage spread of stock *i* in year *t*, Effective $\text{Spread}_{i,t}$ is the trade-weighted mean effective percentage spread, $\text{Gov-Index}_{i,t}$ is the governance index, $\text{Price}_{i,t}$ is the mean stock price, Return $\text{Volatility}_{i,t}$ is the standard deviation of daily closing quotemidpoint returns, Trading $\text{Volume}_{i,t}$ is the mean daily dollar trading volume, $\text{Assets}_{i,t}$ is the book value of total assets, $\text{Age}_{i,t}$ is the company age, Number of $\text{Analysts}_{i,t}$ is the number of analysts following firm *i* in year *t*, Institutional $\text{Ownership}_{i,t}$ is the percentage of shares held by institutions, Asset $\text{Tangibility}_{i,t}$ is a measure of asset tangibility, and $\varepsilon_{i,t}$ is the error term. We calculate t-statistics using White's (1980) standard errors and report them in parentheses.

Because we combine data from different sources (e.g., analyst following from the I/B/E/S database, liquidity measures from the TAQ database, and R&D data from the COMPUSTAT database), some variables have many missing observations in the merged dataset. The frequency of missing observations is particularly high for the number of analysts and R&D expenditure because many firms are not included in the I/B/E/S database and also because many firms do not report R&D expenditure.[12] To

12) Chung(2000) shows that only 1,947 (62.9%) of the 3,097 NYSE/AMEX companies

maximize data utilization and also to assess the sensitivity of our results to different variable measurement methods, we employ two approaches. In the first approach, we assume that a firm has no analyst following if its analyst following information is not included in the I/B/E/S database and zero R&D expenditure if its R&D expenditure is not reported in the COMPUSTAT database. In the second approach, we simply drop all missing observations before we estimate the above regression model. Panel A of Table 2 shows the OLS regression results using the first approach and Panel B shows the results using the second approach.

The results show that the coefficients on Gov-Index in the quoted spread model are all negative and significant for NYSE/AMEX firms, NASDAQ firms, and the combined sample of NYSE/AMEX and NASDAQ firms, regardless of how we treat missing observations on analyst following and R&D expenditure (i.e., in both Panel A and Panel B). We obtain qualitatively similar results for the effective spread, except that the regression coefficient on Gov-Index is insignificant for NASDAQ stocks and the combined sample in Panel A.

We can gauge the effect of governance on liquidity by calculating the marginal effect of an increase in the governance index from the 25th to 75th percentile. For NASDAQ firms, this corresponds to an increase in the governance index from 8 to 12. Multiplying the change in the (log) governance index by the coefficient on governance in the quoted spread model yields a change in spreads that is approximately -4.7% of the mean quoted spread for NASDAQ firms. Hence, our results suggest that introducing governance standards that raise a NASDAQ firm's Gov-Index from the 25th to 75th percentile would decrease its quoted spread by 4.7%, which is economically significant. Overall, these results are in line with our conjecture that better corporate governance leads to higher stock market liquidity.[13)]

Consistent with the finding of prior research, the quoted and effective spreads are significantly and positively related to 1/price and return volatility, and negatively to trading volume in both markets. The relation between spreads and firm size is negative and significant for the NASDAQ sample, but the relation is mixed for the NYSE/AMEX sample. The quoted and effective spreads are positively and significantly related to the number of analysts in both markets, regardless of how we treat the missing

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included in the COMPUSTAT database are covered by the I/B/E/S database and only 1,782 (44.1%) of the 4,042 NASDAQ companies include in the COMPUSTAT database are covered by the I/B/E/S database in 1996.

13) We have identified a total of 30 stocks that are cross-listed on the London Stock Exchange or Toronto Stock Exchange in our final study sample. Our main results remain the same when we include a dummy variable representing these stocks. The results are available from the authors upon request.

observations on analyst following and R&D expenditure. This result is in line with the finding of Chung et al. (1995) and Van Ness, Van Ness, and Warr (2001). Chung et al. (1995) interpret the result as evidence that financial analysts have a greater incentive to follow a stock with greater information asymmetry because the value of private information increases with informational asymmetry, and market makers post wider spreads for stocks that are followed by more analysts.[14)]

The results show that spreads are negatively and significantly related to institutional ownership for NYSE/AMEX stocks in both panels. One possible interpretation of this result is that institutional investors provide effective monitoring of corporate managers and thus reduce the information asymmetry between insiders and liquidity providers. Alternatively, institutional ownership may be negatively correlated with insider ownership and thus companies with higher institutional ownership have less insider trading and lower spreads. For NASDAQ firms, however, we do not find a significant relation between spreads and institutional ownership, indicating perhaps that the role of institutional investors in corporate monitoring is much weaker on NASDAQ.

We find that stocks included in the S&P 500 index have wider quoted and effective spreads. Given the finding of Gompers, Ishii, and Metrick (2003) that firms in the S&P 500 have, on average, poorer governance than others, our regression may be capturing governance features in S&P 500 firms that are not included in our governance index. We find mixed results for other control variables (e.g., firm age, asset tangibility, and R&D expenditure). Our regression models capture a large fraction of the variation in quoted and effective spreads, with the R^2 for each regression in excess of 0.56.

If corporate governance affects the spread and depth simultaneously, then our empirical analysis of the relation between spreads and Gov-Index is an incomplete characterization of the relation between liquidity and corporate governance. To examine the relation between corporate governance and liquidity more fully, we regress the market quality index on Gov-Index and the control variables. Because the dependent variable is no longer the spread, we use Log(Price) instead of 1/Price in the regression model. As noted in Section II.B, because meaningful market depth data are not available (from TAQ) for NASDAQ-listed stocks, we estimate the model using only our study sample of NYSE/AMEX stocks and report the regression results in Table 2.

The results show that the coefficients on Gov-Index are positive and significant in both panels, indicating that firms with higher governance scores exhibit higher market quality. The results also show that market quality is higher for firms with lower return

14) Van Ness, Van Ness, and Warr (2001) also show that the adverse selection component of the spread is positively related to the number of analysts following the firm.

volatility, greater trading volume, larger assets, higher institutional ownership, smaller R&D expenditure, and lower asset tangibility. In contrast, we find that younger firms and firms included in the S&P 500 index exhibit a lower market quality index. Our regression models explain a large fraction of the variation in market quality, with R^2 of 0.9 and 0.88 in each panel.

Our hypothesis linking corporate governance to stock market liquidity is that poor governance gives rise to greater information asymmetry between the insiders (e.g., mangers/controlling shareholders) and outside owners. Such information asymmetries, in turn, amplify information asymmetries among market participants, which adversely affects liquidity. Our results show that shares of the companies with higher Gov-Index tend to be significantly more liquid, with narrower spreads and higher market quality index, than shares of the companies with lower Gov-Index. These results are remarkably robust across our sample of both NYSE/AMEX firms and NASDAQ firms and with respect to different variable measurement methods. Our empirical results thus far support the hypothesis that better corporate governance is associated with higher stock market liquidity.

2. Robustness Tests

In this section, we check the robustness of our results with respect to different estimation methods. In particular, we analyze the relation between liquidity and corporate governance using two panel-data regression methods. We first use the fixed effects regression method, which controls for omitted variables that differ across firms but are constant over time. This method focuses on changes in the variables over time to estimate the effects of the independent variables on the dependent variable. Because the fixed-effects regression method estimates the relation between stock market liquidity and corporate governance from the time-series variation in these and other control variables, and because a causal relation between variables can be tested using their time-series co-variation, this method sheds additional light on the empirical link between corporate governance and stock market liquidity.

We report the results of the fixed effects regression in Panel A of Table 3. Our results are qualitatively similar regardless of how we treat the missing observations on analyst following and R&D expenditures, so we report only the results from the inclusive data hereafter (e.g., a firm that is not included in the I/B/E/S database is assumed to have no analyst following). We find again that quoted and effective spreads are negatively and significantly related to Gov-Index, while the market quality index is positively and significantly related to Gov-Index for both NYSE/AMEX and NASDAQ stocks. These results provide further evidence that better corporate governance improves stock market liquidity. Note also that the regression coefficients on the control variables are qualitatively similar to those in Table 2.

To further examine the sensitivity of our results to different estimation methods, we also employ the Fuller and Battese (1974) error component model that permits a more general error structure. This model assumes that the error term is composed of three independent components: one associated with the cross-sectional units, another associated with time, and the third varying in both dimensions (i.e., $\varepsilon_{i,t} = \mu_i + \upsilon_t + \omega_{i,t}$). If the behavior of the cross-sectional error component is different from the behavior of the error term of a given cross-sectional unit over time, the Fuller-Battese model would give more accurate coefficient estimates. Because the Fuller-Battese model requires that the number time-series observations be identical across all cross-sectional units (i.e., companies), we include only those companies with complete data during the entire four-year study period. This reduces our sample size significantly, so we report results from the combined sample of NYSE/AMEX and NASDAQ stocks, although the results obtained from each market separately are similar.

Panel B of Table 3 reports the results of the Fuller-Battese model. The results indicate that the quoted and effective spreads are significantly and negatively related to Gov-Index, and the market quality index is significantly and positively related to Gov-Index, providing additional evidence to support our hypothesis that firms with better corporate governance exhibit greater liquidity. Note again that the coefficients on the control variables are qualitatively similar to those in Table 2 and Panel A of Table 3.

3. Regression Results using Changes in the Variables

To further assess the robustness of the relation between the governance index and market liquidity, we also estimate our regression models using changes in both the dependent and independent variables instead of levels. Regression analyses using changes in the variables have at least two advantages over those using the level variables. First, these regressions are generally less likely to show spurious relations between the variables than the regressions using the level variables.[15] Second, these

15) Year-to-year changes in variables provide a stronger test of causal relations than do levels of these variables because the levels of many variables are cross-sectionally correlated without any direct causal link. While correlations in changes do not imply causality either, a failure to find correlation in changes is likely to indicate no causal relation.

regressions allow us to examine the longer-term effect of corporate governance on stock market liquidity. We have assumed so far that the relation between corporate governance and liquidity is contemporaneous, at least on a yearly basis. However, the effect of corporate governance on stock market liquidity may be gradual. For example, a change in Gov-Index in year t may have an impact on stock market liquidity in both year t and year $t + 1$. To examine this possibility, we include both the contemporaneous and previous year's changes in Gov-Index in the regression model, together with contemporaneous changes in the control variables. As in Panel B of Table 3, we report the results from the combined sample of NYSE/AMEX and NASDAQ stocks.

The results (see Table 4) show that the coefficient on the change in Gov-Index is negative and significant in both the quoted and effective spread models, indicating that a decrease in spreads tends to be associated with an increase in the firm's Gov-Index. The results also show that an improvement in the market quality index occurs when the firm's Gov-Index increases. We find that the coefficient on the previous year's change in Gov-Index is not significantly different from zero in both the quoted and effective spread model, indicating that the negative relation between spreads and Gov-Index is contemporaneous. We find that the coefficient on the previous year's change in Gov-Index in the market quality index model is positive and significant at the 10% level. However, the coefficient (0.073) on the previous year's change in Gov-Index is much smaller than the corresponding figure (0.2493) for the contemporaneous change in Gov-Index. Hence, it appears that the positive relation between the market quality index and Gov-Index is largely contemporaneous also.

4. Corporate Governance, Price Impact, and Information-Based Trading

Does good corporate governance reduce the price impact of trades? To address this question, we regress Price Impact on Gov-Index and the control variables that are included in the spread regression model. Panel A of Table 5 shows the OLS results and Panel B shows the results of the fixed-effects regression. Both the OLS and fixed-effects regression results show that Price Impact is negatively related to Gov-Index for both NYSE/AMEX and NASDAQ stocks, although the relation is statistically significant only for the NASDAQ sample. These results suggest that firms with better governance mechanisms exhibit smaller price impacts of trades, especially for those listed on NASDAQ.

The smaller average price impact of trades for the companies with higher governance scores is likely to be driven by their smaller information-based trading. To examine whether better corporate governance results in lower information-based trading, we regress the probability of information-based trading (PIN) on Gov-Index and the same control variables used above. Panel A of Table 5 shows the OLS results and Panel B shows the results of the fixed-effects regression. Both the OLS and fixed-effects regression results show that PIN is negatively related to Gov-Index for both NYSE/AMEX and NASDAQ stocks and the relation is statistically significant only for the NASDAQ sample. These results are consistent with the above result that companies with better governance structure exhibit smaller price impacts.

IV. Summary and Concluding Remarks

Companies with good corporate governance are likely to have liquid secondary markets for their shares because good governance improves financial and operational transparency, which ultimately reduces information asymmetries between the insiders and outside owners/liquidity providers. Liquidity providers are therefore likely to post smaller spreads and larger depths for stocks of these companies. Whether these effects on liquidity are discernable and economically significant is an empirical question, and our study addresses this question.

We isolate a number of governance standards that are likely to be related to financial and operational transparency and, using these standards, create a composite index of corporate governance for each company. Our empirical results show that companies with better corporate governance generally have greater stock market liquidity as measured by narrower quoted and effective spreads, higher market quality index, smaller price impact of trades, and lower probability of information based trading. We also find that changes in our liquidity measures are significantly related to changes in governance index over time, suggesting that firms can improve stock market liquidity by adopting better governance standards. Our results are robust to alternative estimation methods, across markets, and different measures of liquidity.

Prior research shows that companies with poor stock market liquidity exhibit higher stock returns and lower market values.[16] Our finding of a positive relation between stock market liquidity and corporate governance quality provides at least a partial explanation of why firms with poor governance structure have lower market values

16) See Amihud and Mendelson (1986), Eleswarapu (1993), Brennan and Subrahmanyam (1996), and Brennan, Chordia, and Subrahmanyam (1998).

(Gompers et al., 2003): poor corporate governance results in lower stock market liquidity which, in turn, increases the required rate of return, thus decreasing market values. By establishing a clear empirical link between corporate governance and liquidity, our study suggests that shareholder wealth may increase as the firm adopts corporate governance standards that improve financial and operational transparency and better protect shareholder interests.

Our results also suggest that, all things being equal, firms in countries with more stringent and fairer disclosure rules and better protection of minority shareholders are likely to be valued higher (through their enhanced liquidity) than firms in countries with poor disclosure rules and poor legal protection of investors. In this perspective, the implementation of Regulation Fair Disclosure (Reg FD) by the U.S. Securities and Exchange Commission (SEC), which prohibits selective disclosure by public companies to market professionals and certain shareholders, should ultimately prove to make U.S. corporations more competitive in global financial markets.[17)]

Although the results of our study suggest that good governance could enhance firm value through its effect on stock market liquidity, whether companies choose to adopt additional governance standards remains a question. As suggested by Aggarwal et al. (2008), governance standards may be selected by the controlling shareholder to maximize his private value of the firm. The controlling shareholder's decision of whether to adopt additional governance standards therefore involves weighing the benefits of greater liquidity and lower cost of equity capital against the cost associated with, for example, the diminished ability of the controlling shareholder to expropriate firm value.

17) In the past, many firms released important information in meetings and conference calls where most shareholders and the general public were excluded. The goal of Reg FD is to even the playing field between individual investors and institutional investors by mandating that publicly traded companies must disclose material information to all investors at the same time. Reg FD sought to stamp out selective disclosure, in which large institutional investors received market moving information before smaller, individual investors. Reg FD changed fundamentally how companies communicate with investors by bringing better transparency and more frequent and timely communications -- perhaps more than any other regulation in the history of the SEC.

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Table 1. Descriptive Statistics

Panel A. Results for NYSE/AMEX Firms

Variable	Mean	Standard Deviation	Percentile Min	25	50	75	Max
Gov-Index	11.49	2.84	3	9	12	13	20
Price ($)	29.75	24.70	5.01	15.89	25.56	37.65	500.31
Return Volatility	0.0239	0.0157	0.0027	0.0158	0.0211	0.0288	0.5685
Trading Volume ($ in thousands)	21,554	48,805	12	1,221	5,011	19,800	717,106
Assets ($ in millions)	14,008	68,470	6	695	1,939	6,316	1,484,101
Age	25.15	19.74	1	9	19	34	80
Number of Analysts	6.92	7.06	0	1	5	11	38
Institutional Ownership (%)	60.33	23.23	0.01	45.65	64.43	78.09	99.81
Asset Tangibility	0.40	0.18	0.00	0.32	0.44	0.52	0.99
R&D Expenditure	0.0193	0.1866	0.00	0.00	0.00	0.0087	9.8670
Quoted Spread	0.0036	0.0043	0.0003	0.0011	0.0020	0.0042	0.0542
Effective Spread	0.0026	0.0032	0.0002	0.0008	0.0014	0.0029	0.0328
Market Quality Index	8,168	10,721	50	2,138	4,998	10,207	174,400
Price Impact	0.1859	0.1599	-0.2567	0.0873	0.1353	0.2232	1.4676
PIN	0.1826	0.0827	0.00	0.1350	0.1654	0.2180	0.8786

Panel B. Results for NASDAQ Firms

Variable	Mean	Standard Deviation	Percentile Min	25	50	75	Max
Gov-Index	10.45***	2.65	2	8	10	12	20
Price ($)	19.67***	13.23	5.01	10.16	17.04	25.71	319.56
Return Volatility	0.0460***	0.0293	0.0079	0.0304	0.0421	0.0559	0.9654
Trading Volume ($ in thousands)	14,465***	76,946	9	319	1,448	6,226	2,198,750
Assets ($ in millions)	1,433***	4,840	3	143	360	961	94,500
Age	11.44***	7.78	1	6	9	15	45
Number of Analysts	4.57***	5.52	0	0	3	7	43
Institutional Ownership (%)	46.58***	26.97	0.01	22.51	46.61	69.21	99.74
Asset Tangibility	0.56***	0.17	0.00	0.46	0.55	0.66	0.99
R&D Expenditure	0.5432***	3.3739	0.00	0.00	0.00	0.1367	71.4473
Quoted Spread	0.0115***	0.0114	0.0004	0.0040	0.0083	0.0148	0.1603
Effective Spread	0.0087***	0.0083	0.0003	0.0032	0.0064	0.0113	0.0966
Price Impact	0.4110***	0.2400	-0.6694	0.2122	0.3994	0.5993	1.2215
PIN	0.1729***	0.1075	0.00	0.1115	0.1724	0.2437	0.6941

Gov-Index denotes the governance index. We determine whether a particular governance standard is met using the minimum standard provided in *ISS Corporate Governance: Best Practices User Guide and Glossary (2003)*. We then obtain Gov-Index for each firm by awarding one point for each governance standard that is met. Price is the mean stock price, Return Volatility is the standard deviation of daily closing quote-midpoint returns, Trading Volume is the mean daily dollar trading volume, Assets is the book value of total assets, Age is the company age, Number of Analysts is the mean number of analysts, Institutional Ownership is the percentage of shares held by institutions, Asset Tangibility is a measure of asset tangibility detailed in Almeida and Campello (2007), R&D Expenditure is the ratio of annul R&D expenditure to sales, Quoted Spread is the time-weighted mean quoted percentage spread, Effective Spread is the trade-weighted mean effective percentage spread, Market Quality Index is the ratio of the time weighted mean quoted depth to the time-weighted mean quoted percentage spread, Price Impact is the mean price impact, and PIN is the probability of information-based trading. *** denotes that the mean value of the variable for NASDAQ firms is significantly (at the 1% level) different from the corresponding value for NYSE/AMEX firms.

Table 2. Ordinary Least Squares (OLS) Regression Results

Panel A. Regression Results When Missing Observations on Analyst Following and R&D Expenditure are Replaced with Zero

	Quoted Spread			Effective Spread			Market Quality Index
	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX
Intercept	0.0256***	0.1337***	0.0859***	0.0192***	0.0841***	0.0552***	0.8437***
	(25.74)	(12.69)	(14.34)	(26.53)	(12.73)	(14.66)	(6.98)
Log(Gov-Index)	-0.0009***	-0.0025***	-0.0012**	-0.0006***	-0.0013*	-0.0007	0.3281***
	(-5.57)	(-3.45)	(-2.41)	(-4.86)	(-1.68)	(-1.54)	(13.65)
1/Price or Log(Price)	0.0260***	0.0440***	0.0305***	0.0189***	0.0310***	0.0217***	-0.4578***
	(8.78)	(6.33)	(4.53)	(8.66)	(6.44)	(4.70)	(-16.01)
Return Volatility	0.0453***	0.1777***	0.2183***	0.0335***	0.1265***	0.1522***	-8.5476***
	(3.13)	(4.39)	(5.40)	(3.08)	(4.35)	(5.38)	(-2.74)
Log(Trading Volume)	-0.0015***	-0.0063***	-0.0042***	-0.0011***	-0.0041***	-0.0027***	0.5349***
	(-18.89)	(-27.45)	(-24.02)	(-19.02)	(-24.25)	(-21.18)	(43.29)
Log(Assets)	-0.0001	-0.0024***	-0.0017***	-0.0001**	-0.0013***	-0.0011***	0.0553***
	(-1.22)	(-7.74)	(-7.77)	(-2.54)	(-5.56)	(-7.27)	(6.36)
Age	-0.0000	0.0001***	-0.0000	-0.0000	0.0000**	-0.0000**	0.0011***
	(-0.41)	(3.91)	(-1.05)	(-0.21)	(2.38)	(-2.46)	(2.83)
Number of Analysts	0.0001***	0.0002***	0.0002***	0.0000***	0.0001***	0.0001***	0.0005
	(9.99)	(4.99)	(9.55)	(10.48)	(3.88)	(8.60)	(0.41)
Institutional Ownership (%)	-0.0027***	-0.0012	-0.0044***	-0.0022***	-0.0001	-0.0029***	0.1245***
	(-13.49)	(-1.08)	(-5.62)	(-14.20)	(-0.13)	(-5.24)	(3.67)
Asset Tangibility	0.0008***	-0.0058***	0.0036***	0.0008***	-0.0028***	0.0034***	-0.2206***
	(2.76)	(-5.10)	(3.72)	(3.62)	(-3.60)	(4.91)	(-4.40)
R&D Expenditure	0.0010***	-0.0000**	-0.0000**	0.0006***	-0.0000***	-0.0000***	-0.0551**
	(4.38)	(-2.54)	(-2.51)	(3.95)	(-3.08)	(-3.03)	(-2.53)
S&P 500 Dummy	0.0019***	0.0128***	0.0091***	0.0016***	0.0088***	0.0058***	-0.0519***
	(18.66)	(11.39)	(25.08)	(18.40)	(10.34)	(23.84)	(-2.79)
Adjusted R^2	0.73	0.63	0.59	0.72	0.56	0.56	0.90
# of Observations	4,449	4,629	9,078	4,449	4,629	9,078	4,449

Table 2. (Continued)

Panel B. Regression Results When Missing Observations on Analyst Following and R&D Expenditure are Dropped

	Quoted Spread			Effective Spread			Market Quality Index
	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX
Intercept	0.0190***	0.1027***	0.0632***	0.0135***	0.0697***	0.0434***	0.8119***
	(26.05)	(19.12)	(25.90)	(22.56)	(16.83)	(24.16)	(6.35)
Log(Gov-Index)	-0.0005***	-0.0037***	-0.0018***	-0.0003***	-0.0024***	-0.0013***	0.3070***
	(-4.30)	(-5.50)	(-4.08)	(-3.84)	(-5.20)	(-3.85)	(11.19)
1/Price or Log(Price)	0.0272***	0.0517***	0.0365***	0.0198***	0.0302***	0.0213***	-0.5076***
	(10.18)	(8.58)	(5.38)	(10.09)	(6.58)	(3.99)	(-11.92)
Return Volatility	0.0345***	0.2071***	0.2116***	0.0246***	0.1690***	0.1659***	-10.1562**
	(2.63)	(8.71)	(5.93)	(2.59)	(7.42)	(5.68)	(-2.12)
Log(Trading Volume)	-0.0012***	-0.0054***	-0.0033***	-0.0008***	-0.0038***	-0.0023***	0.5604***
	(-18.96)	(-21.41)	(-16.81)	(-17.27)	(-17.66)	(-13.46)	(31.18)
Log(Assets)	0.0001***	-0.0012***	-0.0014***	0.0001**	-0.0005**	-0.0009***	0.0469***
	(2.70)	(-4.80)	(-6.82)	(2.12)	(-2.47)	(-5.46)	(4.54)
Age	-0.0000***	0.0001***	-0.0000	-0.0000***	0.0001***	-0.0000	0.0010**
	(-3.72)	(4.72)	(-0.86)	(-3.65)	(4.06)	(-1.62)	(2.10)
Number of Analysts	0.0000***	0.0002***	0.0002***	0.0000***	0.0001***	0.0001***	0.0004
	(6.33)	(3.43)	(7.06)	(6.57)	(3.37)	(6.57)	(0.25)
Institutional Ownership (%)	-0.0018***	0.0007	-0.0035***	-0.0014***	0.0014*	-0.0022***	0.0868
	(-9.49)	(0.67)	(-4.98)	(-9.85)	(1.69)	(-3.92)	(0.25)
Asset Tangibility	0.0002	-0.0040***	0.0019**	0.0002	-0.0020**	0.0019***	-0.2335**
	(0.88)	(-3.69)	(2.50)	(1.28)	(-2.53)	(3.31)	(2.57)
R&D Expenditure	0.0017**	0.0000**	0.0000**	0.0012**	0.0000**	0.0000**	-0.1048***
	(2.56)	(-2.08)	(-2.12)	(2.52)	(-2.18)	(-2.37)	(-3.72)
S&P 500 Dummy	0.0011***	0.0086***	0.0067***	0.0008***	0.0063***	0.0045***	-0.0677***
	(13.56)	(8.93)	(21.03)	(12.24)	(8.52)	(19.82)	(-3.44)
Adjusted R^2	0.73	0.58	0.56	0.72	0.57	0.56	0.88
# of Observations	3,758	3,559	7,317	3,758	3,559	7,317	3,758

This table shows the OLS results of the following regression model: Quoted Spread$_{i,t}$, Effective Spread$_{i,t}$, or Market Quality Index $_{i,t}$ = β_0 + β_1 Log(Gov-Index$_{i,t}$) + β_2 (1/Price$_{i,t}$) or Log(Price$_{i,t}$) + β_3 Return Volatility$_{i,t}$ + β_4 Log(Trading Volume$_{i,t}$) + β_5 Log(Assets$_{i,t}$) + β_6 Age$_{i,t}$ + β_7 Number of Analysts$_{i,t}$ + β_8 Institutional Ownership$_{i,t}$ + β_9 Asset Tangibility$_{i,t}$ + β_{10} R&D$_{i,t}$ Expenditure + β_{11} S&P 500 Dummy + Dummy Variables for One-Digit SIC Industry Code + $\varepsilon_{i,t}$ where Quoted Spread$_{i,t}$ is the time-weighted mean quoted percentage spread of stock i in year t, Effective Spread$_{i,t}$ is the trade-weighted mean effective percentage spread, Market Quality Index$_{i,t}$ is the market quality index, Gov-Index$_{i,t}$ is the governance index, Price$_{i,t}$ is the mean stock price, Return Volatility$_{i,t}$ is the standard deviation of daily closing quotemidpoint returns, Trading Volume$_{i,t}$ is the mean daily dollar trading volume, Assets$_{i,t}$ is the book value of total assets, Age$_{i,t}$ is the company age, Number of Analysts$_{i,t}$ is the number of analysts following firm i in year t, Institutional Ownership$_{i,t}$ is the percentage of shares held by institutions, Asset Tangibility$_{i,t}$ is a measure of asset tangibility, R&D Expenditure is the ratio of annul R&D expenditure to sales, and $\varepsilon_{i,t}$ is the error term. We calculate t-statistics using White's (1980) standard errors and report them in parentheses.

***Significant at 1% level.

**Significant at 5% level.

*Significant at 10% level.

Table 3. Regression Results from Alternative Estimation Methods

Panel A. Fixed-Effects Regression Results

	Quoted Spread			Effective Spread			Market Quality Index
	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX
Intercept	0.0000	0.0008	0.0002	0.0000	0.0005	0.0001	0.0125
	(0.17)	(0.33)	(0.11)	(0.43)	(0.26)	(0.13)	(0.22)
Log(Gov-Index)	-0.0007***	-0.0080***	-0.0036***	-0.0005***	-0.0066***	-0.0030***	0.5375***
	(-5.22)	(-9.54)	(-7.66)	(-5.22)	(-9.68)	(-8.52)	(19.91)
1/Price or Log(Price)	0.0212***	0.1675***	0.1141***	0.0180	0.0962***	0.0665***	-0.4249***
	(6.55)	(20.17)	(14.03)	(8.13)	(14.30)	(9.14)	(-10.91)
Return Volatility	0.0236**	0.1673***	0.1411***	0.0173***	0.1279***	0.1080***	-6.8021***
	(2.45)	(27.86)	(6.01)	(2.67)	(26.28)	(5.79)	(-2.78)
Log(Trading Volume)	-0.0014***	-0.0028***	-0.0023***	-0.0010***	-0.0028***	-0.0022***	0.4715***
	(-13.48)	(-9.14)	(-6.53)	(-13.13)	(-11.33)	(-5.28)	(19.39)
Log(Assets)	-0.0001	0.0061***	0.0028***	-0.0001	0.0044***	0.0022***	0.1856***
	(-0.53)	(7.90)	(6.09)	(-0.80)	(7.08)	(5.84)	(4.82)
Number of Analysts	-0.0000	0.0002**	0.0001***	-0.0000	0.0002***	0.0001***	0.0118***
	(-1.53)	(2.14)	(3.73)	(-1.13)	(2.80)	(4.25)	(4.88)
Institutional Ownership (%)	-0.0048***	0.0073***	0.0029**	-0.0032***	0.0070***	0.0035***	0.9870***
	(-10.55)	(3.40)	(2.09)	(-10.43)	(4.04)	(2.79)	(8.59)
Asset Tangibility	0.0000	0.0041*	0.0014	0.0003	0.0046**	0.0024*	0.1599
	(0.05)	(1.68)	(0.87)	(0.67)	(2.35)	(1.67)	(1.45)
R&D Expenditure	0.0012***	-0.0000***	-0.0000***	0.0010***	-0.0000**	-0.0000***	0.0280
	(4.26)	(-2.62)	(-4.07)	(4.07)	(-1.99)	(-4.25)	(0.48)
S&P 500 Dummy	-0.0000	0.0003	0.0001	-0.0000	-0.0001	0.0000	0.0096
	(-0.22)	(0.50)	(0.66)	(-0.16)	(-0.15)	(0.14)	(1.06)
Adjusted R^2	0.50	0.29	0.24	0.50	0.25	0.21	0.52
# of Observations	4,449	4,629	9,078	4,449	4,629	9,078	4,449

Table 3 (Continued)

Panel B. Results of the Fuller-Battese Error-Component Model using the Combined Sample of NYSE/AMEX and NASDAQ Stocks

	Quoted Spread	Effective Spread	Market Quality Index
Intercept	0.0429***	0.0338***	2.1366***
	(15.21)	(16.14)	(10.12)
Log(Gov-Index)	-0.0012***	-0.0007**	0.0644**
	(-2.75)	(-2.01)	(2.19)
1/Price or Log(Price)	0.0336***	0.0125***	-0.5790***
	(8.65)	(4.35)	(-30.85)
Return Volatility	0.2873***	0.2456***	-17.0498***
	(38.54)	(43.70)	(-22.10)
Log(Trading Volume)	-0.0030***	-0.0025***	0.5206***
	(-25.08)	(-28.33)	(46.32)
Log(Assets)	-0.0000	0.0001	0.0693***
	(-0.09)	(1.19)	(5.91)
Number of Analysts	0.0001**	0.0001***	0.0006
	(2.10)	(3.92)	(0.97)
Institutional Ownership (%)	-0.0002	0.0004	0.0047***
	(-0.22)	(0.81)	(2.96)
Asset Tangibility	0.0023***	0.0018***	0.1294**
	(3.18)	(3.52)	(2.45)
R&D Expenditure	-0.0000	-0.0000	-0.2071***
	(-1.13)	(-1.07)	(-3.41)
S&P 500 Dummy	0.0036***	0.0028***	-0.0271
	(8.19)	(8.72)	(-0.89)
Adjusted R^2	0.48	0.51	0.76
# of Observations	4,480	4,480	2,580

This table shows the fixed-effects (Panel A) and Fuller-Battese error component model (Panel B) results of the following regression model: Quoted Spread$_{i,t}$, Effective Spread$_{i,t}$, or Market Quality Index$_{i,t}$ = β_0 + β_1 Log(Gov-Index$_{i,t}$) + β_2 (1/Price$_{i,t}$) or Log(Price$_{i,t}$) + β_3 Return Volatility$_{i,t}$ + β_4 Log(Trading Volume$_{i,t}$) + β_5 Log(Assets$_{i,t}$) + β_6 Number of Analysts$_{i,t}$ + β_7 Institutional Ownership$_{i,t}$ + β_8 Asset Tangibility$_{i,t}$ + β_9 R&D$_{i,t}$ Expenditure + β_{10} S&P 500 Dummy + $\varepsilon_{i,t}$ where Quoted Spread$_{i,t}$ is the time-weighted mean quoted percentage spread of stock i in year t, Effective Spread$_{i,t}$ is the trade-weighted mean effective percentage spread, Market Quality Index$_{i,t}$ is the market quality index, Gov-Index$_{i,t}$ is the governance index, Price$_{i,t}$ is the mean stock price, Return Volatility$_{i,t}$ is the standard deviation of daily closing quotemidpoint returns, Trading Volume$_{i,t}$ is the mean daily dollar trading volume, Assets$_{i,t}$ is the book value of total assets, Number of Analysts$_{i,t}$ is the number of analysts following firm i in year t, Institutional Ownership$_{i,t}$ is the percentage of shares held by institutions, Asset Tangibility$_{i,t}$ is a measure of asset tangibility, R&D Expenditure is the ratio of annul R&D expenditure to sales, and $\varepsilon_{i,t}$ is the error term. We calculate t-statistics in Panel A using White's (1980) standard errors and report them in parentheses.

***Significant at 1% level.

**Significant at 5% level.

*Significant at 10% level.

Table 4. Regression Results with Changes in the Variables

	Quoted Spread	Effective Spread	Market Quality Index
Intercept	0.0021***	0.0017***	0.1986***
	(7.25)	(7.53)	(16.91)
ΔLog(Gov-Index)	-0.0104***	-0.0077***	0.2493***
	(-11.99)	(-11.60)	(7.63)
ΔLog(Gov-Index)$_{t-1}$	0.0008	0.0007	0.0730*
	(0.82)	(0.88)	(1.91)
Δ1/Price or ΔLog(Price)	0.1289***	0.0652***	-0.2584***
	(6.29)	(3.74)	(-6.04)
ΔReturn Volatility	0.2942***	0.2751***	-4.9827***
	(9.16)	(9.05)	(-4.85)
ΔLog(Trading Volume)	-0.0020***	-0.0024***	0.4189***
	(-2.67)	(-2.75)	(14.19)
ΔLog(Assets)	0.0022*	0.0020**	-0.0972**
	(1.89)	(2.11)	(-2.21)
ΔNumber of Analysts	0.0000	0.0000	0.0019
	(0.49)	(1.29)	(1.02)
ΔInstitutional Ownership (%)	-0.0026	-0.0005	0.7956
	(-0.84)	(-0.17)	(5.80)
ΔAsset Tangibility	0.0035	0.0030	-0.2759
	(0.89)	(0.97)	(-1.64)
ΔR&D Expenditure	0.0000**	0.0000	-0.3434
	(-2.30)	(-1.63)	(-0.89)
Adjusted R^2	0.36	0.40	0.27
# of Observations	2,756	2,756	1,614

This table shows the OLS results of the following regression model: △Quoted Spread$_{i,t}$, △Effective Spread$_{i,t}$, or △ Market Quality Index $_{i,t}$ = β_0 + β_1 △Log(Gov-Index$_{i,t}$) + β_2 △Log(Gov-Index$_{i,t-1}$) + β_3 △ (1/Price$_{i,t}$) or △Log(Price$_{i,t}$) + β_4 △Return Volatility$_{i,t}$+β_5 △Log(Trading Volume$_{i,t}$) + β_6 △Log(Assets$_{i,t}$) + β_7 △Number of Analysts$_{i,t}$ + β_8 △ Institutional Ownership$_{i,t}$ + β_9 △Asset Tangibility$_{i,t}$ + β_{10} △R&D$_{i,t}$ Expenditure + $\varepsilon_{i,t}$ where Quoted Spread$_{i,t}$ is the time-weighted mean quoted percentage spread of stock i in year t, Effective Spread$_{i,t}$ is the trade-weighted mean effective percentage spread, Market Quality Index i,t is the market quality index, Gov-Index$_{i,t}$ is the governance index, Price$_{i,t}$ is the mean stock price, Return Volatility$_{i,t}$ is the standard deviation of daily closing quotemidpoint returns, Trading Volume$_{i,t}$ is the mean daily dollar trading volume, Assets$_{i,t}$ is the book value of total assets, Number of Analysts$_{i,t}$ is the number of analysts following firm i in year t, Institutional Ownership$_{i,t}$ is the percentage of shares held by institutions, Asset Tangibility$_{i,t}$ is a measure of asset tangibility, R&D Expenditure is the ratio of annul R&D expenditure to sales, and $\varepsilon_{i,t}$ is the error term. We calculate t-statistics in Panel A using White's (1980) standard errors and report them in parentheses.

***Significant at 1% level.

**Significant at 5% level.

*Significant at 10% level.

Table 5. Regression Results for PIN and Price Impact

Panel A. OLS Results

	Price Impact			Probability of Information-Based Trading (PIN)		
	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX	NASDAQ	Combined
Intercept	1.1863***	1.6869***	1.4125***	0.3032***	0.5234***	0.4456***
	(44.45)	(21.08)	(32.20)	(14.58)	(11.73)	(18.59)
Log(Gov-Index)	-0.0092*	-0.0589***	-0.0396***	-0.0048	-0.0102*	-0.0055
	(-1.70)	(-7.00)	(-7.13)	(-0.99)	(-1.89)	(-1.47)
Log(Price)	-0.0252***	-0.0159***	-0.0304***	0.0035	0.0050*	0.0068***
	(-5.22)	(-3.12)	(-8.74)	(1.25)	(1.69)	(3.33)
Return Volatility	4.0587***	0.3687**	1.7728***	0.4402***	-0.1387*	-0.0854
	(9.84)	(2.04)	(6.94)	(3.30)	(-1.73)	(-1.20)
Log(Trading Volume)	-0.0625***	-0.0657***	-0.0598***	-0.0089***	-0.0234***	-0.0214***
	(-23.34)	(-20.26)	(-26.50)	(-5.11)	(-14.48)	(-18.70)
Log(Assets)	-0.0005	-0.0138***	-0.0125***	0.0001	0.0033*	0.0075***
	(-0.23)	(-3.86)	(-5.93)	(0.03)	(1.86)	(6.83)
Age	-0.0001	-0.0025***	-0.0011***	-0.0002**	-0.0006***	-0.0001
	(-1.17)	(-7.78)	(-11.15)	(-2.46)	(-2.86)	(-1.00)
Number of Analysts	0.0018***	-0.0036***	-0.0001	-0.0003	-0.0016***	-0.0010***
	(8.24)	(-5.71)	(-0.42)	(-1.41)	(-4.72)	(-4.69)
Institutional Ownership (%)	-0.1063***	-0.1740***	-0.1627***	0.0032	0.0072	0.0101*
	(-13.03)	(-11.21)	(-15.77)	(0.43)	(0.97)	(1.87)
Asset Tangibility	0.0166*	-0.0144	0.0871***	-0.0097	-0.0100	-0.0188***
	(1.69)	(-0.94)	(9.43)	(-1.18)	(-1.19)	(-3.34)
R&D Expenditure	0.1112***	1.6869*	-0.0002*	0.0136	-0.0001	-0.0001
	(2.74)	(-1.87)	(-1.92)	(0.66)	(-1.17)	(-1.24)
S&P 500 Dummy	0.0678***	0.0647***	0.0823***	-0.0033	-0.0247***	0.0116***
	(17.27)	(5.04)	(18.91)	(-0.80)	(-3.80)	(3.19)
Adjusted R^2	0.73	0.65	0.70	0.07	0.29	0.17
# of Observations	4,257	4,128	8,385	4,258	4,128	8,386

Panel B. Fixed-Effects Regression Result

	Price Impact			Probability of Information-Based Trading (PIN)		
	NYSE/AMEX	NASDAQ	Combined	NYSE/AMEX	NASDAQ	Combined
Intercept	0.0065	-0.0000	0.0033	-0.0073	-0.0000	-0.0041
	(0.74)	(-0.00)	(0.11)	(-1.11)	(-0.00)	(-0.33)
Log(Gov-Index)	-0.0082	-0.1267***	-0.0595***	-0.0082	-0.0245***	-0.0117**
	(-1.54)	(-12.20)	(-9.79)	(-1.17)	(-3.34)	(-2.30)
Log(Price)	-0.0201***	0.0092	-0.0273***	-0.0066	0.0372***	0.0147***
	(-2.90)	(0.65)	(-3.01)	(-1.00)	(5.43)	(3.04)
Return Volatility	1.9481***	0.1371	0.4813***	0.0757	0.0114	0.0503
	(5.03)	(0.81)	(3.07)	(0.60)	(0.13)	(0.69)
Log(Trading Volume)	-0.0524***	-0.0387***	-0.0314***	-0.0020	-0.0314***	-0.0193***
	(-11.13)	(-4.12)	(-4.71)	(-0.51)	(-7.74)	(-6.57)
Log(Assets)	-0.0120	-0.1480***	-0.0894***	-0.0231***	-0.0341***	-0.0282***
	(-1.55)	(-13.13)	(-12.37)	(-3.70)	(-6.31)	(-6.77)
Number of Analysts	-0.0009***	-0.0002	-0.0011***	-0.0005	-0.0012***	-0.0007**
	(-3.69)	(-0.18)	(-3.13)	(-1.17)	(-2.65)	(-2.49)
Institutional Ownership (%)	-0.1538***	-0.6667***	-0.4498***	0.0196	-0.1070***	-0.0359***
	(-7.56)	(-21.05)	(-20.27)	(1.03)	(-6.52)	(-2.79)
Asset Tangibility	0.0549**	0.0499	0.1027***	0.0408	0.0319*	0.0434***
	(2.06)	(1.52)	(4.33)	(1.55)	(1.94)	(3.11)
R&D	-0.0572	-0.0002	-0.0002*	0.0833	0.0001	0.0001
	(-0.83)	(-1.29)	(-1.72)	(1.58)	(0.81)	(0.59)
S&P 500 Dummy	-0.0004	-0.0000	-0.0017	-0.0012	-0.0000	-0.0010
	(-0.29)	(-0.01)	(-1.08)	(-0.59)	(-0.01)	(-0.58)
Adjusted R^2	0.34	0.42	0.34	0.00	0.09	0.04
# of Observations	4,257	4,128	8,385	4,258	4,128	8,386

This table shows the OLS results (Panel A) and fixed effects results (Panel B) of the following regression model: Price $Impact_{i,t}$ or $PIN_{i,t}$ = β_0 + β_1 Log(Gov-$Index_{i,t}$) + β_2 Log($Price_{i,t}$) + β_3 Return $Volatility_{i,t}$ + β_4 Log(Trading $Volume_{i,t}$) + β_5 Log($Assets_{i,t}$) + β_6 $Age_{i,t}$ + β_7 Number of $Analysts_{i,t}$ + β_8 Institutional $Ownership_{i,t}$ + β_9 Asset $Tangibility_{i,t}$ + β_{10} $R\&D_{i,t}$ Expenditure + β_{11} S&P 500 Dummy + $\varepsilon_{i,t}$ where Price $Impact_{i,t}$ is the mean price impact of firm i in year t and $PIN_{i,t}$ is the probability of information-based trading, Gov-$Index_{i,t}$ is the governance index, $Price_{i,t}$ is the mean stock price, Return $Volatility_{i,t}$ is the standard deviation of daily closing quotemidpoint returns, Trading $Volume_{i,t}$ is the mean daily dollar trading volume, $Assets_{i,t}$ is the book value of total assets, $Age_{i,t}$ is the company age, Number of $Analysts_{i,t}$ is the number of analysts following firm i in year t, Institutional $Ownership_{i,t}$ is the percentage of shares held by institutions, Asset $Tangibility_{i,t}$ is a measure of asset tangibility, R&D Expenditure is the ratio of annul R&D expenditure to sales, and $\varepsilon_{i,t}$ is the error term. We calculate t-statistics using White's (1980) standard errors and report them in parentheses.

***Significant at 1% level. **Significant at 5% level. *Significant at 10% level.

Appendix A. Governance categories and factors used by Institutional Shareholder Service (ISS)

This appendix reports the 24 governance standards related to financial and operational transparency that comprise our index. The standards are drawn from data compiled by Institutional Shareholder Service (ISS). Where appropriate, the associated category and variable in Gompers, Ishii, and Metrick (GIM) is also reported. GIM's index is based on 22 governance standards and six state laws, as collected by the Investor Responsibility Research Center (IRRC), and is designed to capture anti-takeover provisions in a firm's charter, bylaws, and state law.

ISS Governance Categories and Standards		GIM (#)
Audit		
1	Audit committee consists solely of independent outside directors.	
Board		
1	Board is controlled by more than 50% independent outside directors.	
2	Nominating committee is comprised solely of independent outside directors.	
3	Compensation committee is comprised solely of independent outside directors.	
4	Governance committee meets at least once during the year.	
5	Board members are elected annually.	Delay (#2)
6	Size of board of directors is at least six but not more than 15 members.	
7	Shareholders have cumulative voting rights to elect directors.	Voting (#3)
8	CEO serves on no more than two additional boards of other public companies.	
9	No former CEO serves on board.	
10	The CEO and chairman duties are separated or a lead director is specified.	
11	Board guidelines are disclosed publicly.	
Charter		
1	Company has no poison pill.	Other (#5)
2	A majority vote is required to amend charter/bylaws (not supermajority).	Voting (#5)
3	A simple majority vote is required to approve a merger (not supermajority).	Voting (#5)
4	Shareholders may act by written consent and the consent is non-unanimous.	Delay (#4)
5	Shareholders are allowed to call special meetings.	Delay (#3)
6	Board cannot amend bylaws without shareholder approval or only in limited circumstances	Voting (#1,2)
7	Company is not authorized to issue blank check preferred stock.	Delay (#1)
Compensation		
1	Directors receive all or a portion of their fees in stock.	
Ownership		
1	All directors with more than one year of service own stock.	
2	Executives are subject to stock ownership guidelines.	
3	Directors are subject to stock ownership guidelines.	
State		
1	Incorporate in a state without any anti-takeover provisions.	State

Appendix B. Calculation of the probability of information-based trading (PIN)

The EKOP model of the trade process for firm i over trading day j is represented by the following likelihood function:

$$L_i(B_{i,j}, S_{i,j} \mid \theta_i) = (1-\alpha_i)e^{-\varepsilon_i T_{i,j}} \frac{(\varepsilon_i T_{i,j})^{B_{i,j}}}{B_{i,j}!} e^{-\varepsilon_i T_{i,j}} \frac{(\varepsilon_i T_{i,j})^{S_{i,j}}}{S_{i,j}!}$$
$$+ \alpha_i \delta_i e^{-\varepsilon_i T_{i,j}} \frac{(\varepsilon_i T_{i,j})^{B_{i,j}}}{B_{i,j}!} e^{-(\mu_i+\varepsilon_i)T_{i,j}} \frac{[(\mu_i+\varepsilon_i)T_{i,j}]^{S_{i,j}}}{S_{i,j}!}$$
$$+ \alpha_i(1-\delta_i)e^{-(\mu_i+\varepsilon_i)T_{i,j}} \frac{[(\mu_i+\varepsilon_i)T_{i,j}]^{B_{i,j}}}{B_{i,j}!} e^{-\varepsilon_i T_{i,j}} \frac{(\varepsilon_i T_{i,j})^{S_{i,j}}}{S_{i,j}!};$$

where $B_{i,j}$ is the number of buyer-initiated trades for the day, $S_{i,j}$ is the number of seller-initiated trades for the day, α_i is the probability that an information event has occurred, δi is the probability of a low signal given an event has occurred, μ_i is the probability that a trade comes from an informed trader given an event has occurred, ε_i is the probability that the uninformed traders will actually trade, $T_{i,j}$ is total trading time for the day, and Θ_i = (α_i, δ_i, ε_i, μ_i) represents the vector of parameters to be estimated.

We estimate these parameters Θ_i for firm i for each year by maximizing the joint likelihood over the J observed trading days in a calendar year:

$$L_i(M_i \mid \theta_i) = \prod_{j=1}^{J} L_i(B_{i,j}, S_{i,j} \mid \theta_i).$$

We then estimate the probability of information-based trading (PIN) for firm i for each year as

$$PIN_i = \frac{\hat{\alpha}_i \hat{\mu}_i}{\hat{\alpha}_i \hat{\mu}_i + 2\hat{\varepsilon}_i}.$$

CHAPTER III-2

Foreign Investors and Corporate Governance in Korea

by

In Joon Kim* Jiyeon Eppler-Kim** Wi Saeng Kim*** Suk Joon Byun****

Abstract

This paper has two aims. The first aim is to investigate whether poor corporate governance negatively affects equity participation of foreign investors. The second aim is to investigate whether firm-level efforts for better corporate governance attract more foreign investments. Our regression results suggest foreign equity ownership is negatively associated with firms' ownership concentration but is positively associated with firms' efforts for better corporate governance. Interestingly, foreign investors show different behavioral patterns from their domestic counterparts, as the latter group shows less sensitivity to the corporate governance issue than the former group.

JEL Classification Codes: G15, G34

Keywords: Foreign investors, Corporate governance, Emerging markets

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I. Introduction

Weak corporate governance in emerging markets is well documented in many studies (La Porta et al., 1998 and Shleifer and Vishny, 1997). Claessens et al. (2000) and Johnson et al. (2000) show that large single-family conglomerates dominate economies in many emerging countries. In regards to the management behavior of these dominant shareholders, Claessens et al. (2000), Johnson et al. (2000), and Rajan et al. (2000) suggest that controlling shareholders tend to ignore minority shareholders' interests and misallocate corporate resources toward less efficient business units. On the other hand, Khanna and Palepu (2000) highlights the benefits of business groups by stating the diversified structure of business groups could generate values unattainable otherwise, especially in those countries whose financial markets are underdeveloped.

Recent studies indicate that a weak governance system in emerging markets may affect the inflow of foreign investments. Dahlquist et al. (2003) suggests that there is a close relationship between corporate governance and the portfolio composition held by foreign investors. Dahlquist and Robetsson (2001) also shows that foreign investors invest less in firms with concentrated ownership. Meanwhile Reese and Weisbach (2002) and Kim, Lyn and Zychowicz (2004) propose that firms may devise internal mechanisms to overcome deficiencies in their existing institutional environments.

This paper has two aims. The first is to investigate whether corporate governance affects portfolio formation of foreign investors. The second is to investigate whether firms' internal mechanism to defeat poor corporate governance attracts more foreign investment flows.

Special features in the context of two external events in Korea provide ideal settings for examining these issues. First, the wedge between ownership and control is substantial in many Korean firms, especially in Chaebols (a Korean term for conglomerates) and their affiliates, and this leads to the nationwide weak corporate governance.[1] Historically, Chaebols have played a dominant role in the development of the Korean economy. They have built their realms with government support when the Korean economy was managed under national development plans. These Chaebols, however, have excessively expanded their controlling powers via intricate cross shareholdings and reciprocal shareholdings, which has led to the current status of severe disparity between ownership and control in these firms.[2]

1) According to Klapper and Love (2002), Korea exhibits 40.66 for the firm-level governance index, 2.00 for shareholder rights, and 6.00 for judicial efficiency. These governance scores of Korea are lower than the averages cores of emerging market countries, which demonstrate 54.11, 3.57 and 6.30 in each respective section.

After the financial crisis in 1997, the Korean government enacted strict corporate laws to improve corporate governance on a national level. However, corporate reactions to these governmental efforts were mixed.[3) For example, some firms found they could circumvent the law by cutting the size of boards so that they could appoint a manageable number of outside directors. Other firms have voluntarily appointed non-Korean outside directors even though there was no such legal requirement. Considering that Korean society did not welcome foreign influence in the past, the appointment of a non-Korean outside director, based purely on his or her business expertise, may send signals to foreign investors. Our objective is to investigate whether or not such firm-level endeavor to mitigate the nation-wide poor corporate governance sends any positive signals to foreign investors. Given the steady inflow of foreign investment into the Korean stock market, a market which demonstrates unique features in its corporate ownership structure, our research on the relationship between foreign investors and corporate governance is worth exploring.[4)]

Following Dahlquist and Robertsson (2001) and Dahlquist et al. (2003), we test whether firms' poor corporate governance hinders foreign capital inflow. We also explore whether firm-level efforts for better corporate governance, such as the voluntary appointment of foreign outside directors send positive signals to foreign investors. The remainder of this paper is organized as follows: Section 2 reviews the literature and develops hypotheses. Section 3 provides descriptive statistics and models. Section 4 presents the results of our empirical tests. The final section presents the summary and conclusions.

2) According to the recent announcement by the Fair Trade Commission, each chairperson and his/ or her relatives hold 1.95% and 2.66% of ownerships in country's 36 Chaebol groups as of April 1 2003. However, the actual controlling power they represent increases to 41.71% via complicated cross shareholdings and reciprocal shareholdings within affiliates.

3) One example of these newly enacted corporate laws to improve corporate governance is the outside director law, where all listed firms were required to meet the certain quota of outside directors in their boards.

4) As of June 2004, foreign investors account for 43.6% of the total market value in the Korean Stock Exchange. This figure is the 4th highest in the world, following Hungary (72.6%), Finland (55.7%) and Mexico (46.4%).

II. Literature Review & Hypotheses Development

1. Corporate Governance and Foreign Investors

Grossman and Hart (1998) claims that concentrated ownership helps in solving managerial agency problems, which was originally proposed by Jensen and Meckling (1976), as controlling shareholders have power and incentives to discipline management. On the other hand, Bebchuk et al. (2000) and Claessens et al. (2002) argue that concentrated ownership creates new agency problems as controlling shareholders' interests and minority shareholders' interests are not perfectly aligned. The severe disparity between cash flow rights and voting rights in many Korean firms, especially in Chaebol firms, adds more complexities to the relationship between ownership structure and agency problem. Claessens et al. (2000) proposes that the ultimate owner of a business group may ignore minority shareholders' interest, and may therefore exacerbate agency problems. Ferris et al. (2003) and Kim et al. (2004) also suggest that these conglomerates create incentives to mislead managers toward non-value-maximizing investment decisions. Based on these theoretical arguments, we associate Chaebol with high agency costs organizations. Given the negative relationship between agency costs and corporate governance, we also associate Chaebol with a weak corporate governance proxy in our model.

The possible implication of corporate governance and agency costs on investment decisions may vary across investor groups. We argue that the valuation effects of corporate governance may differ between foreign investors and local investors as the former group assigns higher monitoring costs in comparison to the latter group, and therefore may discount corporate governance more severely than domestic investors. Following Dahlquist et al. (2003), which indicates a close relationship between corporate governance and foreign investors' investment behavior, this paper attempts to further specify this relationship.

2. Outside Directors and Their Independence

Fama (1980), and Fama and Jensen (1983) suggest that corporate boards could play an important role to prevent controlling shareholders from expropriating minority shareholders. They especially attribute reduced agency problems to the role of outside director boards. Perry and Shivdasani (2001) indicates that after significant performance decline, outsider-dominated boards are more likely to initiate disciplined restructuring programs than insider-dominated boards. Rosenstein and Wyatt (1990) also suggests that outside director appointment is positively related to the stock return. Meanwhile, Mace (1986) and Patton and Baker (1987) question the incentives of outside directors to make meaningful contribution to the shareholder's wealth creation. Mace (1986), Patton and Baker (1987), and Lorsch and Maclver (1989) cite the lack of sufficient incentives as one of the major constraints for outside directors to perform their monitoring roles effectively.

The effectiveness of a board is also related to the degree of independence in the board member selection process. Shivdasani and Yermack (1999) argues that chairpersons and CEOs wield major influence upon board member selection processes, and those directors selected directly by management are associated with strong negative entrenchment effects, or agency problems. The evidence of the negative relationship between management-affiliated directors and their monitoring effectiveness is also shown in McWilliams and Sen (1997), Cotter etal (1997), Perry and Shivdasani(2001) and Yeh and Woidtke (2004). Therefore, the extent of outside directors' independence can be one measure to assess how effectively boards can play their expected roles (Kaplan and Reishus, 1990 and Byrd and Hickman, 1992)[5)]

We recognize foreign directors bring different cultural dimensions to boards, and therefore affect the overall monitoring performance of boards. We posit that foreign board members are likely to monitor the management more independently and effectively than local outside directors, as well as designate foreign outside directors as a proxy for good corporate governance. Furthermore, since some firms voluntarily appoint foreign outside directors, we regard such actions as firm-level efforts to improve corporate governance.

III. Descriptive Statistics and Regression Model

1. Foreign Ownership

We use KIS Value data, provided by the Korean Information Service, in order to obtain foreign ownership data as well as other firm-specific data. Our data set includes all firms listed either in the Korea Stock Exchange (hereafter KSE) or in KOSDAQ from 1992 to 2003.[6)] When the Korean stock market embraced the first foreign investors in

5) Other factors affecting the board effectiveness include board size (Yermack, 1996 and Eisenberg et al., 1998) and board membership (Brickley et al., 1997).

6) KOSDAQ was introduced in 1996 to help small but rapidly growing IT venture

January 1992, foreign investors had to face restrictions imposed by the Korean government. However, these restrictions were alleviated over time and eventually abolished completely on May 25th, 1998. Since then, foreign investors can enjoy the equal rights as domestic investors on their investments in the local stock market. During our sample period, the total market capitalization of the Korean stock market increased by 5 times, from 72 trillion won in 1992 to 369 trillion won in 2003. Interestingly, the participation of foreigners jumped even higher during the same period by 30 times, from 4.6 trillion won in 1992 to 141.6 trillion won in 2003.

We categorize investors into four groups; foreign investors, domestic institutional investors, domestic retail investors and government institutions. Fig. 1 shows investor composition in the Korean stock market and its trend over time. Each year, we computed the value-weighted average ownership of each investor group, defined by the investment amount held by each investor group to the total market capitalization in percentage. In 1992, participation of foreign investors was only 6.4% of the total Korean stock market, whereas domestic institutional investors, domestic retail investors and government institutions participated in 28.2%, 35.5% and 29.9% of the total market, respectively. The participation of foreign investors in the Korean stock market demonstrated a steady growth over time and became the biggest participant in the market with 38.4% of market share in 2003. Domestic institutional investors, domestic retail investors and government institutions held 15.9%, 23.7% and 22.0% of the total Korean stock market, respectively.

firms easily access to the local capital markets with more eased listing requirements.

Figure 1. Historical Investor Composition in the Korean Stock Market, 1992-2003

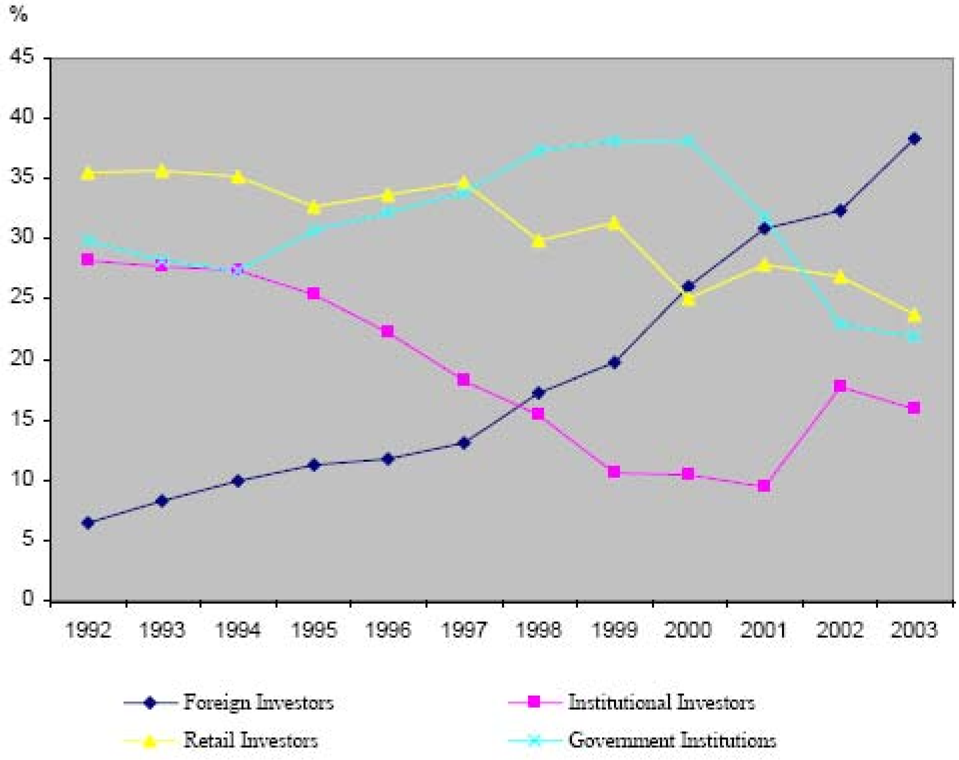

Table 1 provides the mean, the median and the maximum value of foreign ownership across all firms each year. The foreign ownership of each firm is equally weighted without reflecting its market capitalization. The second and the third column present the total listed firms and firms with foreign participation each year.

Table 1. Equally Weighted Average Foreign Ownership, 1992 - 2003

Year	Sample	firms with foreign ownership	Mean	Standard deviation	Median	Maximum
1992	582	337 (57.9%)	4.29	[10.14]	0.35	88.2
1993	581	454 (78.1%)	5.62	[8.11]	2.9	67.8
1994	605	480 (79.3%)	6.34	[8.72]	4.3	79.1
1995	637	531 (83.4%)	5.79	[7.26]	3.2	50
1996	677	530 (78.3%)	6	[8.70]	2.2	81.5
1997	884	520 (58.8%)	3.56	[11.82]	0.5	100
1998	846	452 (53.4%)	5.31	[11.46]	0.1	89.1
1999	928	540 (58.2%)	5.7	[12.90]	0.2	100
2000	1087	624 (57.4%)	5.22	[12.49]	0.1	99.8
2001	1282	754 (58.8%)	5.43	[12.70]	0.1	99.9
2002	1411	1004 (71.2%)	5.02	[11.91]	0.12	98.63
2003	1464	1072 (73.2%)	6.45	[13.44]	0.28	96.74
Average	915	608 (67.3%)	5.36	[10.80]	1.20	87.56

Note the value-weighted average of foreign ownership in 2003 is 38.4 % in Fig 1 whereas the equally weighted average foreign ownership is just 6.45 % in Table 1. This is because the equally weighted average ownership does not reflect the market capitalization of each firm. The higher number in value-weighted average foreign ownership compared to the equally weighted average foreign ownership implies that foreign investors invest disproportionately more in large firms.

2. Foreign Ownership by Industry

We classified firms into nine industry sectors using the industry code provided by the KIS Value. Table 2 shows different industry weights and investor groups in 2003.7) For comparison, we showed the market portfolio's industry allocation at the start of the table. The difference in industry weights between the market portfolio and each investor group's portfolio indicates how much each investor group's portfolio deviates from the market portfolio across industries.

Table 2. Industry Weight by Investor, 2003

	Market portfolio		Foreign Investors		Institutional Investors		Retail Investors		Government Institutions	
Market capitalization (billion Korean won)	369,295		141,618		58,912		87,686		81,077	
	N	Weight	N	Weight	N	Weight	N	Weight	N	Weight
Agriculture Forestry Fishery & Mining	(8)	0.1	(6)	0.00	(8)	0.02	(8)	0.21	(8)	0.02
Manufacturing	(986)	57.6	(734)	60.70	(792)	65.06	(981)	60.99	(918)	43.03
Utilities	(11)	4.5	(10)	3.00	(11)	1.68	(11)	1.15	(11)	12.66
Construction	(58)	2.2	(52)	1.50	(53)	2.10	(58)	2.60	(56)	3.25
Wholesale & Retail	(87)	3.3	(64)	3.10	(73)	2.40	(87)	5.48	(81)	1.97
Shipping	(21)	1.4	(15)	0.90	(20)	1.65	(21)	2.07	(21)	1.58
Communication	(14)	9.8	(11)	10.60	(12)	4.20	(14)	5.93	(14)	16.45
Financial	(79)	15.9	(61)	17.50	(72)	20.82	(78)	10.40	(78)	15.29
Services	(200)	5.3	(137)	2.60	(159)	2.06	(200)	11.16	(193)	5.75
All	(1464)	100	(1090)	100	(1200)	100	(1458)	100	(1380)	100
			74.45		81.97		99.59		94.26	

Note : This table shows industry allocation in each investor categories. The number of firms each investor group holds for each industry and its industry weight are shown here.

7) We calculated the statistics during 1992-2002, although not reported here, and observed the similar industry preference patterns.

Industry weights shown here are value-weighted averages, defined by the market capitalization of each industry by each investor group in proportion to the investor group's total market capitalization. The observation is consistent with Dahlquist and Robertsson(2001) who reported that the industry preference by foreign investors and domestic institutional investors appears to be similar, while retail investors and government institutions show quite different investment patterns. To elaborate, foreign investors overweight manufacturing, communication and financial industries compared to the overall market. A similar pattern is also observed in the participation of domestic institutional investors, with a small difference that the institutional investors under weigh in the communication industry in comparison to the overall market. Government institutions overweigh in both the communication and utility industries. In particular, the government institutions' investment portion in the utility industry is the highest among all investor groups. This is perhaps due to the fact that the utility industry had been historically nationalized. Retail investors tend to overweigh in wholesale & retail, services, shipping and construction industries, which are generally shunned by foreign investors.

The last row of Table 2 shows the number of firms invested by each investor group in proportion to the total number of listed firms. Retail investors appear to invest in almost all firms with a participation of 99.6%. Government institutions invested in 94.3% of the total available firms in the market. However, foreign investors and domestic institutional investors appear to be more selective, and invest in 74.5% and 82.0% of the total firms, respectively.

3. Chaebol Firms vs. Non-Chaebol Firms

Every April, the Korean Fair Trade Commission announces the updated list of Chaebols and their affiliates, based on total asset size of all affiliates within business group.[8] Firms nominated as Chaebols are governed under special laws which are generally more restrictive in terms of conducting businesses within groups. Such restrictions include limitations on equity holding and loan guarantee within affiliates. Bae et al. (2002) indicates that Chaebol firms are different from other firms in that they display more extensive cross shareholdings and reciprocal shareholdings. Bae et al.

8) The Fair Trade Commission has been updating Chaebol groups and their affiliates since 1987, based on total asset size of all affiliates within business group. Historically the basis for identifying Chaebol groups from other firms alternated between ranking basis and absolute value basis. The most recent change was in 2002 when the basis changed from top 30 business groups by asset (ranking basis) to groups with over 2 trillion KRW assets (absolute value basis).

(2002) further suggests that founding families of Chaebol groups have stronger incentives to tunnel corporate resources from affiliates to increase their personal wealth.

We classify firms into two categories; Chaebol firms and non-Chaebol firms. By definition, Chaebol firms are much larger in size than non-Chaebol firms. The average market capitalization of Chaebol firms is 1.5 trillion won while that of non-Chaebol firms is 90 billion won in 2003. The third column of Table 3 shows the number of Chaebol firms each year.

Table 3. Chaebol Firms and Firms with Foreign Outside Directors

Year	Sample	*Chaebol* Firms	Foreign Outside Director	
			Number of foreign outside directors	Number of firms with foreign outside directors
1992	582	90	N/A	N/A
1993	581	99	N/A	N/A
1994	605	107	N/A	N/A
1995	637	128	N/A	N/A
1996	677	135	N/A	N/A
1997	884	143	N/A	N/A
1998	846	136	6	6
1999	928	126	26	20
2000	1087	126	55	29
2001	1282	129	59	30
2002	1411	158	53	26
2003	1464	165	63	35
Average value		128.5	43.6	24.3

4. Foreign Outside Directors

In June 1998, the Korean government, as an attempt to improve corporate governance, enforced outside director laws upon which all listed firms were required to appoint a certain ratio of outside directors on their boards. In general, listed firms must appoint at least one fourth of their boards(a minimum of one member) as outside directors.[9] Interestingly, reactions to the new regulation were mixed. Some firms cut the size of boards so that outside directors required by the regulation would be kept at a minimum. Other firms welcomed the new regulation and appointed not only enough outside directors stipulated by the law but also voluntarily appointed more foreign outside directors.

Foreign outsider directors may bring global experience and expertise to the firm which domestic outside directors may not. More importantly, foreign outsider directors may act more independently as their personal attachment to management is weaker than domestic outside directors. It is arguable, therefore, that such appointments can be perceived by investors as a sign of improved governance. We will later follow up on this issue and draw implications. The last two columns in Table 3 show the total number of foreign outside directors each year and the number of firms who appointed foreign outside directors. We were able to identify these figures by tracking all public announcements of the appointment of outside directors.

5. Regression Model

We divide our sample period into three periods; the pre-Asian financial crisis period between 1992 and 1996, the Asian financial crisis period between 1997 and 1998, and the post-Asian financial crisis period between 1999 and 2003. It should be noted that the post-financial crisis period coincides with the period when restrictions on foreign capital inflows into the Korean stock market were completely abolished. As we investigate independently for the three different sample periods, we wish to have better understanding of the impact of such regulatory changes the investment behavior of foreign investors.

Following Dahlquist and Robersson (2001), we calculate the relative ratio of firm's weight in foreign portfolio in comparison to its weight in the market portfolio. Then we subtract 1 from this value in order to adjust the base point to zero. This is our

9) Chaebol groups are set to be governed under even more restrictive regulations where they must fill at least half of their boards as outside directors.

dependent variable. The numerical representation of this is as following.

$$y_i = w_i^f / w_i^m - 1,$$

where w_i^f denotes the firm i's weight in the market's total foreign portfolio, and w_i^m denotes the firm i's weight in the total market portfolio. The ratio w_i^f / w_i^m is equivalent to the ratio of firm i's notional foreign ownership percentage in proportion to the total market's value-weighted average foreign ownership.

We recalculate the relative value of a firm's foreign ownership instead of simply using each firm's notional foreign ownership percentage because of following reasons. First, each firm's notional foreign ownership percentage itself does not give an appropriate implication of dollar amount because it does not reflect the firm's market capitalization. That is, 1% foreign ownership in a large firm and in a small firm definitely carries different dollar investment amount and this difference should be taken into account. Second our dependent variables need to convey comparability implication in order to gauge whether a certain firm factor is specially favored or disfavored by foreign investors in comparison to the benchmark. For example, if a certain firm characteristic is preferred by all investors in general, we can't say that this characteristic is specifically sought by foreign investors. Therefore, we set up market portfolio as a benchmark in order to compare the preference pattern of foreign investors in a more relative manner to the market's overall pattern.

Note that $y_i = 0$ means the firm's foreign weight and the market weight is in balance, meaning that the firm's notional foreign ownership shows an equivalent ratio to the market's value-weighted average foreign ownership. A positive y_i means the firm's foreign ownership is disproportionately higher in comparison to the firm's market weight. In other words, foreign investors overweigh in the firm as compared to in the market portfolio. Similarly, a negative y_i means that foreigners under weigh in the firm than in the market portfolio. For example, while Samsung Eletronics accounts for 18.4% of the entire market in 2003, the foreign weight of the firm accounts for 28.9 % of the total foreign portfolio in the Korean stock market. This difference means that foreigners overweigh in Samsung Electronics than in the market portfolio. The calculated dependent variable for Samsung Electronics is 0.57065.

The lowest possible value of y_i is -1, for firms with zero foreign ownership. However the highest possible value of y_i is beyond 1. A firm with $y_i > 1$ indicates the firm's foreign weight exceeds more than 2 times of the firm's market weight. In our sample, Jeil Steel Manufacturing Co. shows the highest y_i at 6.63 in 1997. The firm appears to have quickly changed hands from retail investors to foreigners during the turmoil of the financial crisis and in 1997, the firm showed 100% foreign ownership, while the market's value-weighted average foreign ownership was 13.11%.

The main focus in our regression is to estimate the relationship between foreign ownership and the corporate governance. We set the following three factors as corporate governance related variables; Chaebol status, ownership concentration, and foreign outside director status. Apart from these corporate governance related variables, we also include other firm-specific factors that may influence foreign equity participation. We run multi variate regressions after clustering our samples by firms as it is both cross sectional and time series data. We include a year dummy to reflect the time fixed effect. We estimate the following regression model:

y_i = f (CHAEBOL, OWNERSHIP, FRNOD, SIZE, FRNL, EXP, TURNOVER, DY, RISK, Q, ROA, YEAR)

In the following, we briefly describe the firm-specific attributes of independent variables.

(a) CHAEBOL is a dummy variable equal to one for Chaebol firms, and zero otherwise.

(b) OWNERSHIP is the equity holdings of large shareholders in percentage.[10)]

(c) FRNOD is a dummy variable equal to one for firms with foreign outside directors on their board, and zero otherwise.

(d) SIZE is the log of a firm's market capitalization on the last trading day of the sample years.

(f) FRNL is a variable equal to one for firms listed in foreign exchanges, and zero otherwise.[11)]

(e) EXP is measured as export sales volume divided by total sales volume, as a proxy for recognition to foreign investors.

(g) TURNOVER is share turnover (annual trading volume divided by total outstanding shares of a firm), as a liquidity measure of a firm's share.

(h) DY is dividend yield.

10) Under the current Korean Securities and Exchanges Act, large shareholders are defined as either those who represent more than 1 % share of the firm or those who represent over 300 million won in its share market value. Also those who have special relation with controlling shareholders are considered as large shareholders.

11) The first wave of foreign listing by Korean firms was driven by chaebol firms, for example Samsung Electronics and Hyundai Motors, in early 1990s. In general, when firms issue shares in foreign exchange, one way of doing this is as a form of depository receipts (DR) which is indexed to the original share in home countries. We were able to identify firms with foreign listings by checking ADR (American Depository Receipt for listing in the stock exchange in the U.S.) and GDR (Global Depository Receipt for listing in the European stock exchange) issuance status of each firm.

(j) RISK is the beta coefficient in the market model, the systematic risk of a firm, provided by the KIS value data.

(l) Q is Tobin's q ratio, the valuation measure of a firm, measured as market value of equity divided by the book value of asset.

(o) ROA is measured as a firm's annual net income divided by a firm's total assets.

(p) YEAR is an annual dummy to control for fixed annual factors

IV. Empirical Results

1. Corporate Governance and Foreign Ownership

Table 4 presents the regression result for the post-Asian financial crisis period. Constants and year dummy coefficients are not reported here. Firms with higher-than-average foreign ownership in one year are typically likely to have higher-than-average foreign ownership in other years. If so, the residuals of a given firm may be correlated across years. Peterson (2007) shows that, of the most common approaches used in the literature, only clustered standard errors are unbiased in this sort of data. Therefore, following Peterson (2007), we run the regressions with firm clustering of standard errors which treats only observations with different firms as independent. The results of all regression models show that a positive relationship exists between foreign ownership and the presence of foreign outside director, suggesting that foreign portfolio investors overweigh in firms with foreign outside directors. The estimated coefficients for stock turnover variable are negative and statistically significant, but the coefficients for Tobin's Q ratio and ROA are positive and statistically significant. Interestingly, the estimated coefficients for Chaebol dummy are positive when the firm size is not controlled for. Once the firm size enters in the regression models, however, coefficients for Chaebol dummy are no longer statistically significant. The results show that firm size dominates the Chaebol dummy and ownership concentration. There is a positive correlation between firm size and Chaebol dummy because Chaebol firms are larger than non-Chaebol firms by definition. The statistics show that in 2003, the average market capitalization of Chaebol firms is 15 times larger than that of non-Chaebol firms. A negative relationship is expected to exist between ownership concentration and firm size.

Table 4. Foreign Ownership Regression on Firm Characteristic, 1999-2003

1999 – 2003	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8
CHAEBOL	0.2341 ***	0.0218	0.2336 ***	0.2353 ***	-0.0205	-0.0206	0.0134	0.0127
	(6.95)	(0.65)	(6.92)	(6.05)	(-0.51)	(-0.51)	(0.32)	(0.31)
OWNERSHIP	-0.0864 **	-0.0316	-0.0862 **	-0.1396 **	-0.0872	-0.0887	-0.0575	-0.0570
	(-2.22)	(-0.86)	(-2.21)	(-2.13)	(-1.47)	(-1.48)	(-0.92)	(-0.90)
FRNOD	0.9125 ***	0.6820 ***	0.9120 ***	0.8881 ***	0.6541 ***	0.6542 ***	0.6694 ***	0.6694 ***
	(8.00)	(6.53)	(8.00)	(7.77)	(6.34)	(6.34)	(6.38)	(6.38)
SIZE		0.2442 ***			0.3178 ***	0.3177 ***	0.2862 ***	0.2861 ***
		(11.58)			(10.73)	(10.69)	(9.15)	(9.12)
FRNL		0.2267 ***			0.1339	0.1344	0.1248	0.1245
		(2.82)			(1.47)	(1.47)	(1.39)	(1.38)
EXP			0.0194		0.0037	0.0047		0.0228
			(0.65)		(0.08)	(0.10)		(0.50)
TURNOVER				-0.0000***	0.0000 ***	0.0000 ***	-0.0011 ***	-0.0011 ***
				(-4.62)	(3.89)	(3.89)	(-2.59)	(-2.62)
DY						0.0604		0.0789
						(0.29)		(0.29)
RISK							-0.0422	-0.0435
							(-1.46)	(-1.53)
Q							0.0872 **	0.0898 **
							(2.18)	(2.22)
ROA							0.2221 **	0.2191 **
							(2.34)	(2.16)
N	6170	6170	6170	2981	2981	2981	2807	2807
Adjusted R-square	13.87	25.03	13.88	19.37	37.09	37.10	38.34	38.37

Note : T-statistics are in parentheses. ***, ** and * indicate that the coefficients are statistically significant at 0.01, 0.05 and 0.10 level, respectively.

Table 5 presents the regression result for the pre-crisis period. Outsider directors were not mandatory during this time period, so the foreign outside director dummy variable was removed from our regression models. Some interesting points are detected during the pre-crisis period as compared to the post-crisis period. First, foreign investors overweigh in large firms and firms listed on foreign stock exchanges. Second, the estimated coefficient for Chaebol dummy indicates that foreign investors disfavor Chaebol firms during the pre-crisis period, but overweigh in Chaebol firms during the post-crisis period, although not statistically significant. Additionally, foreign investors overweigh in high dividend yield firms during the pre-crisis period, but show no particular preference during the post-crisis period.

Table 5. Foreign Ownership Regression on Firm Characteristic, 1992-1996

1992-1996	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8
CHAEBOL	0.1939 ***	-0.0281	-0.0348					-0.0215
	(2.73)	(-0.37)	(-0.46)					(-0.28)
OWNERSHIP	-0.1047	0.1637	0.1623					0.1479
	(-0.60)	(0.98)	(0.96)					(0.90)
SIZE		0.4694 ***	0.4445 ***	0.4545 ***	0.4338 ***	0.4325 ***	0.4259 ***	0.4171 ***
		(8.39)	(7.64)	(9.41)	(9.19)	(9.13)	(8.83)	(7.24)
FRNL			0.4699 **					0.4710 **
			(2.44)					(2.34)
EXP				0.0604				0.0770
				(0.60)				(0.77)
DY					6.3409 ***	6.4681 ***	5.2439 ***	5.5290 ***
					(3.87)	(3.70)	(2.98)	(2.80)
Q						0.0344		-0.0027
						(0.37)		(-0.03)
ROA							0.9890	0.8928
							(0.92)	(0.79)
N	3082	3082	3082	3082	3082	3082	3077	3077
Adjusted R-square	1.15	6.38	6.62	6.34	7.05	7.05	7.22	7.57

Note : T-statistics are in parentheses. ***, ** and * indicate that the coefficients are statistically significant at 0.01, 0.05 and 0.10 level, respectively.

Table 6 presents the regression results during the financial crisis period. During this unstable and volatile period, foreign investors overweigh in large firms, firms with low systematic risks, firms with low share turnover, and firms with low ownership concentration. The coefficient for the Chaebol dummy is negative and statistically significant even after the firm size is controlled for. This evidence indicates that foreign investors disfavored the Chaebol firms during the crisis and pre-crisis period.

Table 6. Foreign Ownership Regression on Firm Characteristic, 1997-1998

1997-1998	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8
Chaebol	0.1646 ***	-0.0695	-0.0752					-0.0115
	(2.68)	(-1.22)	(-1.32)					(-0.20)
OWNERSHIP	-0.3609 ***	-0.2640 **	-0.2589 **	-0.2449 *	-0.2657 *	-0.2628 *	-0.2677 **	-0.2621 *
	(-2.88)	(-2.07)	(-2.03)	(-1.95)	(-1.91)	(-1.86)	(-2.01)	(-1.95)
SIZE		0.3686 ***	0.3502 ***	0.3335 ***	0.4643 ***	0.4553 ***	0.4627 ***	0.4543 ***
		(9.90)	(9.06)	(8.95)	(8.55)	(8.29)	(8.60)	(7.77)
FRNL			0.3774 **	0.3646 *	0.2357	0.2461	0.2369	0.2481
			(2.06)	(1.95)	(1.18)	(1.24)	(1.19)	(1.24)
EXP				0.1108				0.0483
				(1.44)				(0.68)
TURNOVER					-0.0359 ***	-0.0361 ***	-0.0358 ***	-0.0365 ***
					(-4.25)	(-4.49)	(-4.18)	(-4.37)
DY					1.2177	1.2613	1.1874	1.2511
					(1.58)	(1.61)	(1.44)	(1.53)
RISK					-0.4306 ***	-0.4174 ***	-0.4286 ***	-0.4081 ***
					(-3.57)	(-3.50)	(-3.47)	(-3.29)
Q						0.0504		0.0527
						(0.33)		(0.34)
ROA							0.0464	0.0311
							(0.11)	(0.07)
N	1730	1730	1730	1730	1070	1070	1070	1070
Adjusted R-square	2.07	10.08	10.35	10.42	21.40	21.44	21.40	21.50

Note : T-statistics are in parentheses. ***, ** and * indicate that the coefficients are statistically significant at 0.01, 0.05 and 0.10 level, respectively.

To sum up, it is interesting to note that investment strategy of foreign investors changed over time in that they disfavored Chaebol firms prior to and during the Asian financial period when the firm size is controlled for. But during the post-crisis period, we found no statistically significant relationship between foreign ownership and the Chaebol dummy once the firm size is controlled for. In all regressions, foreign resident outside directors and firm size showed the biggest explanatory power to foreign ownership. Interestingly, the stock picking strategy of foreign investors, the size of the firm becomes a less of a factor and corporate governance proxy variables become more important over time in the Korean stock market.

For a robustness check on our results, we conducted the estimation for each industry separately. We also considered dummy variables to pick up industry-specific fixed effects. These results support our main findings in that foreign ownership is positively associated with foreign resident outside directors, firm size, and foreign listings, while negatively associated with systematic risks. This pattern is most apparent in the manufacturing industry. The export ratio, for example, shows a positive relation with foreign ownership in the regressions of manufacturing industry. This pattern is shown the most obviously in the manufacturing industry. The export ratio shows a positive association with foreign ownership in manufacturing industry.

Our results revealing the preference for large firms and firms with foreign listings are consistent with those of both Kang and Stulz (1997) and Dahlquist and Robertsson (2001). Consistent with the works by Merton (1987), Falkenstein (1996), and Huberman (1999), we find foreign investors prefer firms with which they are familiar. Chari and Henry (2001) cites that regulatory guidelines in the U.S. often restrict portfolio managers to holding stocks that are included in investible indices such as the IFCI (International Finance Corporation's Investible Index). In order to be included in the IFCI, firms must pass the minimum size screening process. Thus these regulatory restrictions seem to have additional explanatory power to the preference of large firms by foreign investors.

2. Foreign Investors vs. Other Investors

Dahlquist and Robertsson (2001) argues that the investment pattern of foreign investors converges to that of institutional investors.[1] Therefore, we investigate if the investment pattern of foreign investors differs from that of other investor groups by conducting the regression analysis separately for each investor category. The model

1) According to Sundin and Sundqvist (1998), the representative foreign investor is mostly a large institution.

specification is identical to that of foreign investors with the exception that the dependent variables are adjusted to investor categories. The dependent variables in the regressions of other investor categories are as follows.

$$y_i = w_i^* / w_i^m - 1$$

where, w_i^* is the weight of firm i in the portfolio held by each investor category.

The regression results are reported in Table 7. We only present the results in the post-crisis period, when all restrictions to foreign investors were lifted. We also report the results for foreign ownership at the start for an easy comparison.

Table 7. Investor Ownership Regression on Firm Characteristic, 1999-2003

	Foreign Investors	Institutional Investors	Retail Investors	Government Institutions
CHAEBOL	0.0127	-0.0531	-0.2986 ***	0.3017 ***
	(0.31)	(-0.70)	(-4.66)	(4.89)
OWNERSHIP	-0.0570	-0.1630	-0.8349 ***	0.9548 ***
	(-0.90)	(-1.08)	(-5.70)	(6.40)
FRNOD	0.6694 ***	-0.2440 **	-0.4181 ***	-0.1792 *
	(6.38)	(-2.13)	(-3.59)	(-1.74)
SIZE	0.2861 ***	0.4725 ***	-0.7359 ***	0.1614 ***
	(9.12)	(6.88)	(-15.38)	(3.42)
FRNL	0.1245	-0.4173 ***	0.0516	-0.0253
	(1.38)	(-2.82)	(0.41)	(-0.19)
EXP	0.0228	-0.0679	0.0969	-0.1030
	(0.50)	(-0.84)	(1.22)	(-1.49)
TURNOVER	-0.0011 ***	-0.0013	0.0037 **	-0.0012
	(-2.62)	(-0.92)	(2.48)	(-1.08)
DY	0.0789	0.1383	0.6954	-0.7247 **
	(0.29)	(0.20)	(1.64)	(-2.47)
RISK	-0.0435	0.1492 *	0.1293 **	-0.1381 **
	(-1.53)	(1.80)	(1.99)	(-2.28)
Q	0.0898 **	-0.1299 **	0.0596	-0.0781
	(2.22)	(-1.99)	(0.98)	(-1.60)
ROA	0.2191 **	0.3050	-0.2591	-0.1258
	(2.16)	(1.07)	(-1.38)	(-0.74)
N	2807	2807	2807	2807
Adjusted R-square	38.37	10.23	41.96	18.69

Note : T-statistics are in parentheses. ***, ** and * indicate that the coefficients are statistically significant at 0.01, 0.05 and 0.10 level, respectively.

As observed in earlier regression models, the foreign-resident outside director dummy variable and firm size have the strongest explanatory powers for foreign equity ownership. Additionally, foreign listings, high Tobin's q, high ROA, dispersed ownership structure, low share turnover and low systematic risk play a significant role for explaining foreign ownership. As for institutional investors, firm size explains the institutional ownership the best. Here those variables which are considered significantly positive by foreign investors, for example foreign resident outside directors and foreign listings, show negative signs. This result suggest that domestic institutional investors' investment patterns differ from those of foreign investors, and the former group overweights firms with concentrated ownership structure and under underweight firms listed on foreign stock exchanges. Interestingly, only foreign investors overweight firms with foreign- resident outside directors and listed on foreign exchanges. The stock holdings by retail investors and government institutions are largely explained by Chaebol dummy, ownership concentration, and firm size. However, the estimated coefficients for Chaebol dummy and firm size are negative and statistically significant. This observation indicates that Korean retail investors disfavor large firms and Chaebol firms in their investment patterns, favor small and non-Chaebol firms.

In sum, foreign investors weigh disproportionately more shares in firms that appoint foreign outside directors, firms with high Tobin's q, and firms with higher ROA. Interestingly, except foreign investors, all domestic investors disfavor firms which appointed foreign outside directors. Foreign investors do not distinguish between Chaebol and non-Chaebol firms once the firm size is controlled for. But, domestic investors disfavor in Chaebol firms, even after the firm size is controlled for.

V. Conclusion

This paper investigates the association between firm-level corporate governance and portfolio investment patterns by foreign institutional investors in the Korea stock market. We find that foreign investors allocate a disproportionately higher share of their funds to the firms with foreign outside directors. We interpret this finding as evidence that improvements on corporate governance attract more foreign investments. We also find that foreign investors do not disproportionately allocate their funds to Chaebol firms, once the firm size is controlled for. We find that foreign equity ownership is determined by firm-specific attributes such as, liquidity, systematic risk, Tobin's q, and ROA. Interestingly, domestic investors tend to under weigh in firms with foreign-resident outside directors, indicating that they care less about corporate governance than their foreign counterparts.

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Comments on "Foreign Investors and Corporate Governance in Korea"

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The purpose of the paper is to investigate the relationship between foreign ownership and corporate governance using the firm-level data over the period of 1992-2003 in Korea. The authors divide the sample into three period, pre-crisis, during-the-crisis, and post-crisis. From the period-by-period regressions, the authors find that foreign equity ownership is negatively associated with firms' ownership concentration but is positively associated with firms' efforts for better corporate governance. In addition, foreign investors are more sensitive to the corporate governance issues than domestic institutional investors.

I believe that the paper is on a very interesting and important topic. However, I have some difficulties in finding sufficient evidence from current version of the paper. I hope that my comments help improve the paper.

The first thing that catches my eyes is that financial firms are included in the analysis. It is well-known that accounting standards for financial firms are different from those for firms in other sectors. As a result, it is hard to interpret the regression results because it may distort the whole picture when non-financial firms as well as financial firms are treated in one framework. It might be better to treat financial firms and non-financial firms separately.

In the regression model, the authors use foreign ownership as a dependent variable and ownership concentration as an independent variable. According to the paper, ownership concentration is the equity holdings of large shareholders. If the foreigners hold more than 1% share, then these foreigners are classified as large shareholders. Checking the top 5 shareholders from KIS Value Database, the database used by the paper, one can find that many foreigners belong to this group. That is, it seems that many foreigners are also classified as large shareholders. If the authors want to check the relationship between foreign ownership and ownership concentration of other investors, then the authors need to carefully examine the ownership data and to exclude foreign large shareholders. Otherwise, the estimates would be biased.

Moreover I am not convinced that ownership concentration as defined in the paper is a good measure of corporate governance. In my view, distribution of ownership has more important meaning than the sum of large shareholders' share in terms of voting power. That is, the existence and power of controlling shareholders is an important criterion for investment decision.

For example, compare the following ownership structure of hypothetical two firms.
Firm A: 10 shareholders with 10% each
Firm B: 10 shareholders, One with 55% and the others with 5% each

Applying the definition given in the paper, these two firms have the same level of ownership concentration. But each shareholder's voting power is quite different. I understand that it is almost impossible to collect data about all the shareholders. But there might be a better measure of corporate governance reflecting voting power at least partially, for example sole-ownership, or ownership-control disparity.

In addition, it is better to include industry dummy in regressions and to control industry effect. Not to mention the different accounting standards between financial and non-financial firms, other heterogeneities may exist across industries. Even in manufacturing sector, firms are heterogeneous from paper and pulp to electronics and information technology. Some sectors are still under regulation on foreign ownership. As the paper correctly notes, the Korean government lifted up the limitations on the foreign shareholding in 1998. However, some industries such as defense, energy, broadcasting, telecommunications and airline, to name a few, are still subject to regulations of foreign shareholding. Considering these, I would like to suggest controlling for industry effect, at least 2 digit level of KSIC(Korea Standard Industry Classification) Code. Preferably it might be better to control firm heterogeneity, too.

The authors seem to compare results from different regression models. Regression model for <Table 4> is different from that for <Table5> in that variables such as "TURNOVER" and "RISK" are not included as control variables for <Table 5>. I don't know whether this is standard in the literature but it seems odd to compare <Table 4> to <Table 5>. And I fail to find that "Investment strategy of foreign investors changed over time in that they disfavored Chaebol firms prior to and during the Asian financial period when the firm size is controlled for.(p.18)" because no statistically significant relationship exists between Chaebol dummy and foreign ownership once size effect is controlled. I wonder where it comes from.

As for methodological issue, I wonder if one should run Tobit regression or not because on average, foreign ownership, the dependent variable, has a mass of 32.7% at (-1). Lastly the regressions could suffer from endogeneity problems. It is true that, theoretically, firms with better corporate governance can potentially attract higher foreign ownership. Nevertheless, one should be careful in the interpretation of the empirical results since the results do not necessarily imply causal relations. We should note that the empirical results are also consistent with an alternative explanation in that foreign investors can potentially enhance corporate governance of a firm and that we may have some evidence for disciplinary role of foreign investors. Therefore careful interpretation is needed.

CHAPTER III-3

Economic Crisis, Learning and Innovation in Korean Firms

by

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Geon-Cheol Shin**

Abstract

Korean firms(chaebols) faced increasing global competition as Korea became a member of the WTO and OECD, and the world economy continued to globalize. These changes led to economic crisis in Korea and the crises caused Korean firms to transform. This paper investigates factors that contributed to the economic crisis and Korean firms' learning and innovations in response to the crisis. Some Korean firms' financial resource selection and deployment were ill-prepared for the changes these firms were dissolved as the economic environment drastically changed. Other Korean firms learned the importance of multiple factors: managers' awareness and adaptabilities to changes in market conditions, corporate core competency and capability, managers' investment decision, and principles of corporate management. Many Korean firms increased competitiveness by making changes in their competitive mind set and adopting new business practices after the economic crisis. Emphasis on competence-creation and globalization, the most prevalent changes, made Korean firms competitive.

Key Words: business practice innovation, competence creation, dynamic capabilities, evolutionary economics, knowledge, learning, novelty creation, self-organization, selection environment

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I. Introduction

The 1997 Korean economic crisis was a major economic environmental shock for many Korean firms. Since then, Korean firms have undergone many changes in response to the crisis. Many researchers and observers have studied causes of the crisis (Graham, 2003; Joh 2001a, 2001b, 2003; Yoo, 1999).There are a number of studies on the Korean economic crisis at the macro-level (Adelman and Song, 1999; Baliño and Ubide, 1999; Joh, 2003: Krueger and Yoo, 2002) however, there is a paucity of empirical studies on the micro-level, particularly at the corporate level, in spite of the importance of corporate roles in economic performance. This study focuses on the corporate responses and transformation of management practices after the Korean economic crisis.

Most studies report that the financial structure of Korean firms and government intervention in capital markets were main causes of the crisis. We take a different approach in understanding the nature of the crisis. This paper will examine economic, environmental and corporate level factors of the economic crisis and study corporate responses to the crisis from the evolutionary economics perspective of the firm. Evolutionary economics focuses on the analysis of dynamic processes, change and innovation (Buenstorf, 2006; Nelson and Winter, 1982; Winter, 1984). Winter (1984) emphasizes the importance of economic change in our changing world. Nelson (2006) also identifies aspects of evolutionary economics: scientific knowledge, technology, and business organization and practice. Teece, Pisano and Shuen (1997) appropriately capture the elements of evolutionary economics in their dynamic capabilities theory and emphasize the key role of strategic management in adapting, integrating and recon figuring internal and external skills, resources and functional competencies to match the requirements of a changing environment (p. 515).

Korean firms faced a drastically changing environment in the '90s, including becoming a member of the WTO and OECD. Some Korean firms adapted well to the changing environment, but a significant number of firms were dissolved, or changed ownership and management, in 1997 and 1998. The Korean firms' experiences offer a unique opportunity to study the evolutionary approach to the firm. Although extensive writings on evolutionary economics have emerged in the last three decades, there is a paucity in empirical studies. The evolutionary approach to the firm can be applied to understanding Korean corporate changes in a rapidly changing global economic environment. The paper will first review the evolutionary economics approach to the firm, then we will use the firms' financial statements as well as survey data obtained in our earlier study (Park and Shin, 2004a) for the empirical analysis.

Section 2 reviews the evolutionary economics approach to the firm to establish a theoretical framework for our analysis of changes in Korean firms. Section 3 considers the causes of the economic crisis and recovery, to grasp environmental changes in the Korean economy. Section 4 examines corporate learning and changes. Section 5 attempts to provide concrete evidence in the form of survey results. Section 6 discusses the survey results and evidence. Section 7 concludes the paper.

II. Theoretical Framework

1. The Evolutionary theory of the firm

The evolutionary approach sees the firm as a bundle of routines (Nelson and Winter, 1982; Williamson, 1999), and the unit of analysis is a routine (Foss et al., 1995). Nelson and Winter (1980, 1982) compare changes in the business firm with natural selection in biology. We can find the same line of thinking from Alchian (1950), who asserts that an analogy to the imitation, innovation and profit in economics can be found in biology: the gene, mutation and natural selection.

Nelson and Winter (1982) base their evolutionary approach to the firm on Schumpeter's innovation and creative destruction (1934). They propose three concepts in their evolutionary theory of the firm: (1) routines, (2) search routine and (3) selection environment. Nelson and Winter (1982) define organizational routine as regular and predictable behavioral patterns of firms, such as the ways to perform everyday tasks and to make decisions. Activities and tasks performed by everyday routines do not imply that they are not changing, but that their scopes of activities are limited. Becker (2004) in his review article on organizational routines points out that many empirical studies document routines as "recurrent interaction patterns" (e.g., Cohen and Bacdayon, 1994; Pentland and Rueter, 1994; Zellmer-Bruhn, 1999, 2003; Burns, 2000; Costello, 2000). Feldman (2000) claims that organizational routines have a potential for change even if defined as unchanging.

Search routines, the second concept, include the assessment, modification and substitution of all activities that the firm is currently performing. Search routines create probabilistically a mutation just as the mutation in biology is equivalent to innovation in economics (Nelson and Winter, 1982), innovation is a source of variation.

The selection environment of a business organization, the third concept, includes all factors affecting the expansion and contraction of the business organization for example, the supply of production factors, the demand for the product and the nature and activities of competing firms in the same industry. Selection means that inefficient firms are weeded out and exit from competition and the industry (Alchian, 1950; Teece et al., 1994b). Selection in firms occurs through the entry and exit of the market process. Traits of subset selection (Hodgson and Knudsen, 2006) can explain the nature of the selection in Korean firms. Hodgson and Knudsen define the subset selection as:

> *One cycle of environmental interaction and elimination of entities in a population, so structured that the environmental interaction causes elimination to be differential (p. 479).*

The evolutionary approach to the firm lately has focused on the process of firms' self-transformation within (Nelson and Winter, 1982;Witt, 2006). Witt (2004) argues that cognition, learning and growing knowledge play a crucial role in economic evolution, but are not given enough attention in the selection metaphor. Witt (2006) states that

> *The better firms perform, the more likely they are to grow, and the less reason they have to change their routines. The opposite holds for poor performance firms. Much as differential productive success raises the share of better adapted genes in the gene pool of a population, differential firm growth thus raises the relative frequency of better adapted routines in the 'routine pool' of the entire industry (p. 4).*

Korean firms did not recognize their mistakes until they faced the economic crisis, which made them adopt better business practices. It is often observed that losses of the firm make managers realize their mistakes and provides an impetus for corrections and changes. Therefore, loss and crisis can serve an important role of correcting mistakes in the market economy.

From this review we apply the evolutionary economics and dynamic capabilities framework to understand the Korean economic crisis. Evolutionary economics deals with the dynamic process of environmental perturbation, and firms' learning, adaptation and self-organization. Many Korean firms' competence from 1960 to the early 1990s was manufacturing. They had well-educated, young and skilled labor forces which were well-suited for manufacturing, and technological competence had been transferred from advanced economies such as the U.S., Japan and Germany. As workers' wages outpaced their productivity, however, manufacturing in labor intensive industries, such as shoes and textile manufacturing, reached its limits. The wage/productivity ratio in Korea increased significantly in the '90s and Park's study (2006b) shows that the wage/productivity ratio is an important factor for U.S. firms' global outsourcing choices. U.S. firms buy parts more from the lower wage/productivity countries.

Therefore, Korean firms needed to create new competence. Cantwell and Mudambi's work (2003) on competence-creation and competence-exploitation is useful in explaining the transition of the Korean economy. Korean firms were compelled to rely on competence-creation (Cantwell and Mudambi, 2003) to overcome the limitations of given manufacturing competence-exploitation. Kim (1999) also indicated that Korea's national innovation system, which had functioned effectively in the mature technology stage, became problematic in the subsequent stage. Despite a need for competence-creation, several chaebol groups entered into the automobile, pharmaceutical and steel industries (e.g., Samsung and Ssangyong's automobile; Jinro's pharmaceutical products Sambo and Sammie's steel refinery Hatae's electronics) in their expansions they had to depend on excessive borrowing from domestic financial institutions and foreign banks with high interest rates. Both financial capital and technical competence are resources. The Korean firms' acquisition of these resources and deployment for their diversification were not complementary to their existing technological competences expansions in a non complementary field expose the firm to additional risks (Cantwell and Fai, 1999 Cantwell and Kosmopolou, 2001; Cantwell and Mundambi, 2003).

The selection environment has been weak before the '90s because the Korean government-supported banks had made favorable low interest rate loans to large firms, and domestic markets had been protected with high tariffs and import restrictions. As the Korean government was attempting to become members of the WTO and OECD, it had to liberalize trade and capital markets. These changes created a strong selection environment, as a result many firms were dissolved and changed ownership and management. Through the economic crisis, Korean firms learned the importance of core competence and prudent investment decisions, the problems of heavy debt expansion, and the limits of manufacturing competence-exploitation.

2. The dynamic capabilities approach to the firm

There are two fundamental positions in evolutionary economics according to Dosi et al. (2000): (1) Firms have ways of doing things that show strong elements of continuity, and (2) firms have distinct ways of doing things. Dosi et al. point out that capabilities research advances evolutionary economics agenda. In capabilities research the dynamic capabilities approach emerged as a new paradigm of the modern business. The dynamic capabilities approach concerns change as evolutionary economics does. Helfat et al. (2007) argue that firms must develop the "dynamic capabilities" to survive and prosper under conditions of change. The original definition of dynamic capabilities refer to "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments."(Teece, Pisano, and Shuen, 1997, 516). Helfat et al. (2007) define a dynamic capability as the capacity of an organization to purposefully create, extend, or modify its resource base (Helfat et al., 1). The dynamic capabilities approach may also be appropriate for an analysis of the 1997 Korean firms' experiences. We, therefore, will apply evolutionary economics as well as dynamic capabilities framework to examine Korean firms' learning and innovation after the economic crisis.

III. Changes in Korean Firms after the 1997 Economic Crisis

1. The Nature of the Rapidly Changing Economic Environment

South Korea was the world's 10th largest economy in 1997, but faced economic crisis in that year. The Korean stock exchange index fell from 981 in April 1996 to 471 at the end of October, 1997 the unemployment rate rose from 2% in October, 1997, to 6.5% in June of 1998 and Korean currency, the "won," depreciated more than 100%. Many large companies went bankrupt and large chaebols lost money during the crisis. Korean exchange reserves were depleted and the Korean government received an IMF loan package of $58.35 billion in bailout, along with the IMF regime for crisis management.

The crisis was caused by a number of economic factors: financial liberalization and high interest rates (Krueger and Yoo, 2001), an incorrect mix of government-intervention with market forces (Adelman and Song, 1999), deteriorated profits (Joh, 2003), structural problems in financial and corporate sectors (Baliño and Ubide, 1999), and asymmetric information (Hahm and Mishkin, 2000). We have investigated some of these factors and added our own. We examine them from two perspectives: (1) policy and market factors; (2) business side factors. The policy and market factors are external factors and include inefficient allocation of financial resources due to government intervention; failing of government exchange rate policy; loss of market competitiveness earlier in the '90s the sudden exit of foreign capital high wages due to the strengthened labor unions outflows of business funds to politicians and opening the domestic market to comply with the WTO and OECD. The internal business side factors include heavy debt-driven business expansion pursuit of business growth without considering changes in external market conditions a business group not exiting an unprofitable business unit; a decline in business profits due to the lack of effective responses to market changes and high foreign debt dependency.

We conducted a survey to learn business leaders' perceptions of the 1997 economic crisis and how they have changed in response to the economic crisis. We created a website with a questionnaire and asked managers to answer questions. A total of 204 managers, who represent 50 large business groups (chaebols) and 154 small and medium-size firms, responded to our survey. The questionnaire was designed for respondents to rank the top three items in order of importance among the listed factors in each question. To avoid confusion in priority ranking, we did not ask respondents to rank all items in each question. The survey question regarding policy and market factors of the economic crisis was designed to learn the environmental factors of the economic crisis. Each item's weighted total score was calculated by multiplying 1X3; 2X2; 3X1. For example, 32 respondents ranked the government exchange rate policy failure as the most important reason for the crisis; 44 respondents ranked it as the second important reason and 37 respondents ranked it as the third important reason thus the total score for government exchange policy failure is 221 (32 X 3 + 44 X 2 + 37 X 1 = 221).

Table 1. Policy and Market Factors of the Crisis

Factors	Responses				
	1	2	3	Total	Rank
Inefficient allocation of financial resources due to government/business connection	96	38	33	397	1
Failure of government exchange rate policy	32	44	3	221	2
Loss of market competitiveness in the 90s	28	23	39	169	3
Sudden exit of short-term foreign capital	16	30	28	136	4
High wages due to the rigid labor market	8	16	23	79	5
Outflow of business funds to politicians	3	24	14	71	6
Opening domestic market to comply with the WTO and OECD	3	16	14	65	7
Others	5	1	1	18	8

Table 2. Business Side Factors of the Crisis

Facotrs	Responses				
	1	2	3	Total	Rank
Heavy debt-driven business expansion	96	44	27	403	1
Pursuing business growth without considering changes in external market conditions	35	69	43	286	2
Not exiting an unprofitable business unit from a business group	15	34	55	168	3
A decline in business profits due to the lack of effective response to market changes	28	19	45	167	4
High foreign debt dependency	17	25	18	119	5
Others	1	0	2	5	6

The top three factors indicated by survey respondents were (1) the inefficient allocation of financial resources by government-directed loans, (2) failure of the government exchange rate policy, and (3) the Korean economy losing market competitiveness. The top three crisis factors caused by businesses were (1) the heavy debt-driven business expansion, (2) business' pursuit of growth without considering changes in external market conditions, and (3) business groups not exiting unprofitable business units.

2. Factors Contributing to the Recovery from the Crisis

To overcome the economic crisis, policy makers, managers and entrepreneurs made reforms. The survey included questions designed to investigate the effectiveness of these market changes and government policy and business reforms. As Table 3 indicates, survey respondents ranked government-driven reforms as the most important recovery factor an increase in export competitiveness due to the depreciation of the Korean "won" and the government's public funds were rated as the second and third most important factors in overcoming the crisis. The government demand expansion was an interesting factor. The Korean government encouraged bank credit cards usage as a measure of demand expansion people began to use them on a large scale, which increased the demand for goods and services. This helped solve the problem of the lack of demand during the crisis. However, people spent money before they earned it and credit card debt consumption spending have since become a huge problem for banks.

The top three business reform factors were (1) focusing on the business core, (2) raising labor productivity by introducing rational human resource management, and (3) reduction in interest payment by lowering the corporate debt. Tables 3 and 4 provide the detailed responses of the survey respondents.

Table 3. Market and Government Policy Changes

Factors	Responses				
	1	2	3	Total	Rank
Government driven reforms	55	37	25	264	1
Depreciation in exchange rate lowered export prices and helped exports	48	32	26	234	2
Government public funds	28	26	32	168	3
Successful inducement of foreign capital	27	25	32	163	4
A fall in interest rates	14	36	36	150	5
Government's demand expansion policy	12	27	29	119	6
Others	4	2	4	20	7

Table 4. Business Reforms

Reform Measures	Responses				
	1	2	3	Total	Rank
Reductions in diversified business areas and focus on core business	52	28	35	247	1
Raising productivity by introducing rational human resource management	26	31	32	172	2
Reductions in interest payments by cutting the amount of debt	30	29	23	171	3
Reduction in production costs by increasing outsourcing	25	27	30	159	4
Use of temporary labor contracts	18	22	15	113	5
Improvements in work incentives by introducing pay for performance	11	17	15	82	6
Raising global competitiveness by developing new technologies and products	9	11	10	64	7
Raising the entrepreneurial and sense of ownership employees	6	6	15	45	8
Reductions in debt/equity ratio by increasing the equity capital	4	13	6	44	9
Others	5	1	1	18	10

IV. Learning from the Crisis and Changes Responding to the Economic Crisis

1. Learning and Changes

Korean firms made many changes in response to the crisis. Foss (1993b) points out that "the competence perspective is a story about economic organization under circumstances where inputs, outputs and technology are significantly changing" (p.141). Teece et al. (1997) emphasize rapidly changing environments in their definition of dynamic capabilities. Zollo and Winter (2002) define a dynamic capability as "a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness" (p. 340). Some common aspects of these definitions include rapidly changing environment, learning and making innovations. These elements are the main concern of evolutionary economics.

We were interested in what Korean firms have learned from their experiences and what they did with the knowledge. To manage future economic shocks, it was important for business firms to learn to deal with the 1997 economic crisis. An accumulation of such knowledge can help all business groups. Cook and Brown (1999) state that "the generative dance between knowledge and knowing is a powerful source of organizational innovation" (p. 381). A concept about knowledge and knowing can be applicable here: knowledge is acquired through learning, and knowing is a use of this knowledge or practice of knowledge (Brown and Duguid, 1991; Orlikowski, 2002; Zollo and Winter, 2002). Schendel (1996) points out that what really matters is "what the organization can do with the learning"(p. 3). Cohen (1991) makes a similar point in his review essay on individual learning and organizational routine:

> *Building and modifying the repertoire are fundamental activities because they embody learning in routines, thus constituting a major form of organizational memory. The steady refinement of that repertoire generates much of the performance improvement we see in learning curve research (p. 135).*

In the Korean crisis, knowledge learned from the crisis and experiences of the crisis could become very important resources for corporate change, innovation and sustainable firm growth. Table 5 and Table 6 reflect managers' learning and changes during the economic crisis.

Table 5. Learning Through the Crisis

Learning	Responses				
	1	2	3	Total	Rank
Importance of managers'awareness and adaptabilities to changes in market conditions	59	58	47	340	1
Importance of corporate core competency and capability	54	45	48	300	2
Importance of managers' investment decisions	37	44	42	241	3
Importance of principles in corporate management	29	26	29	168	4
Importance of R & D for technology innovation	8	13	71	121	5
Others	1	1	0	5	6

Table 6. Corporate Changes after the 1997 Economic Crisis

Changes	Responses				
	1	2	3	Total	Rank
Increasedawareness of the importance of corporate competitiveness at all levels of employees	52	37	36	266	1
Greater capability for crisis management	28	32	32	180	2
Better preparation to deal with future crisis through crisis management strategy	20	42	33	177	3
Routinization of crisis management	34	19	19	159	4
Introduction of new management techniques	15	25	25	120	5
Increased corporate competitiveness	19	20	22	119	6
Increased capability of new product development	19	12	1	92	7
Others	1	0	2	5	8

Respondents to the survey ranked the importance of managers' awareness and adaptabilities to changes in market conditions at the top. They also learned the importance of corporate core competency and capability, as well as the importance of managers' investment decisions, understanding of corporate management principles and R & D for technology innovation, as Tables 5 and 6 illustrate. Although the total score for the importance of R & D for technology innovation is only 121, ranking it fifth, 71 respondents ranked it as their third most important category, showing that many respondents learned the importance of the new competence-creation (Cantwell and Mudumbi, 2003). The results in Table 6 also indicate that the learning of Korean entrepreneurs and managers did increase from the crisis and they used the acquired knowledge in their organizational changes.

2. Adoption of New Business Practices

We were interested in knowing what business practices Korean business firms adopted after they experienced and learned from the economic crisis. We asked them to select three items that the company put into practice, in order of importance. Results of this survey question are shown in Table 7. Most Korean firms are diversified business groups that realize the importance of core capabilities and core competency. Respondents rated emphasis on development and improvement in core capabilities and core competency as the most important business practice. Establishment and implementation of business strategy and structural reform in human resources management was the second, followed by important business practices adopted. Increasing brand reputation by improvement in product quality and development of new products have also become very important, along with globalization, for large chaebols such as Samsung, Hyundai, LG, SK and POSCO. These groups' introduction of new products and advertising campaigns have become increasingly visible as brand names recognized worldwide today.

Table 7: Adoption of Business Practices

Practices	Responses				
	1	2	3	Total	Rank
Emphasis on development and improvement in core capability and competency	65	38	28	299	1
Establishment, implementation and routinization of business strategy	37	32	38	213	2
Structural reform in human resources management	28	34	33	185	3
Adoption of debt reduction strategy	24	24	16	136	4
Emphasis on acquisition and development of human resources	15	26	27	124	5
Establishing strategies to raise brand reputation by improvement in product quality and development of new products	13	23	33	118	6
Increased globalization	4	7	8	34	7
Others	1	1	1	6	8

V. Evidence Supporting Survey Results

Questions are often raised regarding the validity of survey based research results. Do we have other evidence supporting survey results? Though it is difficult to provide concrete empirical evidence supporting survey results, we will attempt to provide several selected pieces of such evidence, with a risk of selection bias.

Heavy debt driven business expansion was reported as the top rated business side factor of the crisis, while cutting the amount of debt ranked high among business reform measures in survey responses. To improve performance of assets, businesses made reforms in human resource management, parts outsourcing, labor contracts, work incentives, technologies and the entrepreneurial mind set of employees. Financial data reported by the Korean Fair Trade Commission provides supporting evidence of four important changes that occurred in capital structure and in asset performance.

First, we examined financial data on capital structure. Korean firms had financed their business expansions using mainly debt financing. This high debt/equity structure contrasts with the U.S. capital structure, known for its low debt/equity ratio, due to professional managers with small ownership stake (Jensen, 1986). The average debt/equity ratio of the top 35 U.S. manufacturing firms in 2001 was 0.9107 (source: authors' estimation based on 2001 corporate balance sheets) the overall U.S. debt/equity ratio during the '90s was 1.50 (Balaño and Ubide, 1999). The Korean firms, in contrast, tended to utilize debt financing for two main reasons: (1) firms were managed by owner-managers with a strong incentive to protect their ownership and control by maintaining high equity shares (Park and Shin, 2004b) (2) during the government-led economic development, the Korean government had supported large firms with loans below the market interest rate. The debt/equity ratio of most chaebols (business groups) exceeded 400 percent during the '90s (Balaño and Ubide, 1999) when the 1997 Korean economic crisis caused negative profits for Korean firms, this heavy debt led to bankruptcies for many large chaebols. Consequently they recognized that they needed to make adjustments in capital structure, and the survey results reflect these adjustments. The actual debt/equity ratio has declined annually since 2000 from 2.187 in 2000, it was down to 1.077 in 2004 (see Table 8).

Table 8: The average debt/equity ratio of large Korean Chaebols since 2000

Year	1996	2000	2001	2002	2003	2004
Net Profit (billion won)	6315	-16,148	2,115	11,572	28,018	32,686
Debt/Equity Ratio	2.509	2.187	1.712	1.312	1.164	1.077

Source: Calculated by authors based on Korean Fair Trade Commission's financial data on Korean Chaebols published on the FTC website.

As Table 8 shows, Korean firms began paying off their debts as they began to realize net profits, providing supporting evidence for survey results regarding debt reduction. This trend can be interpreted as Korean firms' optimizing capital structure, or as overly cautious investment behavior due to their experiences in the crisis. Overly cautious investments may result in losing a competitive edge in the future. However, when debt-financed investment in R & D is successful in new product and process development, it makes companies competitive. Since firm's R & D creates novelty and variation for selection, both GE in the U.S. and Samsung in Korea maintain relatively high debt/equity ratios compared to other firms because of their large R & D investments.

A second reform measure taken by Korean firms was managers' entrepreneurial actions. Managers adopted new business practices in core competency, business strategy, structural reform, acquisition and development of human resources, quality improvement and new product development. These measures should contribute to improvement in return on assets and can be analyzed from the dynamic capabilities perspective, which offers an analytical framework to capture changing environment and corporate adaptation to a changing environment.

Though there are many business firms in Korea, the Fair Trade Commission (FTC) in Korea closely monitors government designated chaebols (30 or 50 large business groups), making more financial data available for these business groups. Thus we include only these chaebols for our analysis here (see Appendix C and D). However, survey respondents consisted of both the government designated business groups as well as other business groups not included in FTC data.

We conducted a paired t-test to find changes in sales/assets ratio for dissolved or exited business groups, to find the traits of selection.

H0: $\mu 1 = \mu 2$

H1: $\mu 1 \neq \mu 2$

Where $\mu 1$ = the sales/assets ratio of two years prior to business groups' dissolvement or exit, and $\mu 2$ = the sales/asset ratio for one year prior to business groups' dissolvement or exit.

T-test Results[1]
Business groups dissolved or exited in 1997 and 1998:
t = -2.52 (0.065)
Business groups dissolved or exited in 2000, 2001 and 2002:
t = 3.45 (0.007)
*Numbers in parentheses are p-values.

We found that the business groups dissolved or exited in 1997 and 1998 had actually improved sales/assets ratio one year prior to their exits, but both Sammie and Hanbo (steel companies) had extremely high debt/equity ratios of 8.77 and 5.86, respectively. Kia automobile group had a relatively low debt/equity ratio of 1.48; Kia's problem was labor costs; it had losses in 1996 and 1997 and could not pay high interest. However, the sales/asset ratios of business groups dissolved or exited in 2000, 2001 and 2002 had significantly deteriorated one year prior to their exits.

Those groups which exited in 2000, 2001 and 2002 expanded into new businesses which were not complementary to their core competencies. For example, Ssangyong's main business was construction cement production and they ventured into the automobile business. Jinro's core competency was a distillery business and they went into the pharmaceutical field. Thus the data suggest that the selection took place in those chaebols with high debts which had expanded into unrelated industries. They might have survived under a domestic capital market with weak selection environment however, the capital market liberalization that resulted from the WTO and OECD memberships made the selection environment strong, and those firms were not able to survive despite a massive rescue attempt by the government. Korean firms learned from the traits of selection, and the learning made them realize the importance of core competence and competence-creation.

Third, evidence for dynamic capabilities can be found from the performance of Korean firms after the crisis. Corporate reform measures after the crisis should have contributed to improvement in efficiency of the firms and development of new processes and products. Table 9 shows that the average return on assets (ROA) of chaebol groups deteriorated during the crisis, but has been improving since 2000. These results suggest the value of reform measures.

Table 9: Average return on asset of large business groups

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total Assets (billion won)	286924	330304	42626	463569	412947	41928	590401	622953	669733
Total Sales (billion won)	31996	349123	406545	435209	403724	457010	510153	557823	519882
Total Net Profits (billion won)	6315	477	-3187	-19547	-16148	2115	11572	28018	32686
Total Liabilities (billion won)	205170	199836	270448	277523	28337	265083	324779	335021	347301
Return on Assets (%)	2.20	.17	-.75	-4.22	-3.91	.50	1.96	4.50	4.88
Number of Chaebol Groups	30	30	30	30	30	30	43	49	51

Source: Korean Fair Trade Commission. Return on assets (ROA) was estimated by authors.

Fourth, R & D spending for new product and process innovation by leading chaebols such as Samsung, LG, Hyundai, SK and POSCO provides evidence of competence-creation (Cantwell and Mudambi, 2003). Korean firms learned the importance of core competence from the crisis and have focused on increasing competence-creation. Samsung spent $5,428 million on R & D in 2005, ranking 11th among global R & D spenders (Jaruzelski et al., 2006). Samsung, very successful with new technology development in television and memory chips, has become an industry leader. POSCO (iron refinery business) spent $220 million in 2005 (Jaruzelski et al., 2006) and is known as a well-managed innovating firm. POSCO reportedly succeeded in the FINEX refinery process as the first among iron refinery companies in the world (The Central Daily News, May 31, 2007). This new FINEX refinery process will cut production costs by 15 percent and reduce environmental contamination more than 90 percent. POSCO invested over 1.6 billion dollars in the FINEX project and plans to use this new competence for its refinery construction expansion in Vietnam and India. LG's home appliances have increased global market shares. Hyundai automobile's aggressive globalization was noticed by world automobile producers and consumers, as the company improved quality and built factories in the U.S., India, China and Europe. SK, a dominant oil refinery in Korea, is expanding to other countries. These examples illustrate the competence-creation and globalization of Korean firms.

VI. Discussion

From this theoretical framework and the survey results, we can examine changes in business environment, traits of selection, business firms' learning and innovations in business practices.

1. Changes in Business Environment

Survey responses on policy and market factors of the 1997 crisis are interesting. They confirm the governance study findings (Joh, 2001b, 2003). The Korean government had pursued economic growth and relied on large chaebols from 1960 to 1997. The government-led financial resource allocation favored large business groups, and corporate governance was not well designed to monitor performance of these financial resources.

It is also widely reported that the Korean government maintained the overvalued currency and high interest rates (Adelman and Song, 1999). In tandem with these policies, the Korean government liberalized capital markets in preparation for Korea's joining the OECD. The overvalued currency helped accomplish $10,000 per capita income, a sought after policy goal, but it also contributed to trade deficits that built pressures for currency devaluation. High interest rates attracted a large volume of short-term foreign capital to Korea, building up foreign debts. Adelman and Song (1988) argue that

> *Two of Korea's major policy mistakes were in trying to have an exchange rate policy which was out of alignment with its purchasing power parity and an interest rate which was out of alignment with world interest rates while having largely liberalized its capital flows (p.19).*

As the bank of Korea attempted to maintain its overvalued currency, foreign exchange reserves were exhausted and the outflows of short-term capital contributed to the Korean financial crisis. The survey results confirmed these policy mistakes.

Furthermore, the Korean economy lost market competitiveness in manufacturing as low cost manufacturing firms in China and other emerging economies began to have cost advantages over Korean firms. Korean firms also did not develop high-tech products in the early '90s. Therefore, profits of business groups in Korea deteriorated. The over-valued Korean currency contributed to the Korean trade deficits and the trade-dependent Korean chaebols' profits declined. The over-valued Korean "won" and declining foreign exchange reserves of the bank of Korea offered an opportunity for speculative foreign capital to take advantage of the situation. For example, increases in stock price and appreciation of the Korean "won" after the crisis provided opportunities for smart investors to earn large capital gains. Prices of stocks bought during the crisis subsequently appreciated about 300% and the Korean "won" appreciated almost 100%. This increase in stock prices and Korean currency appreciation made investors in Korean stocks realize more than 400% in capital gains in 2006.

Responses to factors of the crisis within business firms illustrate how inefficient financial resource selection and ineffective deployment of financial resources by business groups, accompanied by heavy debt-driven business expansion, were the prime factors that contributed to the crisis. The business groups' growth-driven orientation, without considering changes in external market conditions, along with a decline in business profits due to the lack of effective responses to market changes, are deemed to be contributing factors to the crisis.

2. Government and Business Reforms

Government driven reforms were the most effective factor in overcoming the crisis, according to the survey. The 1997 economic crisis led to a steep depreciation in the exchange rate, which the Korean government tried to prevent. Ironically, the depreciation of the Korean "won" helped business firms, because the Korean economy was relying heavily on foreign trade, and the depreciation of the Korean "won" reduced Korean export prices by more than half. As Korean firms increased exports, Korea realized trade surpluses.

Business firms also implemented reform measures: (1) reductions in diversification and a focus on core business, (2) increased productivity by introducing rational human resource management, (3) reduction in interest payments by cutting the amount of debt and (4) reduction in production costs by increased outsourcing. Reductions in diversified business fields and focus on the core business may offer a direction of change for the diversified Korean chaebols, confirming the assertion of Teece, et al. (1994a) that the boundaries of the corporation are likely to be drawn close in to core competencies as the selection environment becomes tighter (p 22). Some chaebols became several business units. For example, Hyundai was split into several units after the death of the founder, and five units of the former Hyundai group are listed in the top 50 Korean business groups today. Daewoo group was dissolved after the 1997 economic crisis and became several independent single firms (Central Daily News: June 15, 2005) four units of the former Daewoo group now belong to the top 50 business groups in Korea. Currently Hyundai and Daewoo are performing relatively well (see Appendix E).

The survey question on corporate changes investigated what changes were made to specifically deal with the 1997 crisis and future crises. Increased awareness of the importance of corporate competitiveness received the largest response increased capability of crisis management, better preparation to deal with future crises through crisis management strategy and routinization of crisis management were all important changes in response to the crisis. The routinization of crisis management received the second largest number 1 response from survey respondents this may indicate that business firms have been establishing new routines through the process of search routines. Increased awareness of the importance of corporate competitiveness can provide an impetus for changes and reforms, as we saw in U.S. corporations in the 1980s. U.S. management improvement is known as one of the contributing factors to the 1990 economic expansion.

3. Traits of Firms not Selected to Survive

Firms select financial and human resources. Superior selection creates rents, and performance of firms depends on resource selection and deployment. This paper examined the performance of the assets of chaebols. The performance of assets between the continued and exited businesses are significantly different among business groups. The average sales/asset ratio for the continued business groups since 1997 is 1.08, whereas the average sales/asset ratio for the exited business groups is .70[2]. There is a statistically significant difference in the sales/asset ratio between two years before and one year before the business groups' exit. Business groups that collapsed in 1997 and 1998 experienced improvements in sales/asset ratios, whereas business groups that exited in 2000, 2001 and 2002 experienced a significant deterioration of sales/asset ratios one year prior to their exits, compared to two years before the exits; they also showed large net losses.

Many large business firms were dissolved or exited during the Korean economic crisis(see list in Appendix A). Daewoo was the 4th largest in terms of assets in 1997. Assets and rankings of other defaulted chaebols are as follows:

Business Group	# of business units	Total Assets (billion won)	Rank
Daewoo	30	34,240	4
Ssangyoung	25	15,802	6
Kia	28	14,202	8
Hanbo	21	5,147	14
Dongah	16	5,117	15
Hanra	17	4,766	16
Jinro	14	3,946	19
Gohap	11	3,653	21
Haetae	14	3,398	24
Newcore	18	2,798	25
Anam	21	2,638	26
Hanil	7	2,599	27
Sammie	8	2,475	28
Gupyung	22	2,296	29
Shinho	25	2,139	30
*Saehan	16	2,659	30 (1998)

*Saehan's rank in 1998. All other groups' ranks are in 1997.

Korean chaebols' experiences after loan defaults made them realize the importance of business core competency and business strategy, confirming Teece et al. (1994a). Sixteen chaebols out of the top 30 were dissolved; they included 293 business units. According to Adelman and Song (1999), over 10,000 firms defaulted on loan payments between December 1997 and December 1998.

Causes of the demise of these chaebols can be traced to dynamic capabilities of these groups. The groups which improved sales/asset ratios before they were dissolved or exited were likely to have problems in resource selection and deployment. These firms expanded their businesses with high debt. These groups include Hanbo, Sammie, Kia and Daewoo. Business groups such as Hanra, Haetae, Jinro and Ssangyong diversified to areas in which they did not have competencies. Although Samsung managed to overcome the difficulties faced in venturing into the automobile business, it had to sell off the automobile division to French automobile company Renault. After Renault automobile company took over Samsung's automobile division, it became Renault-Samsung. Renault today has a major stake in Nissan automobile, from which Samsung has acquired automobile technology. The company is currently managed by a CEO from Renault and reported to have profits now. Anam, Shinho and Gohap did not foresee that their product markets were shifting mis deployment of resources and ignorance of market shifts led to poor asset performance. Their losses were very large and their experiences provide evidence for resource-based views of the firm and the evolutionary theory of the firm.

These results may also indicate that the selection environment (Nelson and Winter, 1980, 1982) changed from a weak selection environment to a strong selection environment in both input and output markets. Input markets for labor and financial resources adversely affected business groups. As the labor movement gathered strength in the '90s, the financial market became more competitive and market-oriented, rather than relying on government-led loans which were prevalent before 1990 (Joh, 2001a, 2001b; Yoo, 1999). Output markets and capital markets were more open to the world market due to the WTO and OECD. Business groups whose resources were not well deployed were not able to survive in strong selection environment, and collapsed business groups'resources and assets were transferred to new owners and managers. However, firms that do not survive do not completely disappear; their facilities and capabilities are transferred to new owners and managers and most dissolved chaebols are doing relatively well now with new owners and managers.

4. Business Firms' Learning from Crisis

Organizational learning is the key element for organizational reform and knowledge-creation (Nonaka, 1994; Nonaka and Takeuchi, 1995; Grant, 1996; Barney, 1986; Rummelt, 1984; Spender, 1996). Business firms change business practices based on their learning through economic crisis thus crisis increases the intensity of organizational learning (Kim, 1998). Thus business leaders' and employees' learning is very important. As noted by Nelson and Winter (1980, 1982), their learning and experiences are real and should be treated differently from the hypothesis or theory. Such learning includes (1) the importance of managers' awareness and adaptabilities to changes in market conditions, (2) the importance of corporate core competency and capability, (3) the importance of managers' investment decisions, (4) the importance of principles in corporate management, and (5) the importance of research and development for technology innovation.

5. Subsequent Innovations in Business Practices

Korean business firms learned the importance of business core competency and business strategy as they had to deal with problems associated with diversified businesses, high debt and labor costs. Their business strategy focused on novelty creation and improvement of core competency intentional actions addressed problems of high debts, low productivity and competence-creation reflected strategic management (Rubin, 1973 Rumelt, 1984). Firms adapted, integrated and reconfigured internal and external organizational skills, resources and functional competencies to match the requirements of a changing environment, as the dynamic capabilities approach advocates.

Witt (2004) points out that novelty is usually identified with new possibilities of action which, once taken, are called innovation (p. 130). Korean firms took various new actions and adopted new business practices. These actions can be regarded as innovation. One such action, the structural reform in human resources, boils down to reduction in labor costs by increasing labor productivity through changes in employment practices, as Korean firms changed from a seniority-based system to a pay for performance system, adopting bonus systems and stock options based on employee performance. They recognized the importance of securing superior human resources and placed emphasis on the development and improvement of human resources. Korean firms also adopted a two-tier labor employment system by separating the regular and non-regular employees wages and benefits of non-regular employees are much lower than for regular employees, and the non-regular employees' jobs are not secured, as the regular employees' jobs are. Furthermore Korean firms increased equity financing to reduce their outstanding debts and used retained earnings for debt reduction encouraged by the government as well as by their experiences of the economic crisis. Park (2006) found that Korean firms adopted numerous such efficiency enhancing and quality improving business practices after the economic crisis.

These new measures adopted by Korean firms are responses that are outside of the range of existing practice. Schumpeter (1947) refers this kind of response as a "creative response." Entrepreneurs' creative responses are their adaptation to chaotic economic shock and their responses appear to show a global spontaneous order which enhanced efficiency; improved quality; changed organizational structure and created new competences. Korean firms' capacity to react to environmental shock and the global order resulted from those reactions reveal self-organizational characteristics of Korean firms (Heylighen, 2007 Kaufman, 1993; Prigogine and Stengers, 1984). Survey results appear to support that Korean firms have complex adaptive systems and have become autopoietic to sustain their survival (Matura and Varela, 1980; Varela, 1979).

The entrepreneur in the evolutionary theory of the firm is a processor of knowledge (Fransman, 1984) and an innovator of product, process and organization (Nelson and Winter, 1982; Schumpeter, 1934). Survey results show that entrepreneurs in Korean firms during the economic crisis performed the roles of entrepreneur in evolutionary theory of the firm. Korean firms' capabilities in learning from the crisis and making innovations in business practices can become their competences and coherent sets of knowledge acquired through the experiences of the crisis may constitute sources of the Korean firms' competitiveness. Therefore, entrepreneurs and policy makers in Korea need to harness their acquired competences and comprehensive sets of knowledge in dealing with the crisis for their competitive advantage.

VII. Summary and Conclusion

Before the crisis, the selection environment was weak; global openings in input and output markets made the selection environment much stronger. Despite these changes, business firms ventured into fields where they did not have core capability and which were not complementary to their cores. Those firms which did not have foresight on changes in the product and factor markets were not able to adapt to the changing environment.

There is an indication that some Korean firms' poor resource selection skills and resource deployment (e.g., Daewoo and Jinro) led to declines in their asset performances, which could have been one source of the crisis. Korean firms' high debt dependency for their expansion might have stemmed from government-led loans to large business groups and business firms' routines were established to adapt to these weak selection environments and rent seeking opportunities. Consequently, as business firms faced a strong selection environment with global market openings in outputs and production factors, particularly in capital market liberalization, some of the ill-prepared business firms were dissolved.

Traits of the firms that did not survive during the crisis provide useful information and guidance for changes. Traits of subset selection (Hodgson and Knudsen, 2006) include (1) expansion in new business fields with large debts, (2) new business expansions to noncore or noncomplementary field, and (3) ignorance of market changes in products. Through experiences in a radically changing business environment and traits of subset selection, Korean firms' managers/entrepreneurs learned the importance of awareness and adaptabilities to changes in market conditions, corporate core competence, investment decision making, principles in corporate management and R & D for technology innovation and competence-creation.

Korean firms reified their learning by adopting new competence-creation processes, routinizing business strategy, reforming human resource management, reducing debts, and increasing brand reputation and globalization. These changes made Korean firms more flexible and adaptable to a radically changing selection environment. Business firms that survived are now better prepared for changes in selection environments, as the evolutionary approach to the firm asserts (Nelson and Winter, 1982). Several firms in Korea, such as Samsung, LG, Hyundai, SK and POSCO, have gained competitive advantages in their core products and are competing well in the global market. This evidence confirms Witt's argument (2004) that cognition, learning and growing knowledge of the economic crisis and traits of selection (Hodgson and Knudsen, 2006) have played an important role for innovation in Korean firms.

Based on these findings, we conclude that the evolutionary economics approach to the firm offers a good theoretical framework for understanding the process of a firm's learning, innovating business practices in a rapidly changing economic environment and improving firm performances. Korean firms increased knowledge by learning from the crisis and using the knowledge for competence-creation and better exploitation of their given competence. They began to emphasize competence-creation and improvement in core capability and competency. We found that increased global market openings helped Korean firms make transformations in business practices, and as a result they are more competitive today than before the crisis. Thus Korean firms acquired corporate dynamic capabilities which can be sources of sustainable competitive advantages in the future. However, maintaining dynamic capabilities, continuously accumulating learning and making innovations remain challenges for Korean firms, since the urgency of continuous change and experiences in the hardship of the crisis are difficult to maintain, and competing firms in the global market are likely to enact their own dynamic capabilities. The selection environment continues to be stronger in the increasing competition, and firms in the global economy are likely to face various changing selection environments in the future. It is, therefore, essential to strengthen dynamic capabilities of the firm for an enduring competitive advantage.

Notes:

[1]t-scores are estimated by the following test statistic:

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\dfrac{S_p^2}{n_2} + \dfrac{S_p^2}{n_2}}}$$

[2]In 1987 the Korean government designated 30 of the largest chaebols to closely monitor. Some chaebols continue to be in the designated group and some are out of the designated group. Fourteen chaebols listed in Appendix D are in the designated chaebol groups. Currently the group includes the 50 largest chaebols.

Appendix A. Financial Data for Dissolved or Exited Business Groups Since 1997

(Unit : Billion Won)

Year of Dissolved or Exited	Business Group	Assets					Sales				
1997	Year	1992	1993	1994	1995	1996	1992	1993	1994	1995	1996
	Hanbo	--	--	1,628	3,013	5,147	--	--	607	1,312	2,990
	Sammie	2,298	2,202	2,265	2,245	2,475	1,405	1,306	1,357	1,242	1,720
	Kia	5,884	6,959	8,533	9,814	11,427	4,687	5,338	6,282	7,277	9,377
1998	Year	1993	1994	1995	1996	1997	1993	1994	1995	1996	1997
	Hanil	2,747	2,717	2,559	2,180	2,599	1,148	1,137	1,240	1,195	1,277
	Newcore	--	--	--	1,966	2,798	--	--	--	1,297	2,278
	Gupyung	--	--	--	--	2,477	--	--	--	--	1,387
2000	Year	1995	1996	1997	1998	1999	1995	1996	1997	1998	1999
	Dongah	3,874	5,117	6,458	9,054	8,717	4,203	6,471	5,416	6,015	5,128
	Hanra	3,429	4,766	6,640	8,562	5,535	3,027	4,156	5,297	6,163	3,447
	Haetae	2,358	2,873	3,398	3,747	3,977	2,175	2,592	2,715	3,259	2,657
	Shinho	--	--	2,158	3,060	2,701	--	--	1,222	1,938	1,211
	Daewoo	26,144	31,313	35,455	52,994	78,168	20,557	29,413	38,620	50,183	62,794
2001	Year	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
	Anam	--	2,659	4,339	4,097	3,073	--	1,995	2,463	2,964	1,499
	Saehan	--	--	2,659	3,513	3,052	--	--	1,603	1,866	1,753
	Jinro	3,303	3,951	4,258	4,098	2,915	1,239	1,391	1,618	1,170	971
2002	Year	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
	Gohap	3,690	5,193	5,232	3,711	2,501	2,563	3,304	1,695	1,002	-1,289
	Ssangyong	16,457	15,645	14,167	9,749	9,039	20,156	21,770	18,296	11,072	-1,464

Source: The Fair Trade Commission

Appendix B. Financial Data for Continued Business Groups Since 1987 Business Group Designation

Business Group	Assets					Sales				
	1987	1990	1995	2000	2005	1987	1990	1995	2000	2005
Samsung	5,588	10,438	29,414	67,384	107,617	13,565	22,165	51,830	108,827	139,175
LG	5,508	11,186	24,351	47,612	50,880	9,181	13,467	29,570	62,016	63,116
SK	2,499	4,610	12,806	40,147	47,961	5,323	6,087	14,657	38,039	56,137
Hanjin	2,626	4,721	10,629	20,771	24,523	2,194	2,872	7,653	13,198	17.078
Lotte	1,648	3,215	6,628	15,791	30,302	1,627	2,833	6,303	10,191	26,615
Hanwha	1,796	3,033	7,282	11,430	16,219	1,971	2,354	5,579	6,091	20,555
Hyundai	8,038	14,279	37,221	88,649	6,072	11,893	17,348	47,001	95,047	6,840
Kumho	702	1,731	5,374	11,532	11,413	388	990	2,491	7,360	9,889
Doosan	1,073	1,799	4,808	7,646	9,734	1,401	1,732	3,671	3,656	7,179
Dongbu	692	1,191	2,128	5,331	8,171	1,025	1,673	3,377	5,530	9,054
Hyosung	1,002	1,754	3,040	5,716	4,772	1,513	2,363	4,163	3,847	5,570
Daelim	1,777	2,408	4,638	5,674	5,686	1,440	1,376	3,074	5,675	7,354
Kolon	713	1,269	2,535	4,616	4,426	1,020	1,529	3,206	3,995	4,547
Dongguk Refinery	916	1,411	3,237	5,903	5,795	1,152	1,381	3,052	4,129	4,858
Total	34,578	63,045	154,091	338,202	333,571	53,693	78,170	185,627	367,601	377,967
Total (without Hyndae)	26,540	48,766	116,870	249,553	327,499	41,800	60,822	138,626	272,554	371,127

Source: The Fair Trade Commission

Appendix C. Sales/ Asset Ratio for Dissolved or Exited Business Groups Since 1997

Year in dissolved or exited	Business Group					
1997	Year	**1992**	**1993**	**1994**	**1995**	**1996**
	Hanbo	--	--	.37	.43	.58
	Sammi	.61	.59	.60	.55	.69
	Kia	.80	.76	.77	.73	.82
1998	Year	**1993**	**1994**	**1995**	**1996**	**1997**
	Hanil	.41	.42	.48	.54	.49
	New Core	--	--	--	.65	.81
	Gupyung	--	--	--	--	.56
2000	Year	**1995**	**1996**	**1997**	**1998**	**1999**
	Dongah	1.08	1.26	.83	.66	.58
	Hanna	.88	.87	.80	.72	.62
	Haetae	.92	.90	.78	.86	.66
	Shinho	--	--	.57	.63	.44
	Daewoo	.78	.93	1.09	.95	.80
2001	Year	**1996**	**1997**	**1998**	**1999**	**2000**
	Ahnam	--	.75	.56	.72	.48
	Saehan	--	--	.60	.53	.57
	Jinro	.37	.35	.38	.28	.33
2002	Year	**1997**	**1998**	**1999**	**2000**	**2001**
	Gohab	.69	.63	.32	.27	-.51
	Ssangyong	1.22	1.39	1.29	1.13	-.16

Appendix D. Sales/ Asset Ratio for Continued Business Groups Since 1987 Business Group Designation

Business Group	Year				
	1987	1990	1995	2000	2005
Samsung	2.42	2.12	1.76	1.36	1.29
LG	1.66	1.20	1.21	1.30	1.24
SK	2.13	1.32	1.14	.94	1.17
Hanjin	.83	.61	.72	.63	.69
Lotte	.99	.88	.95	.64	.87
Hanwha	1.10	.77	.77	.53	1.27
Hyundai	1.47	1.21	1.26	1.07	1.12
Kumho	.55	.57	.46	.63	.86
Doosan	1.31	.96	.76	.47	.73
Dongbu	1.48	1.40	1.58	1.04	1.11
Hyosung	1.51	1.34	1.37	.67	1.16
Daelim	.81	.57	.66	1.00	1.29
Kolong	1.43	1.20	1.26	.87	1.03
Dongguk Refinery	1.26	.98	.94	.70	.84
Total	1.55	1.24	1.20	1.09	1.13

Appendix E. 2004 Korea Business Group Assets, Sales, Net Profits, ROA and Sales/ Assets Ratio

Business Group		Assets (billion won)	Sales (billion won)	Profits (billion won)	Sales/Assets	ROA Profit/Assets
1.	Samsung	191,072	120,998	7,418	.63	0.039
2.	LG	65,915	70,940	3,557	1.08	0.054
3.	Hyundai Automobile	62,263	56,610	2,797	.91	0.045
4.	SK	50,717	49,847	3,845	.98	0.076
5.	KT	28,295	17,483	1,207	.62	0.043
6.	Hanjin	27,594	16,770	121	.61	0.004
7.	Lotte	26,453	17,417	1,219	.66	0.046
8.	Posco	22,058	19,517	2,103	.88	0.095
9.	Hanwha	42,474	19,511	1,211	.46	0.029
10.	Korea Land Corporation	14,943	4,603	450	.31	0.030
11.	Hyundai Heavy Industry	14,267	10,611	217	.74	0.015
12.	Kumho Asiana	13,945	8,433	55	.60	0.004
13.	Korea Gas	9,700	8,284	290	.85	0.030
14.	Doosan	9,192	6,621	54	.72	0.006
15.	Dongbu	12,143	7,846	-108	.65	-0.009
16.	Hyundai	8,459	5,483	-111	.65	-0.013
17.	Daewoo Construction	5,511	4,319	160	.78	0.029
18.	Shinsege	5,220	7,191	373	1.38	0.072
19.	LG Electric Cable	5,056	7,344	126	1.45	0.025
20.	CJ	5,174	5,634	224	1.09	0.043
21.	Dongyang	13,438	3,784	-81	.28	-0.006
22.	Daelim	4,807	5,682	299	1.18	0.062
23.	Hyosung	5,027	4,926	60	.98	0.012
24.	Dongguk	4,736	3,576	156	.76	0.033
25.	Kolong	4,668	4,194	-137	.90	-0.029
26.	GM Daewoo	4,605	4,317	-223	.94	0.048
27.	KT&G	4,370	5,728	527	1.31	0.121
28.	Daewoo Shipbuilding & Marine	3,967	4,338	255	1.09	0.064
29.	Hyundai Department Store	3,647	2,674	198	.73	0.054
30.	KCC	3,419	2,452	240	.72	0.070
31.	Hanaro Communication	3,402	1,437	-169	.42	-0.049
32.	Hansol	3,474	2,515	-132	.72	-0.038
33.	Dongwon	4,634	1,747	123	.38	0.027
34.	Korea Electric Cable	3,073	1,643	87	.53	0.028
35.	Seah	2,955	2,260	159	.76	0.054
36.	Youngpoong	2,885	2,850	31	.99	0.011
37.	Hyundai Development	2,784	3,080	219	1.11	0.079
38.	Taekwang	6,775	3,359	-31	.49	-0.005
39.	Daewoo Auto	2,631	289	67	.11	0.026
40.	Booyoung	2,453	595	11	.24	0.005
41.	Nongshim	2,369	2,669	233	1.13	0.098
42.	Height Beer	2,329	995	100	.43	0.043
43.	Daesung	2,325	2,376	81	1.02	0.035
44.	Dongyang Chemical	2,287	2,270	79	.99	0.035
45.	Moonwha Broadcasting	2,179	1,342	146	.62	0.067
46.	Korea Tire	2,095	2,008	104	.96	0.050
47.	Sam Yang	2,033	2,140	96	1.05	0.047
Total		870,206	586,924	32,291	.67	0.037

Source: The Fair Trade Commission

Sales/assets and profit/assets ratios are estimated by the authors.

Acknowledgements

I would like to express my appreciation to the Fulbright Foundation, Korea Economic Research Institute (KERI) and Saginaw Valley State University for their financial support for this research.

I wish to express my appreciation to my colleague, Professor Diane Boehm, for her tireless editorial help.

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Comment on "Economic Crisis, Learning and Innovation in Korean Firms"

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1. Methodological issue

The review of literature in the paper clearly shows that the evolutionary approach has different, and advantageous, value to view the economic issues. Yet the evolutionary approach does not necessarily exclude the value of mainstream approach, neoclassical economic theory. These two are complementary: evolutionary approach would offer better understanding of some economic issues, whereas neoclassical theory in other ones. In this regard, the paper is valuable in offering, unconventional interpretation of the Korea's economic crisis. Most of publication does ground upon the conventional approach, but this paper tries to give different interpretation and understanding of the nature and impacts of the Korea's economic crisis. In particular, the focus on the firms as the main actors of the crisis is a valuable contribution.

Despite the merits including the main methodological framework, the paper is rather weak in making convincible supportive arguments and evidences. The empirics of the paper are mostly based on an opinion survey and simple summary table thereof. There is a big gap between the theoretical arguments (the first half of the paper reviewing theories) and the empirical supports (the remaining part of the paper dealing with the Korea's economic crisis and firm's responses/changes).I would conceive that this paper is a part of a bigger project composed of several papers. References contain several papers of the author and his colleague about similar, closely related issues. But I think academic paper need be at least self-contained as a single independent one.

The paper offers evolutionary interpretations of the survey results. But the survey results do not exclude neoclassical interpretation. For example, "emphasis on development and improvement in core capability and competency"in Table 7 can be the result of adaptation to the changed environment (an evolutionary interpretation); but it can also be the result of, say, the profit-maximization of the firm, since the changed environment require to change the firm strategy as this way (a neoclassical interpretation).

To add more convincing evidences (for example, case study on the behavioral changes in the Korean firms, which are not able to understand from the neoclassical perspective) is one way to fill the gap between the theory part and empirical part in the paper.

2. Trend/period characterization or distinction

The Korean economy has made rapid, successful economic growth over very short period. Because of this and other factors, periodic characteristics are much different. Roughly speaking, 1960s, 1970s, 1980s, and 1990s are all distinctive in industrial structures and economic development strategies, for example. Of course, today is continuous to yesterday; but periodic delineation frequently offers better picture of the "forestry."

To what extent does the changes reported in the opinion survey in the paper attribute to the behavioral changes, and to what extent to the "zeitgeist"?

A contrary interpretation of the changes in the behavior would be: the environmental changes made after the financial crisis forced the Korean firms to put higher priority over, say, core competence and R&D. Itis very natural response of the firm that tries to survive and maximize even short-term profits.

Hence we need to offer more explicit treatment on the relationship between environmental factors and firm's response. The paper made slight touch on this issue.

3. Avoiding selection bias

The paper does not give clear description on the managers who were surveyed. The surveyed are "A total of 204 managers, who represented 50 large business groups (chaebols) and 154 small and medium-size firms." Based on this statement, it can be inferred that most of the surveyed managers would belong to those companies that survived the financial crisis. If this is the case, it will be very difficult to delineate the differences of traits in survived companies and bankrupt companies. If this is the case again, then the value of an evolutionary approach of the paper will not be arguably high.

The paper does not make any distinction of firm size and/or industry specifics in Tables that summarize the survey results. But these distinctions will add more value to the paper.

CHAPTER IV-1

Analysis of Pay Inequality and its Impacts on Growth and Performance in Korean Industry

by
Yunhee Kim*, Jeong-Dong** Lee and Almas Heshmati***

Abstract

This paper examines the relationship among pay inequality, economic growth and innovation in Korea. We estimate pay inequality in Korea's manufacturing sector using panel-level data for the period 1993 to 2003. The objective is to estimate pay inequality by using Theil's index and to identify the factors determining pay inequality and find the relationship with economic growth and innovation. We first review changes in industrial trend, production, and investment patterns over the period and how those changes led to the creation of a relative pay inequality between and within regions and sectors. We then compare the annual changes in manufacturing pay inequality and annual GDP growth, finding that the previously stable and negative relationship predicted by Kuznets broke down at the height of the period of structural reform in Korea, giving way to a positive relationship after 1998. On the basis of Theil's T statistics, results show a positive relationship between firms' pay inequality and size, location, R&D, export and business sectors. The relation holds even when we control for individual, time period and firm characteristics. The decomposability property of the Theil index enables us to show that manufacturing pay inequality in Korea has risen

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both across sectors and regions, though more strongly across industrial sectors. Despite controlling for changes in the level of real per capita income, the rise in inequality accelerates in the period following the introduction of reforms. It appears that a large part of rising pay inequality can be attributed to rising relative pay in the ICT sector. The findings support the hypothesis of an "augmented" Kuznets Curve according to which some developed countries are found on an upward-sloping addendum to Kuznets'original formulation.

Keywords: Pay Inequality, Financial Crisis, Kuznets curve, innovation
JEL Classification NumbersC43, J31, J38, O4

I. Introduction

Since Kuznets posited his now famous curve in 1955, the issue of relationship between inequality and economic growth has troubled economists and social scientists. Normative questions about social equity aside, whether inequality and growth are correlated and in which direction, if any, causation flows have far-reaching implications for economic and social policy that cannot be ignored. Is inequality an unfortunate but necessary ingredient for growth, or might equality and growth be compatible or, perhaps, even complementary? Such questions are symptomatic of a broader debate regarding the existence of a trade-off between innovation and equality in general Okun (1975). This paper addresses these questions by examining the relationship between inequality and growth in Korea, and how that relationship has been affected by the structural economic reforms of the past years.

Simon Kuznets hypothesized that the relationship between growth and inequality changes based on a country's level of development – or degree of industrialization. In the initial phase of development, income diverges as the rural population migrates to the more unequal, higher wage urban industrial centers. As the urban proletariat matures, however, political institutions are created that increase lower-wage workers' income shares and inequality decreases as industrialization deepens Kuznets (1955).[1] For a given level of income (or industrialization), then, the relationship is assumed to be stable – negative for most countries currently on the downward-sloping portion of the curve.

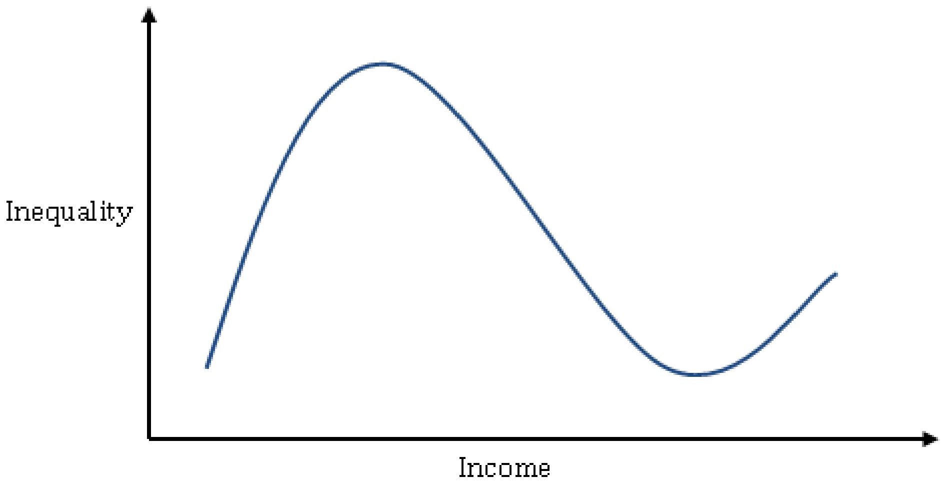
Although Kuznets hypothesized the effect of growth (or development) on inequality, later literature reversed this causal relationship. Empirical work seeking to confirm or reject Kuznets' hypothesis has proliferated in recent years, using both pooled and panel data in attempt to shed light on the relationship across countries and time. Surveying twenty-three different studies, Benabou (1996) concluded that initial inequality is detrimental to long-run growth.

Recent work has found that a few rich countries specializing in high-wage, advanced capital goods have experienced a post-Kuznets rise in inequality. While most developing and industrialized countries are found on the downward portion of Kuznets' inverted U-shape, inequality has been raising with increased income levels in high-income countries like Japan, the United States, and the United Kingdom. Conceição and Galbraith (2001) postulate that Kuznets'original formulation might apply only as long as

1) Among other factors causing decreased inequality might be continuous urbanization and increased coverage of equality enhancing social welfare programs.

countries produce principally consumer goods, and might break down as industrial activity shifts into monopolistic, advanced technology goods for the world market. In that case, the richest and most advanced industrial economies producing capital goods for export would be found on an "augmented" Kuznets Curve with an upward-sloping tail for such countries, as shown in Figure 1. Away from the augmented curve's peak and trough, however, the relationship between growth and inequality is presumed to be a more or less a stable function of income level.

Figure 1. The Augmented Kuznets Curve



The present paper adds a new dimension to this research by showing that the relationship between growth and inequality may change, as it does in the case of Korea, for instance as a result of structural reform. Although Korea's income level doesn't change appreciably during the final decades of the 20th century, data on manufacturing pay inequality show that the stable, negative relationship between growth and inequality predicted by Kuznets reverses at the peak of the reform period, thrusting Korea into a small group of otherwise wealthy and highly industrialized countries for whom inequality rises with economic growth. After a brief review of the reforms undertaken during Korea's financial crisis period, we will examine the evidence for this change and mechanisms by which it may have taken place. Finally, conclude with implications and avenues for further research on the topic.

After a brief introduction to the background to pay inequality and the Korean economy in Section II, the remaining of this paper is organized as follows. Section III presented a review of the previous studies for understanding the pay inequality and the

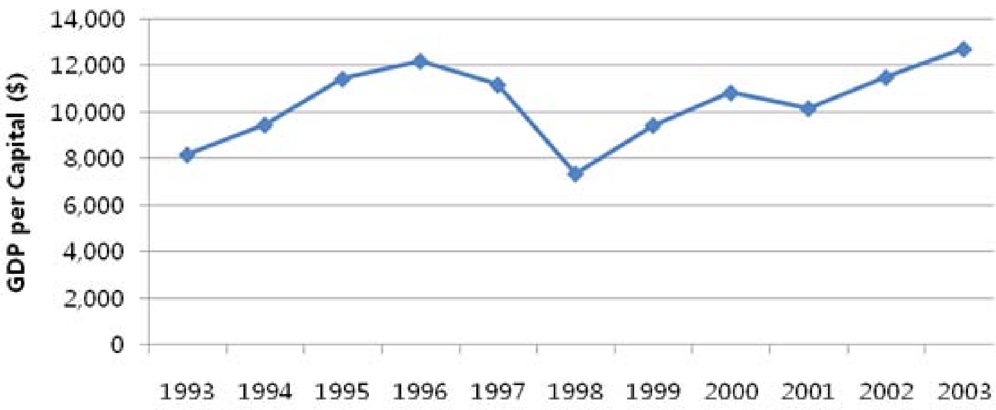
Korea industry. Section IV explains and critiques the methodology of Theil's T statistic. Also there is description of the manufacturing data and variable definitionin Section V. Section VI shows results and we discuss and conclude in section VII with suggestion for policy implication.

II. Overview of the korean economy

As it is well-known, Korea in recent decades has experienced a dramatic economic development. From being one of the worlds' poorest countries in the 1960s, it became a member of the Organization for Economic Cooperation and Development (OECD) in 1996. The economy has made remarkable progress since the early 1960s, with GNP growth averaging 7.8% per annum between 1961 and 2000. In relatively short time period, the country was transformed swiftly from a poor traditional agricultural society to a modern industrial state. Comprehensive investment programs in technology and human capital made the manufacturing sector the engine of its economic growth driven by an outward-looking, government-led development strategy pursued from the early 1960s. During the process, the national government intervened extensively in resource allocation, targeting industries to be promoted and provided necessary incentives at different levels for development and progress.

Many researches including Amsden (1989) and World Bank (1993) chose to study the Korean case as one that could serve as a model for development of other developing countries and the Korean economy was thought to be strong. However the Korean won dropped in value by 50 percent between the end of December 1996 and the end of December 1997 when Korea experienced a financial crisis in the mid 1997. The economic crisis in 1997 – 1998 after three decades of unprecedented economic growth was evident. The outstanding external debt reached US$159 billion in December 1997, the real GDP growth rate declined by 7% and the unemployment rate exceeded 8% in early 1998 from being less than 3% in the early to the mid-1990s. The request by the Korean government for a three-year stand-by credit from the IMF amounting to about $21 billion was approved on December 5, 1997.

Figure 2. GDP per capita of Korea



The Figure 2 shows, despite the economic crisis, the remarkable economic growth of Korea during period (1993-2003) under the consideration in this paper. Per capita income has increased from $8,177 in 1993 to $12,720 in 2003. This rapid change gives an extraordinary chance to examine the relationship between economic growth and income distribution and income mobility in Korea.

Although the Korean economy severely suffered from the Asian financial crisis, it was known for its rapid recovery from the crisis (Yoshitomi, 2003; Koo and Kiser, 2001). However, one can expect that the impact of crisis on firms would differ by various firms' characteristics. The industrial policies for firms with different-sized classes changed dramatically, in the post-crisis period. As a result of the recovery policy, large scale enterprises (LSE) succeeded in necessary downsizing in the immediate aftermath of the financial crisis and grew rapidly in the post-crisis period, especially in the export market. On the other hand, small and medium enterprises (SME) were still suffering from the effects of the recession and, in particular, in the domestic market (Oh et al. Forthcoming). Consequently, pay inequality increased over the entire industry and differences with respect to locations and industries were distinguished.

The heterogeneous impact of the crisis in form of increased pay inequality on firms by size and locations motivated the relationship between the inequality and industry growth to be addressed in the current study. Therefore, this paper examines pay structure and pay inequality in Korea manufacturing sector using Theil's T statistic between 1993 and 2003. As shown in Table 1, manufacturing has one of the big partials of Korea industry. The data set is derived from the Annual Reporting on Mining and Manufacturing Survey in Korea. It consists of firms with five or more employees in 580 manufacturing industries classified by the KSIC (Korean Standard Industrial Classification) at the five-digit level.

Table 1. The development of labor force in Korea and its distribution, (in 1000)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total labor force in 1000	12,245	12,583	13,634	14,006	13,470	12,416	12,920	13,604	14,109	14,608	14,729
Manufacturing in 1000 (%)	3,884 (31.7)	3,695 (29.4)	3,708 (27.2)	3,748 (26.8)	3,312 (24.6)	2,986 (24.1)	3,170 (24.5)	3,333 (24.5)	3,415 (24.2)	3,392 (23.2)	3,411 (23.2)
Mining in 1000 (%)	51,788 (1.3)	43,589 (1.2)	39,748 (1.1)	35,806 (1)	29,888 (0.9)	23,962 (0.8)	21,971 (0.7)	21,406 (0.6)	20,895 (0.6)	20,405 (0.6)	20,537 (0.6)

Hence we can investigate the location, size, R&D, export and business sectors of the firm in pay inequality. Also we evaluate how the Asian financial crisis and policies for recovery impacted on pay inequality. This paper studies the change of pay structure and inequality from a comparative perspective. First of all, this paper looks at the tendency of pay inequality with economic growth between 1993 and 2003. Second, we divide business sectors, locations and firm size and then find differences and characteristics. Finally, we compare the analyzed inequality distribution with economic growth, locate Korea's position according to Kuznet's theory and obtain the relating implication.

III. Review of the literature

Although Kuznets hypothesized the effect of growth (or development) on inequality, later literature reversed this causal relationship. Empirical work seeking to confirm or reject Kuznets' hypothesis has proliferated in recent years, using both pooled and panel data in attempt to shed light on the relationship across countries and over time. The majority of this empirical work found a consistent, negative relationship between inequality and growth, typically based on multivariate cross-country regression models in which inequality is one variable determining economic growth. Birdsall, Ross and Sabot (1995), for example, found that egalitarianism was a key ingredient in the recipe for rapid growth in East Asia. Surveying twenty-three different studies, Benabou (1996) concluded that initial inequality is detrimental to long-run growth.

In 1998 Klaus Deininger and Lyn Squire disrupted the emerging consensus with a study based on their ambitious new global inequality data set compiled for the World Bank from disparate household surveys of 108 countries since 1950. Based on the new data, Deininger and Squire (1998) found no evidence for Kuznets inverted U-shape. Using the same data and panel specification, Forbes (2000) found that initial inequality leads to higher subsequent rates of growth. Several authors pointed out severe problems with the new data, however, casting a shadow over conclusions drawn from it. Galbraith and Kum (2002) show how problems with the Deininger and Squire data lead to multiple and contradictory conclusions about the relationship between inequality and growth (ranging from upright U-shape to inverted U-shape to positive linear and negative linear). It is to be mentioned that, the focus in above studies is yet on a unidirectional causal relationship between growth and inequality. The negative relationship for most countries appears to remain intact, but questions regarding causality and endogeneity notwithstanding.

There are a number competing theories explaining the between-firm wage dispersion. The efficiency wage theory argues that paying a wage premium may be profitable for firms because high wages can reduce monitoring costs, discourage turnover, attract a higher quality pool of applicants, and foster employee loyalty. Hence, wage dispersion across firms is observed when firms differ in their ability to monitor or motivate their workers, to bear the cost of turnover, or to measure labor quality. The theory of insider controls provides another institutional explanation for demand-related wage variation. If firms have product market power and their workers can bargain for a share of the rents, cross-firm differences in rents or in workers' ability to extract rents generate wage differentials between firms.

Although efficiency wage and insider theories explain why wages may be set above their market-clearing levels, their predictions for the impact of a wage premium on firm performance differ. Efficiency wages are compatible with profit maximization because they are intended to increase labor productivity. However, rent-seeking activities of insiders undermine the financial performance of the enterprise because these activities have no effect on worker performance. These competing theories of between-firm wage dispersion have been tested empirically but the extent to which wage dispersion is attributable to competitive versus noncompetitive factors remains unresolved. In this paper, we just look at the tendency of inequality in Korea between 1993 and 2003 then comparing with sectors and regions gives many implications to Korea's industry policy.[2)]

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2) Due to limited spaces, the issues of efficiency wage policy will be discussing in further study.

There has been large volume of studies on pay distribution in Korea since late 1970s. Although estimates of pay inequality slightly different depending upon the data used, most studies agree that pay inequality increases in 1990s, especially after the financial crisis wealth is far less equally distributed than pay (Lee & Hwang, 1998; Lee, 2000). There is no consensus on the direction of pay inequality over the path of economic growth: rising inequality (Kim & Ahn, 1987); inverse-U type (Choo, 1993); falling inequality (Kim & Topel, 1995; Fields & Yoo, 2000). Despite the controversy over the direction of pay inequality, it is believed that factors such as education, industry, occupation, and experience, are important factors in determining the level of inequality over time.

Since in a situation facing a financial crisis, certain institutions are expressing the interests of the enterprises such as the Federation of Korean Industries which ask for further flexibility of labor market (Federation of Korean Industries, 2000), it is doubtful whether its argument would be appropriate for the Korean economy, where job mobility has been quite restricted compared with most of developed economies. Regarding pay inequalities, Stiglitz (1999) admits that pay inequality tends to rise in periods of economic crises, structural adjustment and output contractions.

Although all available measures show widened pay inequalities in Korea during 1997 –1999 (Yoo and Kim, 2002) due to the increase in the number of the irregular workers and the unemployment rate, interpretations of the situation of pay inequalities since 2000 appear to depend on the conducted survey methods. For instance, a measure such as the Gini coefficient based on urban workers' households shows that the Gini coefficient increased from 0.307 in 1996 and 0.296 in 1997 to 0.311 in 1999, but it decreased to 0.301–0.303 in 2000 and 2001. The decline is presumably due to the increased public transfer and decreased unemployment rate; meanwhile, most other measures indicate that the Gini coefficient has been more or less stable since 1999 (Park et al., 2002; Yoo and Kim, 2002).

Most of previous research, however, mainly focuses on pay inequality at a point of time measured by some inequality indices. Although this snapshot view of pay inequality receives attention from the public, it tells us little about the nature and the direction of pay inequality. Different from the previous studies, this paper attempts to analyze pay inequality by using Theil's T statistics through comparing with several between and within units. First of all, this paper looks the tendency of pay inequality with economic growth between 1993 and 2003. The period covers both pre- and post-crisis periods. Second, we divide the data into business sectors, locations and firm size, etc, and then find differences and characteristics. Finally, the effects of firm dynamics on pay inequality will be analyzed in more details.

IV. The methodology

Theil's T statistic is one of the several frequently used indices of inequality that provides a useful alternative approach to measuring the change in earnings inequality within a single country, and to comparing degrees of change across countries.[3] The method has been intensively used in analysis of households and individuals income distribution. Theil's T statistic relies not on surveys, but on the regularly gathered official measures or register data of income by region and sector. This method is to compute the between-groups component of Theil's T statistic across province-sector cells for both locations and business sectors. Theil's T is a very simple measure of inequality, relying only on two pieces of information about each cell: its weight in total population (or employment), and the ratio of average income within the cell to average income in the country as a whole.

The following formulae give the algebra behind Theil's T statistic.[4] While these particular equations use income as the variable of interest, Theil's T can address any number of quantifiable phenomena. When household data is available, Theil's T statistic is written as:

$$T = \sum_{p=1}^{n} \left\{ \left(\frac{1}{n} \right) * \left(\frac{y_p}{\mu_y} \right) * \ln \left(\frac{y_p}{\mu_y} \right) \right\} \tag{1}$$

where n is the number of individuals in the population, y_p is the income of the person indexed by p, and μ_y is the population's average income. If every individual has exactly the same income, T will be zero; this represents perfect equality and is the minimum value of Theil's T. If one individual has all of the income, T will equal ln *n;* this represents utmost inequality and is the maximum value of Theil's T statistic. Thus unlike the Gini coefficient, the Theil's T statistic is not limited to values within the 0-1 interval.

If members of a population can be classified into mutually exclusive and completely exhaustive groups, then the Theil's T statistic is made up of two components, the between group component ($T'g$) and the within group component ($T^w g$) expressed as:

3) For a recent review of inequalities and their measurement see Heshmati (2004).

4) Equations (1), (2), and (3) closely follow: Pedro Conceição, James K. Galbraith, and Peter Bradford; "The Theil Index in Sequences of Nested and Hierarchic Grouping Structures: Implications for the Measurement of Inequality through Time, with Data Aggregated at Different Levels of Industrial Classification," Eastern Economic Journal, Volume 27 (2000), Pages 61–74.

$$T = T_g^{'} + T_{\mathrm{g}}^{\mathrm{w}} \qquad (2)$$

When aggregated data is available instead of individual data, T′g can be used as a lower bound for the population's value of Theil's T statistic. The between group element of Theil's T can be written as:

$$T'_g = \sum_{i=1}^{m} \left\{ \left(\frac{p_i}{P} \right) * \left(\frac{y_i}{\mu} \right) * \ln \left(\frac{y_i}{\mu} \right) \right\} \qquad (3)$$

where *i* indexes the groups, p_i is the population of group *i*, P is the total population, y_i is the average income in group *i*, and μ is the average income across the entire population.

T'_g is bounded above by $\ln(P/p_i(min))$, the natural logarithm of the total population divided by the size of the smallest group. This value is attained when the smallest group holds all the resource. When data is hierarchically nested (i.e. every municipality is in a province and each province is in a country) Theil's T statistic must increase or stay the same as the level of aggregation becomes (i.e. $T_{population}$ μ$T'_{g\ (district)}$ μ$T'_{g\ (county)}$ μ$T'_{g\ (region)}$). Theil's T statistic for the population equals the limit of the between group Theil component as the number of groups approaches the size of the population.

Theil's T has properties that make it attractive for type of calculation described above; in particular it is possible to sum row and column elements so as to arrive at cross-sector and cross-province measures of inequality. It is also possible to look directly at the contribution to overall inequality of each cell, sector or province, and to gauge the change in that contribution from year to year. Of course, the general comparison of the Theil index methodology is made by estimating pay inequality for individual persons between countries or regions. In the current study, we however compare the pay inequality by using firm level data. Dong (2005) analyzed wage inequality and between-firm age in the 1990's by employing the Theil methodology, where data of rural and urban firms were used. Galbraith (2004) evaluated pay inequality of 1979 through 1998 in the Indian manufacturing sector.

V. The data

In this study, we examine the pay inequality of the Korean manufacturing industry according to sector, region, and firm size classification with firm level data of 1993 to 2003.

The data used in this study was the unpublished plant-level data assembled from the Annual Report on Mining and Manufacturing Survey in Korea. The data covers all plants with five or more employees in 580 manufacturing industries at the KSIC (Korean Standard Industrial Classification) five-digit level. It was an unbalanced panel data with about 76,341 to 103,126 observations for each year from 1993 to 2003.

In the survey data, the entry and exit of plants were identified based on the plants appearing and disappearing over time. Entry and exit of plants due to spin-off, split, merger, and acquisition could not be identified with the available plant level data base. During the analysis period, a total of 300,916 distinct plants were observed. As such, the data contains entering, exiting and surviving plants. The data are available at the five-digit industrial classification level for entire Korea manufacturing industry.

The total number of observations was 1,030,643. Plants that had more than 300 employees were denoted as firm size class 5. When the numbers of employees were between 300 and 100, the plants were classified as firm size class 4. And firm size class 3 has employees from 50 to 100, firm size class 2 has less than 50 and more than 20. The last part is firm size class 1 with 5-20 employees. The annual changes in the number of firms, the aggregated firm characteristics and the number of employees for each group were described here.

The descriptive statistics of the data for each year of observation is reported in Table 2. In addition to the number of observation in each year, the distribution of each variable including the number of workers, cost and incomes are presented. The number of observations is increasing over time, while the number of workers declining. The cost and its dispersion are showing an increasing trend. The same applies to the income variables.

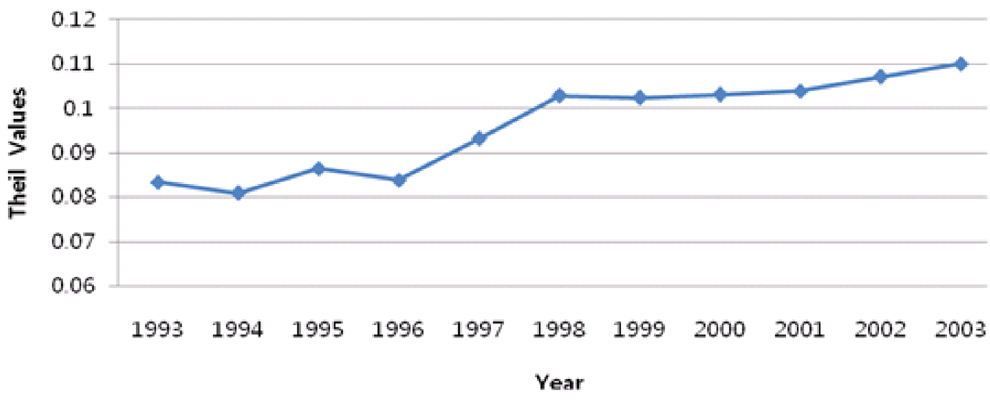
Table 2. A descriptive statistics of firms between 1993-2003

Year	Observations	Variables	Mean	Std.Dev	Sum	Numbers
		worker	31.78	208.75	2724481	85731
1993	85731	cost	379.25	4220.84	32513354	85731
		income	8.63	3.59	739980	85731
		worker	31.31	219.12	2765299	88328
1994	88328	cost	423.51	5402.72	37407943	88328
		income	9.69	3.99	855686	88328
		worker	30.19	220.48	2815581	93267
1995	93267	cost	466.23	5763.59	43483779	93267
		income	10.99	4.71	1024909	93267
		worker	29.39	231.49	2763178	94030
1996	94030	cost	502.28	6389.42	47229078	94030
		income	12.26	5.20	1153255	94030
		worker	27.67	207.74	2462853	88996
1997	88996	cost	519.29	6006.66	46214575	88996
		income	13.20	5.98	1175073	88996
		worker	27.79	191.08	2121474	76341
1998	76341	cost	511.08	6203.56	39016613	76341
		income	12.74	6.174	972350.86	76341
		worker	26.65	181.81	2349268	88140
1999	88140	cost	506.89	6325.64	44677291	88140
		income	13.24	6.26	1167058	88140
		worker	26.36	182.19	2513212	95341
2000	95341	cost	554.16	6956.60	52834699	95341
		income	14.47	6.90	1379405	95341
		worker	24.27	150.81	2502568	103126
2001	103126	cost	549.81	6609.62	56699977	103126
		income	15.83	7.59	1632992	103126
		worker	23.64	142.69	2540690	107459
2002	107459	cost	585.83	6835.44	62952772	107459
		income	17.41	8.47	1871169	107459
		worker	23.55	146.99	2587851	109884
2003	109884	cost	618.99	7598.76	68017011	109884
		income	18.46	9.10	2028859	109884

VI. The results

First of all, we look the tendency of pay inequality with economic growth between 1993 and 2003. We begin by examining the information in the KSIC data at the five-digit classification level, for Korea as a whole. Figure 3 presents the Theil statistic values' resulting from this exercise.

Figure 3. Theil T Statistic measure of pay inequality of Korean manufacturing, 1993-2003



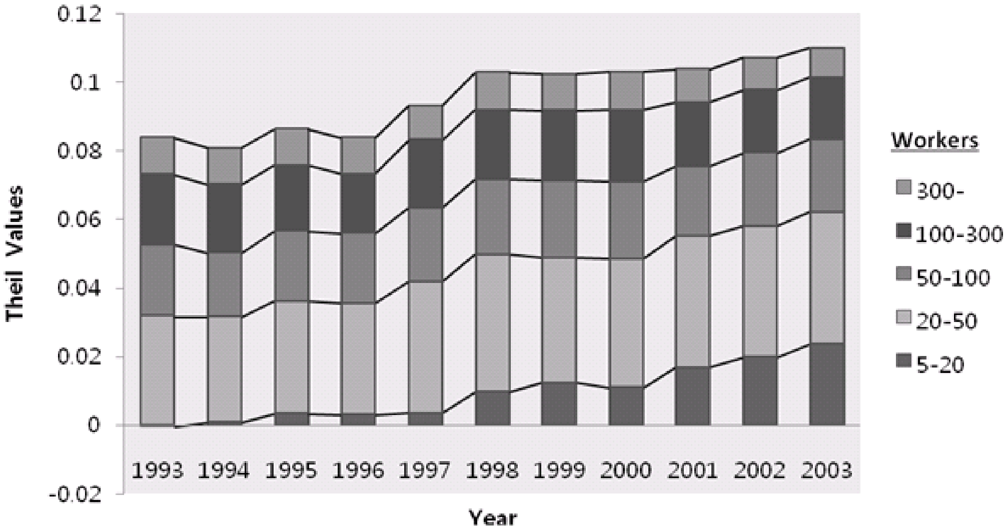
We find out that the inequality trend measured by Theil T statistic remained stable and consistent in the early 90's and that it was slightly on the decline. However we observe that the graph shows a sharp upswing in the year 1993-2003, remains fairly steady till 1993-96, then jump up rapidly in 1996-1998. Thereafter inequality in manufacturing pay remained steady till the year 1999-2003, at which point it began creeping upward. This is definitely different from the "augmented" Kuznets Curve that inequality increases with an increase in economic levels as found in the US, Japan, and UK. The Korean economy didn't reach up to the economic level of developed countries but we just reformed and maintained the economy. Hence, if the economy had been stabilized and reformed properly, the inequality should have become similar to the one before the crisis or it decreased steadily. However, as seen in Figure 2, the inequality increases drastically after the financial crisis. The radical economic reform for too short time period does not result in concurrence of economic growth and inequality but more increased inequality than economic growth. Therefore, this type of reform will be expected to cause some problems stated above. So, based on political consideration of these facts, we have to think over wag distribution and economic development plans.

To further examine whether inequality in Korea is primarily a geographic or a location issue, we aggregate the location-sector elements into two distinct categories, locations on the one hand and sectors on the other. The two digit industrial classification available at the location level is similar to the three digit classification available at the national level. The data are available for sixteen categories across 5 major states for this period of study.

As explained above, we have (i) inequality across sectors within states, (ii) inequality across locations, (iii) inequality across locations within sectors and (iv) inequality across sectors. Through this trend of Theil values, we find that in this data inequality has been steadily increasing post 1996 when the Korean economy faced financial crises, and that in the 2000s pay inequality has continued to increase, taking a sharp jump in the final year observed to levels much higher than in the early 1990s. Thus a temporary law for fostering venture business was enacted in 1997 and the government strongly intervened in the entire process of certification and supporting of specific sectors. As a result, the pattern suggests that the regional element of inequality in Korea started to rise before purely sectoral increases became pronounced and also before the major economic reforms taken place. The next issue we examine is which of the specific sizes, regions and sectors have contributed the most to rising inequality. We first examine the contribution to Theil index of individual states. Figure 4, 5 and 6 below presents this information.

Figure 4 shows the contribution of firm size to pay inequality in Korea. Firm sizes divided by the number of employees. There are in total five firm sizes defined and the standards of firm's employees are 5-20, 20-50, 50-100, 100-300 and over 300. Firm sizes whose pay rates exceed the average form elements above the zero line, while states with pay rates below the national average form elements below the zero line. The size of the component attributable to each region and firm sizes represent the combined influence of labor force and relative income, and it is the change in these influences which the figure highlights. The firms are ranked by the size of their contribution to interstate inequality in the first year under observation.

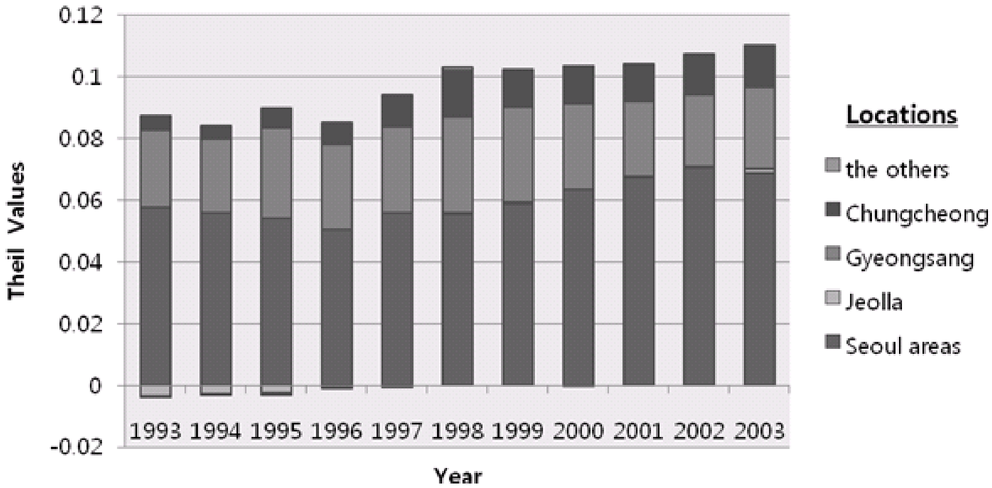
Figure 4. The contribution of firm size classes to the pay inequality in Korean manufacturing, 1993-2003.



Through this figure we can find that the pay inequality of small size rapidly has increased since 1998. This result related with the industrial policies for firms with different-sized classes changed dramatically, in the post-crisis period. As a result of the recovery policy, LSEs succeeded in necessary downsizing during the immediate aftermath of the fiscal crisis and to grow rapidly in the post-crisis period, especially firms specialized in the export market. In the case of LSEs, its portion does not change even if the overall equality increases. On the other hand, the portion of SMEs increases with an increase in the entire inequality. It is shown that SMEs takes an amount of the position. Nevertheless, the fact that the portion has increased since 1997 indicates that SMEs were still suffering from the effects of the recession especially in the domestic market. The impact of the economic crisis on SMEs was of greater severity. As an indication of this problem, the number of SME bankruptcies in 1998 reached 22,800, while it was 11,600 in 1996 (Gregory et al, 2002). The short-term debt in foreign currencies, which was a major factor of causing bankruptcies in some industries, resulted in a series of bankruptcies over the entire economy.

Figure 5 shows the contribution of firm's regions to pay inequality in Korea. Location is divided into 5 areas. There are (1) Seoul areas, (2) Gyeongsang, (3) Jeolla, (4) Chungcheong and (5) the other areas. Seoul areas and Gyeongsang make the largest contribution to inequality during the entire period. This should not come as a surprise

Figure 5. The contribution of firm's locations to pay inequality in Korean manufacturing, 1993-2003

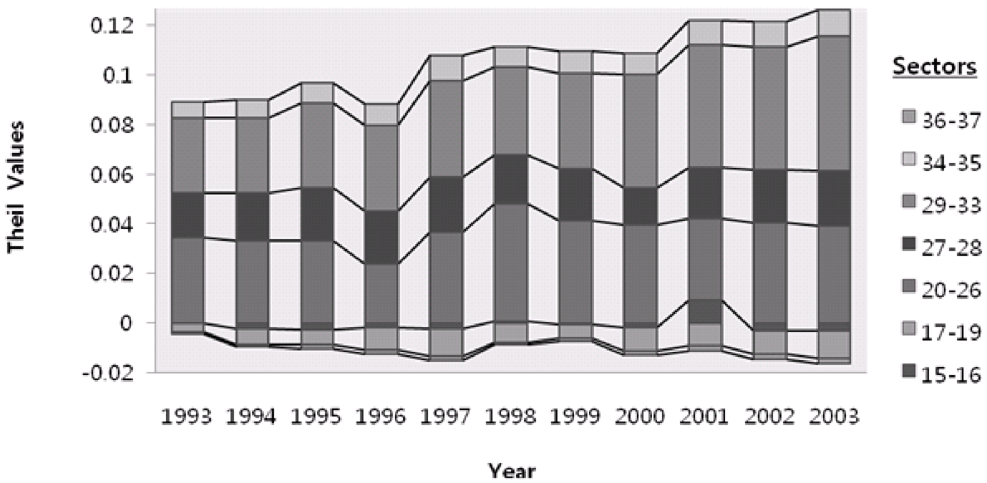


as it is the most advanced industrial area in Korea and all the leading industrial houses have established manufacturing facilities in the Korea. Labor in Seoul areas is also highly organized; therefore almost all industrial groups in Seoul areas and Gyeongsang have pay-rates above the All-Korea average level.

On examining the negative Theil elements we find that two of the Areas have rapidly changes. Pay rates of Jeolla and the others below the national averages in some period. This could be primarily due to the lack of large enterprises from either the public or private sectors in these two states. Most of the industrial establishments in these areas are quite small and belong to such traditional sectors as food processing.

Finally, most of the smaller states make either no contribution or make a small negative contribution to the Theil index. The smallness of their contribution in absolute value is an artifact of their small weight in overall manufacturing employment in Korea. The increase in Theil index from 1997 is primarily attributed to an increase in the Theil element of generation of electrical energy, distribution of electrical energy, manufacture of computers and computer based systems, manufacture of general purpose non electrical machinery and manufacture of motor cars. These sectors are specialized in both domestic and export markets.

Figure 6.[5] The evolution of inequality over time across Korean manufacturing sectors at the two digit level, 1993-2003



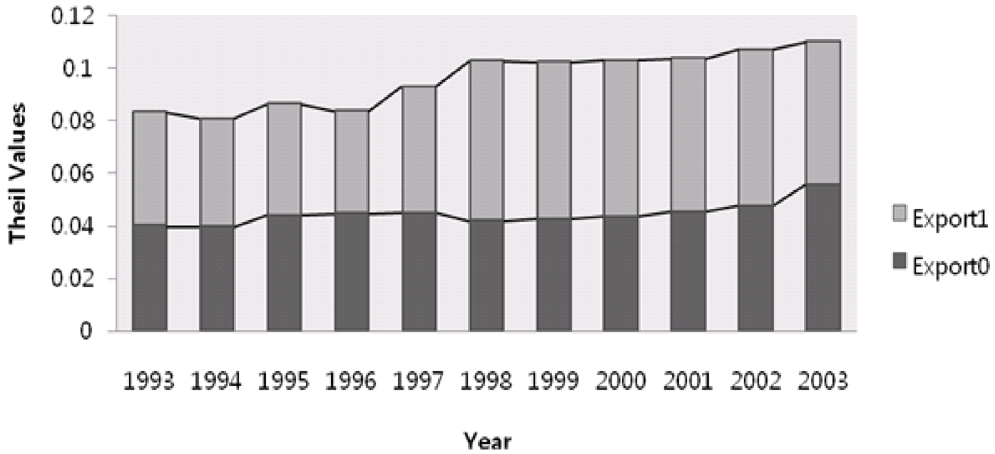
All of these sector areas got a boost after the liberalization of policies regarding production capacities and industrial licensing. We infer from this evidence that one effect of the reforms was to strengthen the market position of those sectors which were already comparatively strong but heterogeneously, and so to increase the dispersion of manufacturing pay across Korea as a whole since Asia Crisis. The Figure 6 shows the firm's distribution of 2-digit enterprises like basic metal industries, rubber, plastic, petroleum and coal, and electricity generation & distribution, as well as the large-scale modern enterprises in chemicals, transport equipment, and machinery and equipment. These are the major winners and contributors to the inequality of manufacturing sector incomes. Sectors like digit 29-33 and 20-26 manufacturing are the long-standing losers. Of particular interest is the increasing contribution of the Theil element in the electricity sector over the years, particularly as the sector has become deregulated and increasingly able to assert its monopoly power. Indeed the rise of the power of the power sector is the single largest and perhaps the only significant contributor to the rise of inter-sectoral

5) This paper using the STAN industry list (based on ISIC Rev. 3) of OECD report (2003)
15-16 Food products, beverages and tobacco
17-19 Textiles, textile products, leather and footwear
20-26 non-metallic mineral products
27-28 Basic metals and fabricated metal products
29-33 Machinery and Electrical
34-35 Transport equipment
36-37 Manufacturing nec; recycling.

inequality in Korean manufacturing under the rule of economic reform.

As seen in Figures 7 and 8, the inequality of firms was evolved over time depending on the aggregate R&D and export activities of firms.

Figure 7. The evolution of inequality over time by export activities 1993-2003



After reforming the economy's structure, the inequality shares of exporting group of firms have increased somewhat. However, the increase in the inequality for the export-oriented group led the fostering policy of economy to concentrate on the recovery of financial deprivation through trade.

Figure 8. The evolution of inequality over time by R&D activities 1993-2003

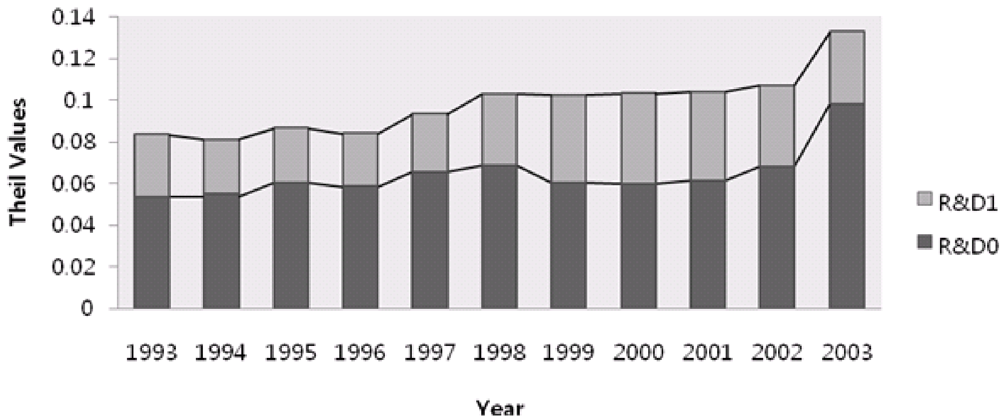


Figure 8 shows that the increase in the pay inequality had influence on the R&D activity of firms. In particular, the inequalities of R&D-intensive firms have increased since the Financial Crisis of Korea because the SMEs-fostering policies of the Korean government, in the post-crisis period, supported and financed venture businesses. On the other hand, the inequality rates of firms not conducting R&D show no variation before and after the Crisis period. Instead, their inequality has increased more since the economy became stable.

VII. Conclusion and policy implication

Since Financial Crisis of 1997 the structural reform has increased and changed pay inequality attributed to firms of relatively large size, capital region, R&D oriented and high technology manufacturing industries whose products were increasingly oriented toward the external market. Using data sets 1993-2003, this paper analyzes pay inequality in Korea manufacturing according to the location, size, R&D, export and business sectors of the firm. Also we evaluate how the Asian financial crisis and policies for recovery impacted on pay inequality. This paper studies the change of pay structure and inequality from a comparative perspective.

First of all, this paper looks at the tendency of pay inequality with economic growth between 1993 and 2003. By Theil T statistics, it is shown that the overall pay inequality increased and the persistent component dominantly shapes the overall pay inequality. We can safely conclude that inequality in Korea manufacturing sector wages have increased since the 1996: both all-Korea and different location measures agree on this point. Korea manufacturing however retains many of the characteristics of a planned and a dual economy, with a strong influence of the firm structure and on relative wages and its distribution.

Second, we divide the business sectors, locations and firm sizes and then find differences and specific characteristics. The result shows some patterns of pay inequality between industrial sectors, locations and firm size classes. We found a positive and significant relationship between pay inequality and firm size, regional location, R&D, export and business sectors, even when we control for unobservable and observable individual, time period and firm characteristics. The decomposability property of Theil index enables us to show that manufacturing pay inequality in Korea has risen both across sectors and across regions, though more strongly across industrial sectors.

Finally, we compare the analyzed inequality distribution with economic growth, locate Korea's position according to Kuznet's theory and obtain the relating implication.

We showed that the rise in inequality accelerates in the period following the introduction of economic reforms, after controlling for changes in the level of real per capita income. It appears that a large part of rising manufacturing pay inequality in the post-reform period can be attributed to rising relative pay in the large high technology industry sectors of capital areas. The findings support the hypothesis of an "augmented" Kuznets Curve according to which some developed countries are found on an upward-sloping addendum to Kuznets' original formulation. Inequality is indispensable to economic growth, yet Korea experienced an extremely fast change in the inequality and industry structure. While most developing and industrialized countries are found on the downward portion of Kuznets' inverted U-shape, inequality has been raising with increased income levels in high-income countries like Japan, the United States, and the United Kingdom. Since Korea is, however, not such a high-income country, the share and change rate of inequality should be monitored and the implication of related policies needs to be sought. These results contain some policy implications.

From the viewpoint of the size of firms, the inequality of the firms hiring 5 to 20 employees heavily increased considering the total share of the inequality. Compared to those before 1996, pay inequality of small-sized companies was relatively worsened, which gave rise to lowering companies' activities and the rise in their risk. Therefore, Fair Standard Act Policy such as minimum wage system to help to solve pay inequality is required. From the geographical perspective, the inequality of Seoul areas and Gyeongsang still take a large portion of the total and in particular that of Seoul has considerably risen since 1996. Thus, firms-aiding policies including tax reform and subsidy policies are needed to reduce the inequality gap between different areas. In addition, overall inequality of Fabricated metal, Chemicals, Electrical machinery, Communication industry was found to rise, which indicates the fact that support policies according to features of each industry is required to reduce and finally eliminate inequality.

In summary, though, inequality has been increasing in manufacturing pay since the 1996, with particular increases since the formal beginning of the reforms. This increase cannot be accounted for strictly by increasing average incomes, as the rise in inequality persists even when changes in average income between regions is fully controlled for. In a further study, we will investigate the relationship between firm dynamics and pay inequality in the same period to find the effect of firms' characteristics according to entry, exit and organization structure of firms on the level and development of inequality in pay.

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Comments on "Analysis of Pay Inequality and Its Impacts on Growth and Performance in Korean Industry"

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Korea Development Institute

1. As mentioned in the paper, the empirical relationship between economic growth and distributional inequality (so called Kuznets hypothesis) is unclear and most studies agree that it follows a country-specific path. Then why should we try to locate Korea's position according to the Kuznets curve?

For example, Korea has experienced decrease in pay inequality in the period of industrialization starting from 1960s. (Kim & Topel, 1995; Field & Yoo, 2000) as opposed to what Kuznets hypothesis predicts.

Kuznets hypothesis is inverted u-relationship between 2 variables, meaning using square of the explanatory variable and checking the sign and significance of it. We look at relationship between economic growth and inequality.

2. Previous studies pointed out that the cause of rising pay inequality are 1) Skill-based technical change in the production methods (Davis& Haltiwanger, 1991; Bound & Johnson, 1992) ; acceleration of international trade among countries (Murphy & Welch, 1991); or 3) decline in the unionization (Freeman, 1991)

In the literature these sources are recognized and you are reasonable. They would be cited properly in the paper.

This paper would be much better to assess the observed rising pay inequality according to three potential causes in turn.

Rather than simply saying that the financial crisis had tremendously influence on pay inequality in Korea, the researchers might start by asking what the economic interpretation on the financial crisis was and to what extent and how it affected pay inequality.

Let's say the financial crisis moved the Korean economy from a domestically oriented to an internationally oriented one. Then a possible hypothesis is that rising pay inequality in the post-financial crisis might be due to the result of international trades and globalization. Several steps can be considered to analyze the effects of globalization on pay inequality. Since the globalization affects all industries with different degrees, this directly implies that between-industry pay inequality become more salient than within-industry pay inequality after globalization.

Furthermore, since the exposures to international market (measured by such as import penetration ratio or export to sales ratio) are different among industries, one might want to test whether a strong correlation could be found between pay dispersion and globalization measures.

Let's say skill bias technical change is the one that is responsible for rising pay inequality. It is known that change in within-industry labor demand reflects production technical change while change in between-industry has to do with changes in demands for final goods according to the terms of trade. Thus, we could observe that within-industry determinant. Furthermore, one could statistically verify this channel by showing the change in wage premium between skilled and unskilled workers.

3. This paper insists that pay inequality had increased across the locations if so, a natural question one might ask is how and by what channel the location of plants meaning of location in explaining the rising pay inequality?

Probably through education, skill, labor productivity, demand and supply of labor, export intensity of the firms and differences in development of consumer and producer prices, differences in tax rates, ...

4. The paper suggests polices to strengthen minimum wage and firms-aiding tax reform and subsidies. It is not clear, however, to what extend workers are affected from the minimum wage in the data. Is a substantial portion of workers around the minimum wage level in the data set?

5. In addition, can policies to reduce corporate tax (targeting on small and medium size firms) successfully transfer the tax benefits to workers'pay in the direction of decreasing pay inequality? Isn't the policy we are interested in to reduce workers pay inequality rather than business performances among the firms?

6. Overall, this paper presents various interesting aspects on the recent rising pay inequality in Korea. Apparently, the paper could be greatly improved it the causes and consequences of pay inequality are economically analyzed in a more systematic way and the policies suggested are refined convincingly.

CHAPTER IV-2

Measuring Living Standard from the Lowest: Height of the Haengryu Deceased in Colonial Korea

by

Duol Kim*

and

Heejin Park**

Abstract

Living standard of Korean during the colonial period (1910-1945) has been debated for a long time. We explored this problem using the height of the male Haengryu deceased, who died without any acquaintances. We found that the height of male Haengryu deceased aged 20 to 30 increased by 2.4㎝ from 1913/5 to 1943/5. This result is consistent with recent quantitative studies measuring income level or demographic information.

JEL Classification Code:

Key words: the Haengryu deceased, height, living standard

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*** Acknowledgement: We presented this work at the 51st Annual Meeting of the Korean Historical Association. We are grateful to Myung Soo Cha and other seminar participants for helpful comments. We also thank to Jee Eun Kim for her excellent data work. Of course, all errors are ours.

I. Introduction

Living standard of Korea during its colonial period from 1910 to 1945 is a sore subject like living standard of U.S. slaves in the antebellum South or performance of the German economy during the Nazi regime. Studies of per capita GDP, real wage or life expectancy for last three decades generally uncover an unpopular fact, that is, living standard of Korean improved under the Japanese rule. However, anthropometric evidence presented so far does not show a clear pattern. Based on some height statistics of contemporary researchers, Mitsuhiko Kimura infers that the height of Korean grew throughout the colonial period. However, Insong Gill and Seong-Jin Choi studied some individual level height information and proposed an inverse U-shape trend with the highest point around the mid-1920s. Although the inference from individual level data is more reliable than that from statistics of various sources, the data consistency problem weakens Gill and Choi's result.[1)]

We shed a new light on this long-lasting controversy by investigating stature of the *Haengryu* deceased aged 20 to 30. The *Haengryu* deceased are those who are found dead but do not have any families or acquaintances to take care of the corpse.[2)] The *Haengryu* deceased included the drowned, deaths of railroad accidents, suicides, travelers, and so on, but most of them belonged to the lowest stratum of a society like beggars, addicted, lepers, and so on. For finding acquaintance of the dead, the Government-General of colonial Korea advertised the *Haengryu* deceased with descriptions on the dead including their height and age. As the advertisement continued from December 1912 to the end of the colonial rule, this data provides valuable consistent individual-level height information. As the lowest income group is the most sensitive to the living condition of an economy, the sampling bias of the data works as a merit rather than a defect.

In the following, we will review previous studies on the living standard of Korea during its colonial period, and will describe the data we analyzed. Then, we will show the trend of the height. Using various dimensions of the data, we will check possibilities that the change of height might originate from factors other than real height change. After that, we will conclude.

1) Kimura (1993), Gill (1995), Choi (2006).
2) The literal meaning of Haengryu is "traveling".

II. Literature Review

The Japanese rule of Korea was, like many other contemporary colonizers, brutal and suppressive. Some scholars claimed that as this brutality was for exploiting Korean and providing economic benefit to Japanese the living standard of Korean got deteriorated throughout the colonial era.[3)] These arguments have been regarded as true without much scrutiny and have been taught in classes for a long time.

Quantitative analysis from the late 1980s, however, uncover that much of these arguments are exaggerated or groundless. Pivotal would be measures of gross income. Recent estimates by Naksungdae Institute of Economic Research show that from 1911 to 1940 real GDP grew by 4.1% per annum and the real GDP per capita grew by 2.7% per annum. At the same time, aggregate real consumption expenditure and its per capita value grew by 3.3% per annum and 1.9% per annum each from 1912 to 1939.[4)] Considering the world-wide stagnation during the inter-war period, this was a remarkable high growth.

Konoske Odaka, Soo-Yeol Huh, Myung Soo Cha and Woo Youn Lee examined real wages of the colonial era using basically wage and price information of T*he Statistical Yearbook of the Government-General of Colonial Korea.* Although their methods and interpretation differ to some extent, all of their estimation indicates a common feature: the real wage of Korean male unskilled workers did not decrease and the real wage of Korean male skilled workers went up.[5)] This result weakly refutes the belief that exploitative policies of the Japanese colonial government generally lowered income of Korean.

Auxological information has been also investigated. Traditional demographic measures show improvement of living condition. The total population of Korea increased about 50%. The crude death rate declined from 34 per thousand in the 1910-1915 period to 23 per thousand in the 1940-1945 period. The life expectancy of male at birth increased from 37.9 in 1925-30 to 42 in 1940-1945.[6)]

As stature reflects cumulative net nutritional condition of human being, economic historians have widely investigated height information for figuring out long-term trend

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3) Most recent effort would be Huh (2005).

4) Kim ed. (2006). Mizoguchi and Umemura (1988) estimated gross domestic expenditure (GDE), which shows that real GDE grew by 4.4% per annum and real GDE per capital by 2.9% per annum.

5) Huh (1981), Odaka (1975; 1988), Cha and Lee (2007)

6) Kwon (1975), p.23. For detail on the demographic transition during the colonial era, see Kwon (1975, 1977).

of living standard.[7] In case of Korea, Mitsuhiko Kimura investigated various height statistics of contemporary researchers and suggested that there were no evidence of height decrease.[8] However, Insong Gill and Sung-Jin Choi explored several individual level height information and proposed an inverse U-shape pattern of height change for the colonial period: the height of Korean grew until the mid-1920s and then declined. This result is interpreted as that the living condition of Korean improved until the mid-1920s and then deteriorated since then.[9]

As Gill and Choi used individual level time series data, the height trend from their work is more persuasive than the pattern from Kimura's work. However, Gill and Choi's studies have a fatal weakness. For measuring the height of the 1930s and the 1940s they projected height of insurers of the National Health Insurance Corporation in the early 1990s, and then they used primary school registers and prisoners cards for the 1910s and the 1920s.[10] This coincidence of data use and change of growing pattern around the mid-1920s raise suspicion that the proposed inverse-U-Shape pattern can be a statistical artifact rather than the actuality.

In sum, studies on income, consumption, and demographic factors so far show that the Korean living standard improved during the colonial era. However, height information does not show a clear result. Better information on height can shed a new light on this ongoing debate.

Ⅲ. Data: Advertisement of the Haengryu Deceased in the Official Gazette.

For exploring the aforementioned problem, we analyzed the height data of the *Haengryu* deceased. A *Haengryu* deceased is a dead person who does not have any families or acquaintances to take care of the corpse. Such misery happens sometimes due to unexpected misfortune like drowning or railroad accident. But as the majority of the *Haengryu* deceased were beggars, addicted, or outcast like lepers, they did not have families or acquaintances at all within reach.

It was, therefore, a duty of municipalities to take care of the corpse. Since municipalities did not have decent preservation facilities for dead bodies and they worried about potential risk of epidemics, the municipalities usually buried or cremated

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7) Steckel (1995; 2008) surveys studies on the biological standard of living.
8) Kimura (1993), pp.644-647.
9) Gill (1995, 1998). Choi (2006).
10) Gill (1995, 1998). Choi (2006).

the dead quite quickly. After the whole procedure, the municipalities reported about the dead using the classified section of *the Official Gazette* of the Government-General. *The Official Gazette* was a daily journal making official announcements of the colonial government.[11] In November 1912, the Government-General announced a rule on the advertisement section of *the Official Gazette*, and this manifested that the *Haengryu* deceased are one item that can be advertised.[12] At the issue of December 11th of the same year, *the Official Gazette* published the first advertisement of the *Haengryu* deceased, and then the advertisement continued until the end of the colonial rule. The number of articles in an issue had large variation, but according to a rough estimation about 1,500 to 3,000 articles on the *Haengryu* deceased were reported in a year.[13]

The format of advertisement was mostly the same throughout the colonial period. As shown in Table 1, they provided information on the dead in detail: the shape of a person, what he or she wore and what were their belongings, where and when the corpse was found, why the person died, and whether the corpse was buried or cremated. Sometimes they provided name and permanent address of the deceased and very rarely even occupation. Such identification is possible since some of them died in institutions, and so on. The most crucial information for this study is definitely height and age.[14] However, other information is also critical for checking robustness of height estimation results.

For this paper, we computerized information of all the *Haengryu* deceased with age 20 to 30 in the third to fifth year of each decade.[15] The 20s is the age when the human being is the tallest in their life. Therefore, the choice of this age ameliorates potential measurement problems that choice of other ages might cause. For example, in case of the teenagers as their height is quite sensitive to age, age composition of the dead could generate non-trivial complications for the estimation. On the other hand, height of the human being starts to shrink after the mid-20s. If we analyze the dead aged over 30, we need additional information or assumptions to discern how much the height of these people is a result of their growing phase and shrinking phase.

More important reason to choose the 20s is related to the length of the colonial period. The height of the 20s in 1913 to 1915 was mostly determined before the colonial

11) The Government-General started to publish the Gazette from 1907. For the history of the Official Gazette in Korea, see Choi (1992).

12) "Rule on the Official Gazette of the Government-General" article 4, The Government-General Instruction, no.57, The Official Gazette, November 21, 1912.

13) Even after the liberation, *the Official Gazette of Korea* reported the *Haengryu* deceased, and it disappeared in the 1960s.

14) The height was originally reported as traditional unit Chock and Cha. Chock is 30.3㎝, and chon is the tenth of Chock, that is 3.3㎝.

15) For example, we computerized for 1913, 1914, and 1915 for the 1910s.

era. People aged 20 to 30 in 1943 to 1945, however, were all born after 1913 and their height was completely determined during the colonial period. The height difference of these two groups without any overlap can remove any potential complexities interpreting the result.

Table 2 shows the number of observations and size of the total death. The number of observation per year is about 200 to 400 for male, and 30 to 150 for female. In case of 1945, the liberation of Korea in August limited the size of the data. They are about 20% of the total male *Haengryu* deceased in each year, and about 1-2% of the total male deceased with age 20-29.[16] Intriguing is the sex ratio. The number of male *Haengryu* deceased is at least twice as large as that of the female *Haengryu* deceased. It seems to be because male were freer to be outside than female, or female might be easier to have a job than male.

The table also compares the number of *Haengryu* deceased with the total dead of the same age. Their share was about 1% for the male and 0.% for the female. Figure 1 illustrates their geographical distribution in 1933/5. The positive correlation between the two variables suggests that the Haengryu deceased data well represents whole Korean Peninsula.

IV. Height of the *Haengryu* Deceased Aged 20 to 30 during the colonial period

The key finding of this paper is Figure 2, changes in the average height of the *Haengryu* deceased aged 20 to 30.[17] The average height of the male Haengryu deceased increased by 2.9㎝ from 1913/5 to 1943/5. The transition from 1913/5 to 1943/5 is reasonably smooth, which supports the reliability of the height growth for the 30 year period. The t-test result reported together verifies that the height differences between years are in most cases statistically significant.

The average height of the female *Haengryu* deceased were about 14㎝ shorter than the male *Haengryu* deceased in the 1913/5. Their height grew by 6.2 ㎝for the thirty year period and the gender gap narrowed to about 10㎝. The t-test result shows that this growth itself is statistically significant. As the number of female observation is

16) Interesting is that the number of the male *Haengryu* deceased relative to the dead of the same age increased through time. It is hard to figure out whether this phenomenon came from increase of the Haengryu deceased or increase of reported *Haengryu* deceased

17) Unless noticed, statistic and number of observation based on all figure in this section is shown in Appendix 1.

rather small, this drastic growth of female height needs further scrutiny. However, this result supplements the finding from the male height growth.

For confirming this height growth, we examined several dimensions of the height information. First, we explored height change according to region. We divided Korean Peninsula into three – the North, the Middle, and the South – and measured height changes of each region.[18] Like the aggregate pattern, the heights of the male *Haengryu* deceased in each region all grew by 2.8-2.9㎝ (Figure 3). Although the South shows fluctuations in the 1930s, transitions from 1913/5 to 1943/5 are generally smooth. Intriguing is the regional hierarchy. The male *Haengryu* deceased of the North is the tallest, those of the South were the next, and those of the Middle were the shortest. Further analysis can shed a new light on the regional economic activities during the colonial period. The female heights by region also demonstrate the similar growing trend and hierarchy with the male heights.

Another factor to be explored is age composition. Since identity information of the *Haengryu* deceased was generally not available for municipal servants, the age recorded at the advertisement should be the best guess from their appearance. The age distribution of the *Haengryu* deceased in Figure 4 shows that the density of age is not even and the age of 20, 25, 30 has larger number of observations than other ages. This unevenness and the bias to certain numbers that are easily chosen for approximation support our inference.

We examined age pattern of the height several ways and found that this inaccuracy does not harm the result. First, although the number of the dead for each age in Figure 4 is not even, the distributional pattern across years is almost the same. This means that the standard of approximation did not change much. Therefore, potential noise from arbitrary assignment of age by civil servants might not be a big problem. Second, we measured the height by disaggregating the age group into three (Figure 5). They grew by about 2.4 to 3.4㎝, and the transition was reasonably smooth.[19] Combined with stable share of each age group, this pattern rejects the possibility that the growth of height in Figure 2 originate from composition changes among age groups.[20] Lastly, we

18) The North includes Pyungan-do, Hamkyung-do, Hwanghae-do, the Middle does Kyunggi-do, Kangwon-do, and Chungcheog-do, and the South does Cheonla-do (including Jeju Island) and Kyungsang-do.

19) Interesting is the hierarchy between age groups. Considering the height growth pattern of the human being, the fact that the height of the 27-30 group surpasses that of the 24-26-year group is not consistent with the general pattern. However, the self selection pattern of the Haengryu deceased can explain this finding. If a person fell into a desperate situation in their late 20s, their health condition in their mid-20s is not likely worse than those who fell into a critical condition in their mid-20s. The figure is consistent with this inference

20) See Appendix.

measured height of those whose identity is published in the advertisement. As mentioned earlier, the advertisement sometimes described name and/or hometown of the *Haengryu* deceased. This information is available sometimes because they were institutionalized before death, and so on. In such cases, their age information can come from the deceased themselves before death. As <Appendix> shows, about 19.4% reported information such as name or hometown. Figure 6 shows the height trend of the identified and the unidentified. Due to insufficient number of observation, the pattern of the identified show unstable pattern. However, the identified is taller than the unidentified, and their height grew from 1913/5 to 1943/5.

Discussion so far assumes that the height growth and living standard has positive correlation. However, someone might claim that in case of the male *Haengryu* deceased the average height growth could come from decline of living standard, not vice versa. The worsening of living condition would make the healthier fall into the hazard of being dead on the street and it might increase average height of the *Haengryu* deceased. Then the growth of height cannot be interpreted as the evidence of improvement of living standard.

One thing we can try to answer to this challenge is to examine the height by causes of death. The major cause of death recorded in the advertisement is definitely, "hunger", "cold", and both. Even for those who died of diseases hunger and cold mattered together. More than 70% of the dead were recorded as dying of income-related cause.[21] However, the remaining 20-30% died of accident like drowning or traffic accident, or committed suicide, or were sometimes murdered. If a person died of these reasons, they can be regarded as dead due to exogenous shock independent of income factor. And measuring height of these people can be free from the above causation problem. Because the number of the deceased died of accident/suicide/murder was quite small in the 1913/5, the pattern is somewhat vulnerable (Figure 7).[22] However, the figure shows that the height of accident/suicide/murder is growing, which is consistent with growth of living standard of Korean.

After all, we measured change of height through time after controlling all the factors reviewed so far. In Table 3, Estimation (1) only includes year dummy, which confirms the result of Figure 2. In Equation (2), we added age variable. The coefficient of the age variables are statistically significant, it reduces the average heights by about 0.1㎝. However, addition of dummies in equation (3) reduces the height by 0.7 – 1.0㎝. This

21) See Appendix

22) Additional problem is that the drowned people or railroad accident were quite decayed or destroyed, many of them could not show their height or even sex. They were, therefore, not used for this analysis.

implies that the height difference were affected by the causes of death. Equation (4) includes every available variable. Compared to equation (1), the height of 1923/5 decreased to 0.58㎝, and the difference from 1913/5 turns out to be statistically insignificant. However, the height of 1933/5 was 1.38㎝ taller than those of 1914, and the male *Haengryu* deceased of 1944 was 2.4㎝ taller than those of 1914, and both of them were statistically significant.

V. Concluding Remarks

We explored a long-standing issue in Korean economic history: did the living standard of Korean improved during the colonial period? We examined a new type of data source, the height of the *Haengryu* deceased. Study of this data not only helps answer to the question but also contributes to the anthropometric analysis in general. Researches of anthropometric work have utilized various data sources like slave record, army, passport, and so on. We added a novel source to this list.

Of course, our contribution does not simply lie on utilization of new data source. Our analysis provides a clear answer to the long-lasting controversy. The fact that the height of male *Haengryu* deceased grew by 2.4㎝ from 1913/5 to 1943/5 is consistent with quantitative analysis of economic condition during the colonial period. The next question to be explored is when the height growth started and how the trend went after the liberation. The *Haengryu* deceased can help answer to this question.

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Appendix 1 Height of the *Haengryu* Deceased by Categories

(1) Male

		1913/5	1923/5	1933/5	1943/5
Total	Height	157.0	158.7	159.2	159.9
	Observation	659	777	885	691
Region					
North	Height	157.8	159.3	160.5	160.6
	Observation	85	157	194	197
Middle	Height	156.6	158.3	159.4	159.5
	Observation	193	293	289	310
South	Height	157.1	158.8	158.4	159.9
	Observation	380	327	402	184
Age					
20-23	Height	155.0	155.9	156.6	157.8
	Observation	179	187	219	162
24-26	Height	157.2	158.5	158.8	160.6
	Observation	184	193	248	186
27-30	Height	158.2	160.1	160.7	160.6
	Observation	296	397	418	343
Identification					
Unidentified	Height	156.6	158.2	159.2	159.8
	Observation	565	522	725	613
Identified	Height	159.6	159.7	159.2	160.9
	Observation	94	255	160	78
Causes of Death					
Accident/Suicide/Murder	Height	156.2	160.0	161.1	161.0
	Observation	43	249	266	113
Disease	Height	157.9	158.7	158.5	159.9
	Observation	283	393	402	375
Hunger/Cold	Height	156.4	156.4	158.0	159.4
	Observation	333	135	217	203

(2) Female

		1913/5	1923/5	1933/5	1943/5
Total	Height	143.0	145.1	146.9	149.2
	Observation	122	204	343	173
Region					
North	Height	145.4	147.7	148.0	149.9
	Observation	19	34	61	30
Middle	Height	144.8	144.0	146.3	149.0
	Observation	34	94	109	70
South	Height	141.5	145.4	146.8	149.2
	Observation	69	74	173	73
Age					
20-23	Height	142.2	144.4	146.4	149.9
	Observation	37	74	114	39
24-26	Height	145.0	145.1	146.2	149.2
	Observation	32	46	102	51
27-30	Height	142.3	145.9	147.9	148.9
	Observation	53	84	127	83
Identification					
Unidentified	Height	143.0	145.4	146.7	149.1
	Observation	110	166	275	159
Identified	Height	143.2	143.9	147.7	151.1
	Observation	12	38	68	14
Causes of Death					
Accident/Suicide/Murder	Height	145.2	145.6	147.5	150.1
	Observation	26	55	102	55
Disease	Height	141.6	144.8	146.9	149.0
	Observation	36	92	150	68
Hunger/Cold	Height	143.1	145.4	146.2	148.7
	Observation	60	57	91	50

Sources: See the text

Table A. An example of Advertisement on the *Haengryu* Deceased

	Content	Reference
Date of Publication	July 14, 1923	
Permanent Address	Anseong, Kyungki-do	
Current Address	Unknown	
Name	Kwang-Yi Kim	
Ethnicity	Korean	
Sex	Male	
Age	30	
Feature	Height 163.6㎝, Average shape, nothing special	
Belonging	None	
Cause of Death	Heart Attack	
Place Found	Seoul Buddist Institute for the Poor	
Date of Death	May 18, 1923	Institutionalized on this date
Treatment	Temporarily buried at the cemetery of the institute	
The Municipality	Seoul	

Sources: The Official Gazette, July 14, 1923, p.150.

Table B. Number of Male *Haengryu* Deceased aged 20-30: Colonial Korea, 1913-1945

	Male		Female	
	The Heangryu Deceased, age 20-30	The total Deceased, age 20-29	The Heangryu Deceased, age 20-30	The total Deceased, age 20-29
1913	213	17,243	31	16,739
1914	281	16,402	39	15,490
1915	165	19,886	52	18,087
1923	294	16,396	75	
1924	268	14,077	59	
1925	215	13,894	70	
1933	378	13,925	145	14,137
1934	315	14,077	107	14,136
1935	192	13,894	91	14,309
1943	408	n.a.	90	n.a.
1944	227	n.a.	66	n.a.
1945	56	n.a.	17	n.a.

Sources: The Official Gazette, Statistical Yearbook of Korea Government-General

Table C. Change of the Height according to Time, 1913 – 1943

(1) Male

Dependent variable = height of the male *Haengryu* Deceased

		Male		
		(1)	(2)	(3)
Year Dummy				
	1923/5	1.68	1.52	0.58
		(0.38)***	(0.37)***	(0.39)
	1933/5	2.13	2.04	1.38
		(0.37)***	(0.36)***	(0.37)***
	1943/5	2.90	2.77	2.40
		(0.40)***	(0.39)***	(0.40)***
Age				
	age		3.50	3.02
			(0.64)***	(0.64)***
	age^2		-0.03	-0.05
			(0.01)***	(0.01)***
Region Dummy				
	middle			-0.07
				(0.29)
	north			0.67
				(0.35)
Cause of Death Dummy				
	Accidents/			2.29
	suicide/murder			(0.38)***
	disease			0.71
				(0.31)*
Identified				1.33
				(0.35)***
Constant		157.03		112.90
		(0.28)***		(8.01)***
R-squared		0.02	0.07	0.09
Observation		2,922	2,922	2,922

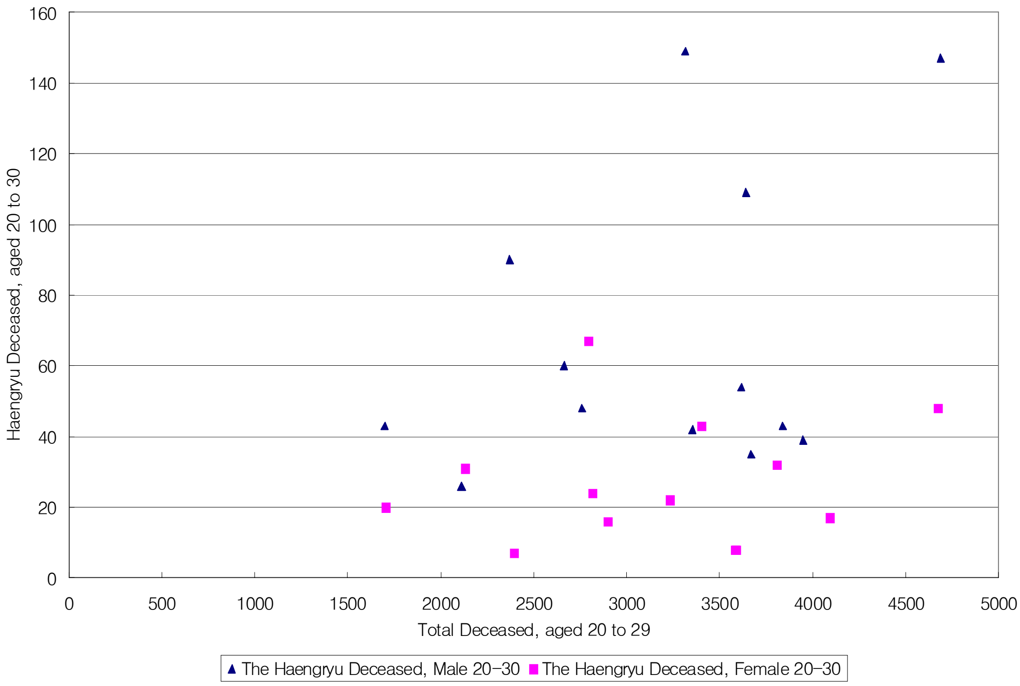
(2) Female

Dependent variable = height of the female *Haengryu* Deceased

		Female	
	(1)	(2)	(3)
Year Dummy			
1923/5	2.13	2.18	2.02
	(1.02)*	(1.02)*	(1.04)
1933/5	3.87	3.93	3.68
	(0.94)***	(0.94)***	(0.96)***
1943/5	6.22	6.17	6.02
	(1.05)***	(1.06)***	(1.07)***
Age			
age		-0.47	-0.37
		(1.47)	(1.48)
age^2		0.01	0.01
		(0.03)	(0.03)
Region			
middle			-0.15
			(0.69)
north			1.61
			(0.87)
Cause of Death			
accident			1.10
			(0.82)
disease			-0.04
			(0.75)
Identified			0.70
			(0.88)
Constant	143.01	147.25	145.50
	(0.81)***	(18.36)***	(18.42)***
R-Squared	0.05	0.05	0.06
Observation	820	820	820

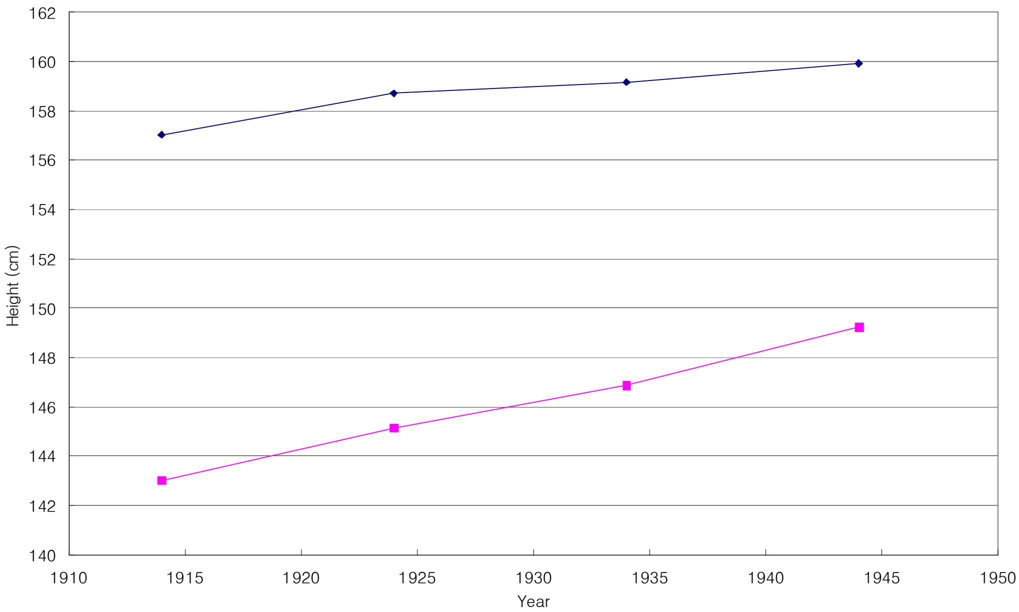
* = significant at the 10% level; ** = significant at the 5% level;
*** = significant at the 10% level;
Sources: See the text

Figure A. Geographical Distribution of the Male Deceased and the *Haengryu* Decased: 1933/5



Note: Each dot represents Korean provinces. Correlation Coefficient for the male is 0.38, for the female is 0.14.
Sources: See the text

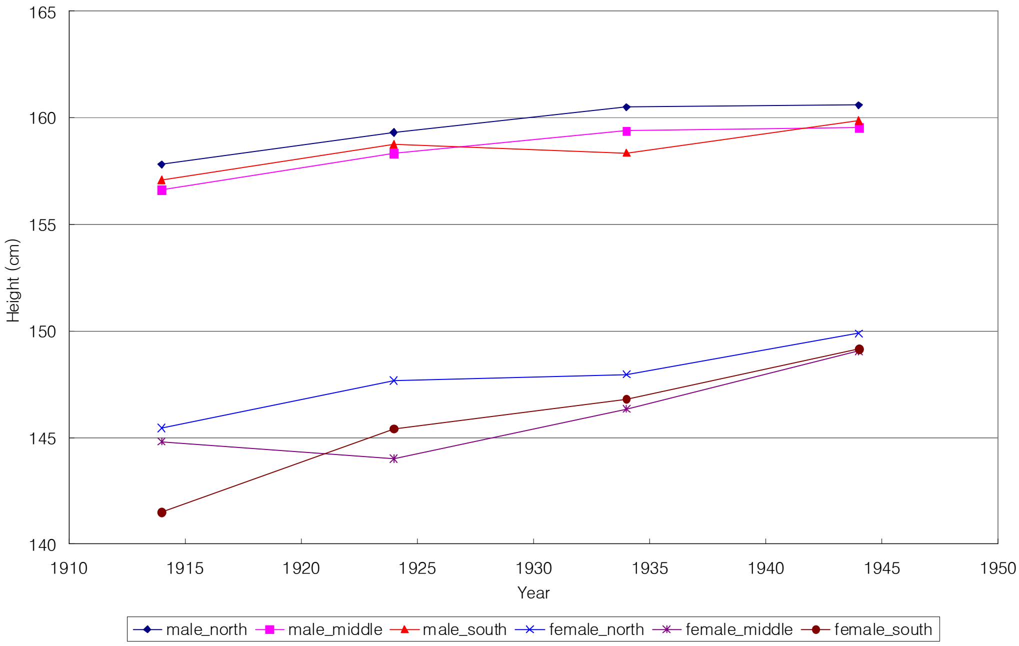
Figure B. Height of the Male and Female *Haengryu* Deceased, 1914-1944



	Height (cm)	Observation	Test of H0: height of year i = height of year j (i, j = 1913,23,33,43)		
			1923/5	1933/5	1943/5
Male					
1913/5	157.0	663	***	***	***
1923/5	158.7	777			***
1933/5	159.2	886			**
1943/5	159.9	691			
Female					
1913/5	143.0	122	*	***	***
1923/5	145.1	204		**	***
1933/5	146.9	343			***
1943/5	149.2	173			

Note: * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 10% level;
Sources: See the text

Figure C. Height of the *Haengryu* Deceased by Region, 1913/5-1943/5

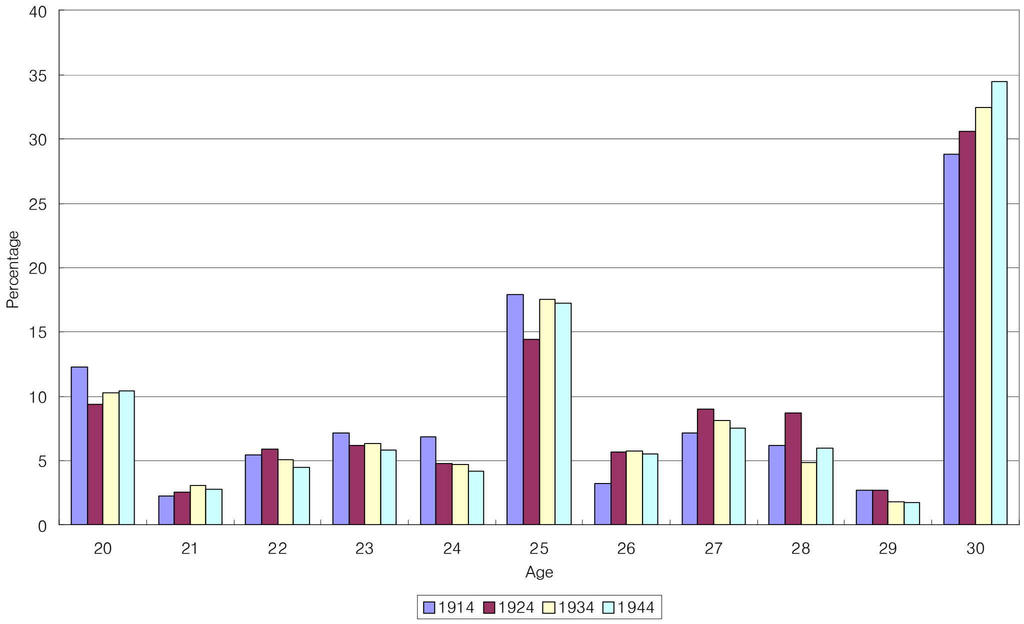


Note: Statistic and number of observation are reported in <Appendix>. In region, North includes Pyungan-do, Hamkyung-do, Hwanghae-do, Middle does Kyunggi-do, Kangwon-do, and Chungcheog-do, and South Cheonla-do (including Jeju Island) and Kyungsang-do.

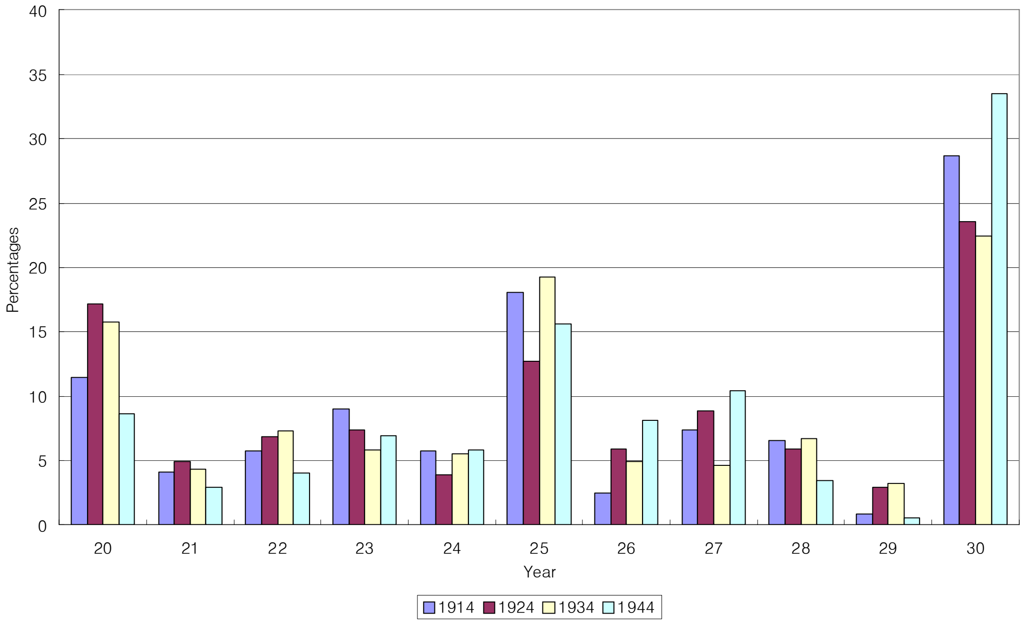
Sources: See the text

Figure D. Age Distribution of the *Haengryu* Deceased

(A) Male

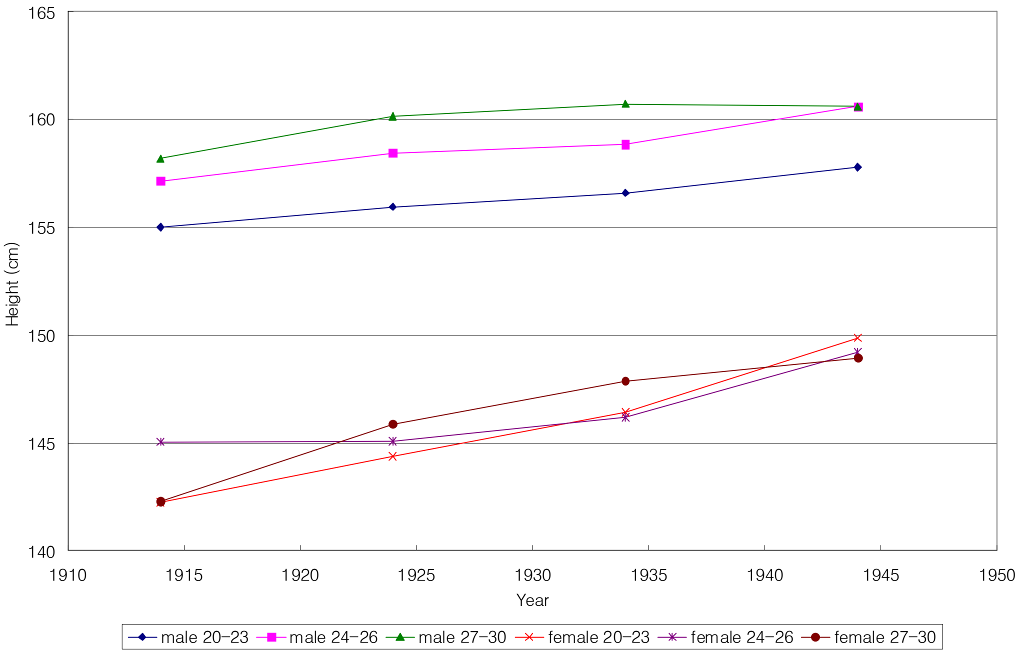


(B) Female



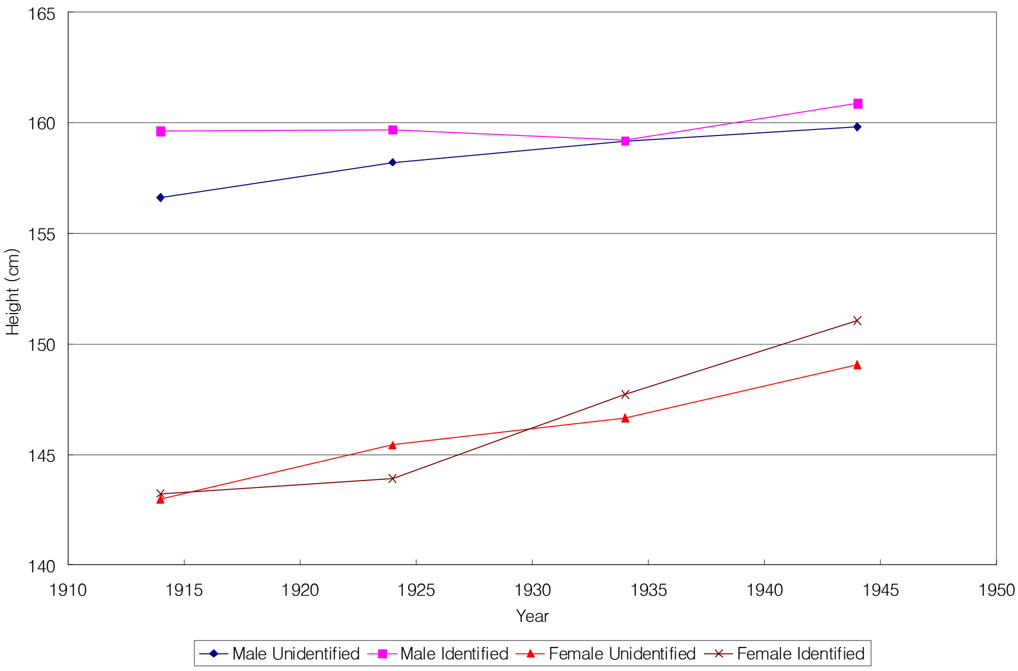
Sources: See the text

Figure E. Height of the *Haengryu* Deceased by Age Group



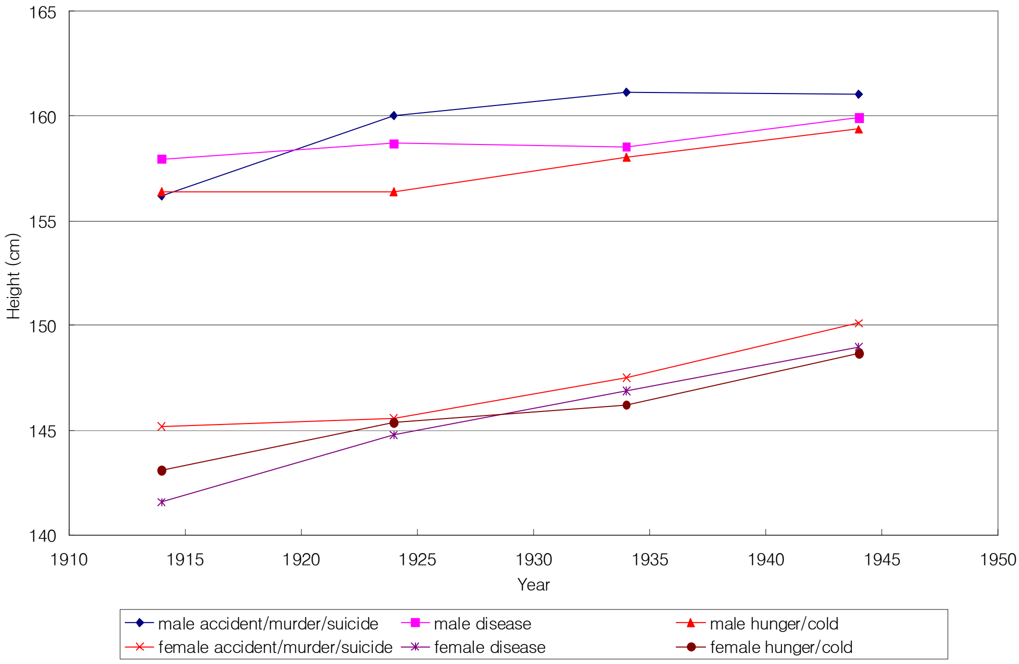
Note: Statistic and number of observation are reported in <Appendix>.
Sources: See the text

Figure F. Height of the *Haengryu* Deceased by Identification



Note: Statistic and number of observation are reported in <Appendix>.
Sources: See the text

Figure G. Height of the *Haengryu* Deceased by Causes of Death



Note: Statistic and number of observation are reported in <Appendix>.
Sources: See the text

Comments on "Living Standard of the Lowest: Height of the Male *Haengryu* Deceased in Colonial Korea"

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This article adds significantly to the on-going debate over the standard of living in colonial Korea in several respects. First, examining adult heights is perhaps a better approach to understanding the standard of living in the past than looking into incomes or wages. It is widely acknowledged that anthropometric measures such as height is a more comprehensive index of standard of living than conventional economic measures, because it is determined by both in takes of and claims on nutrition during the growing period. Since claims on nutrition are determined by various factors such as the hours and intensity of work and severity of disease environment, the size of stature reflects more general living conditions as well as economic status. Secondly, there is no consensus over the trend of adult stature in the colonial era in spite of growing literature pertaining to this issue over the last decade. A recent study by Choi (2006), cited in this paper, suggests that heights first increased and then decreased during the colonial period, based on various micro data. As rightly pointed out in this paper, however, it is unclear whether the observed cycle was real or an artifact of linking different (and possibly incomparable) sources. It is thus a significant contribution of this study to estimate heights based on a sample of (arguably) a homogenous population.

I would like to raise several questions below. I believe this study can strengthen its findings by clarifying these issues. First, it is not entirely clear whether the authors are looking at the individuals from the same segment of the society over time. The *Haengryu* deceased were those who were killed away from home. Thus, as geographic mobility increased and the traditional social networks weakened with urbanization, it is likely that these persons increasingly came from higher social classes. The authors attempt to address this selection bias problem by looking at the individuals killed by accidents. However, the backgrounds of these Haengryu deceased whose death was not directly related to poverty could have changed, too, because socioeconomic differences in the risk of experiencing a fatal accident may have changed over time. It would be helpful to know more about social and institutional backgrounds of the deaths on the road.

Second, it would be misleading to relate the adult height to the age and year of death, as this paper does. Adult height reflects the cumulative net nutritional status from pre-natal period to early twenties. In particular, nutritional status in pre- and neo-natal periods plays a critical role of determining the final height as well as health status over the lifetime. On the other hand, socioeconomic conditions or individual characteristics around the time of death of a person aged 20 and older have nothing to do with his/her height because it was determined much earlier. For this reason, it is more reasonable to estimate adult heights by cohort (year of birth), not by period (year of death). More specifically, it would be better to construct the X-axis of graphs and the dummy variables in the regressions based on the year of birth (or the year the person reaches a particular age).

Finally, the results of this paper, if accepted true, raise a further question: why did adult height increase during the colonial period? Was it attributable to the economic growth achieved under the Japanese colonial regime, as some economic historians argue? Unfortunately, existing estimates of per capita GDP and wages do not seem to be reliable enough to warrant this view. According to Cha and Lee (2008), moreover, wage inequality may have increased during the colonial era that should have diminished the average and low-class heights. Other potential explanations are decline in the relative price of food and improvements in public health. I suspect that improved public health might be the most important determinant of height and other measures of health in the early stage of development. Looking into the health impacts of these factors should be a fruitful way of making the finding of the study more convincing.

CHAPTER IV-3

Socioeconomic determinants of health in North Korea

by

Daniel Schwekendiek*

Abstract

North Korea has survived the breakdown of the communist bloc and has been immune to the democratization process of the 1990s. In spite of national famines and economic collapse, the totalitarian regime in Pyongyang maintains a firm grip. Reliable information on the population's biosocial welfare is scarce. Using height and weight data of 5991 North Korean pre-school children, we investigate socioeconomic determinants of height-for-age (HAZ), weight-for-age (WAZ) and weight-for-height (WHZ) z-scores as an indicator for public health. We find a statistically significant impact of the age of the child and mother, as well as the sex of the child on HAZ and WAZ. In contrast, social status and wealth proxies at the individual and household level are not statistically significant. We do not find a consistent effect for geographic regions or for rural-urban residents. Yet, urban provinces seem to be better-off. Most importantly, we find that children living in families who benefit from food aid of the United Nations are more healthy in terms of HAZ, WAZ and WHZ than those depending on the government. Hence, further delivery of United Nations food aid is likely to mitigate the effects of the ongoing food crisis in North Korea.

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I. Introduction

Until today, the Democratic People's Republic of Korea (DPRK) - has survived the breakdown of the communist system and has largely been immune to the democratization process set off in Eastern Europe in 1989. In spite of national famines and economic collapse, the totalitarian regime in Pyongyang maintains its power over its people and makes hardly any reliable information on their welfare available to the public. Since the regime's economic performance is quite well reflected in the health status of the population, research on the living standard of North Koreans has certainly a political, let alone a humanitarian, dimension. It is for this reason that the government provides so little reliable and replicable information on the health of the nation. Since the partition of the Korean peninsula following World War II, Pyongyang has completely sealed itself off from the rest of the world.

However, over the last decade, a number of nutrition surveys were published which were carried out by the United Nations in collaboration with North Korean agencies. In fact, they provide first-hand evidence on the health of North Korean children. However, the reports published so far primarily limit themselves to the mere documentation of the magnitude of child malnutrition. The aim of this paper is to test a number of determinants of child health in a multivariate context. We discuss a set of potential health determinants which are subdivided into the seven subsections of human biology, social status, household dependency, nutrition, rural areas, household size and provinces. We focus on the post-famine year 2002 in order to relate the results obtained here to the present situation in North Korea, which has probably remained the same in terms of the underlying socioeconomic mechanisms.

It should be mentioned that all of the surveys initiated by the United Nations were carried out on North Korean territory – a fact which will be reviewed critically below. Apart from this, North Koreans living outside the country were also measured: Pak (2004) obtained children's height and weight data by measuring North Korean refugees entering South Korea from 1999 to 2003. Comparing sample data used in this paper to the refugee sample, we find that malnutrition indicated by height-for-age are (9.2%-points) lower, whereas malnutrition rates based on weight-for-age are (28.8%-points) higher.[1)]

1) See Pak (2004), table 7.

II. North Korea in the post-Cold War era

Even though qualitative evidence suggests that North Koreans were already suffering from nutritional stress in the 1970s (Lee, 1999), one rare account exists of a systematic survey carried out in 1987 prior to the onset of the famine. This survey should indicate the nutritional status near the end of the Cold War. Though the survey was based on the Kangwon province only, "[…] it did not find evidence of widespread malnutrition that characterized the province a decade later" (Smith, 2004).

The end of the Cold War did not affect North Korea which managed to maintain communism by controlling the media and the population to an extreme degree. As a consequence, Pyongyang became both politically and economically isolated. With the collapse of the Soviet trade system which was largely based on political concessions rather than economic incentives, North Korea suddenly had to pay in convertible currency for basic agricultural imports such as food and fertilizers. Since its foundation, North Korea had depended on food subsidies from the Soviet Union, as the country cannot produce enough food on its own. This is because only 20% of the country's soil is arable land. Even in 2004 when the best harvest within a decade was brought in, it is estimated that North Korea was still lacking 500,000 tons of cereals for feeding its people in the year to come.[2] Moreover, North Korea's economy was formerly driven by a heavy industrial sector, which broke down completely when formerly subsidized goods such as energy and spare parts for machinery could no longer be afforded on the basis of market prices. The situation was aggravated severely when the country was hit by floods in 1995 and 1996 which can largely be attributed to the El Nino weather anomaly. Since then, North Korea appealed for and also received food aid as well as international assistance for its agricultural sector. Malnutrition peaked around 1998 (figure 1). Thereafter, the country more or less managed to cope by making political concessions in return for international aid ('food for talks'). As early as July 2002, Pyongyang introduced structural reforms to gradually transform its centrally planned economy to a more market based system (Kim, 2006) – following China's successful strategy of government- controlled capitalism under the label of communism.[3]

2) "Despite Bumper Crop, N. Korea Lacks Large Amounts of Food: Report." Yonhap News, November 23, 2004.

3) Officially "Socialism with Chinese characteristics"

III. Data

We investigate the determinants of child health in the post-famine period. In general, child welfare can be measured by the three indicators stunting, wasting and underweight which were first established by the United Nations (Waterlow et al., 1977; WHO, 1995) and were also reported in the few surveys available on the DPRK. Stunting is defined as the percentage of children falling below -2SD for height for age (HAZ), and underweight as the percentage of children falling below -2SD for weight for age (WAZ). Wasting is defined as the percentage of children falling below -2SD for weight for height (WHZ). Stunting, reflected by deficits in height per age, is an indicator of nutritional status but does not quickly change over short periods of time. The use of wasting and underweight can help us to better understand the short-term or acute consequences of nutritional stress. Based on published survey reports, the prevalence of stunting, wasting and underweight in the DRPK is shown in figure 1 for the available years.

However, let for our own analysis, we will not apply the z-score cut-offs below – 2SD but analyze the continuous z-score values in order to explain the underlying causes of individual growth failure.

We here use the nutrition survey carried out in 2002. which was published by the Central Bureau of Statistics of the DPRK and international agencies (CBS et al., 2002). Access to this data was granted to the author by the United Nations with the agreement of the North Korean government, an official co-owner of the dataset. In 2002, the United Nations and its agencies, in cooperation with North Korean authorities, obtained permission to carry out a nutrition survey in the country (CBS et al., 2002; Shrimpton and Kachondham, 2002). Anthropometric and biological variables - height, weight, age and sex - were recorded from 6000 children under the age of seven years.[4] Additionally, them others of selected children were asked to participate in a multiple indicator cluster survey from which the socioeconomic information on the child's household comes. Children, and thus households, were selected randomly, though some areas were previously declared inaccessible by the government – for a further discussion on this, see the next section.

We seek to investigate North Korean health conditions in the post-famine period. Although the famine seems to have been overcome by the year 2002 (figure 1), nutritional stress did continue. As late as 2004, almost 4 out of 10 North Korean

4) We here declared nine observations invalid due to data entry errors. Note that HAZ, WAZ and WHZ were based on the 1977 NCHS/WHO reference curves.

children suffer from chronic malnutrition (HAZ<-2), and as indicated by the WAZ, malnutrition seems to have slightly risen most recently. Understanding the underlying mechanisms of child malnutrition is thus of crucial importance, as it might help to improve the current situation in North Korea.

Let us bear in mind that a fully representative survey is lacking for North Korea. The 2002 survey is conceptually the best survey available due to its large sample size, somewhat random sampling, and also in view of its supra-regional representativeness. All nutrition surveys conducted by the United Nations in the DPRK suffer from a pre-selection bias. For instance, in 1997, the WFP obtained permission to carry out a survey in 40 North Korean kindergartens and nurseries, with all institutions being chosen by the government (Katona- Apte and Mokdad, 1998). In the same vein, children measured for a survey in the year 1998 (EU et al., 1998) and in the year 2004 (CBS, 2004), as well as for the 2002 survey used here were not randomly selected, either.[5] This was mainly because some 20% of the counties were declared inaccessible by North Korean authorities on the grounds of 'security concerns.' In the sampling process for the 2002 survey, all third-order administrative units (Dong and Ri) - whether located in an accessible area or not - were considered as primary sample units, with weights being assigned for population density. Hence, out of these primary sample units, only 3.5% had to be substituted because of inaccessibility issues (Shrimpton and Kachondham, 2002). It is thus clear that the survey is at least representative of the majority of children living in North Korea. As illustrated in figure 2, taking into account the limited sampling macrocosm, almost all geographic regions of North Korea are included in the 2002 survey. It is also remarkable that 10 out of 12 provinces are covered.

Beyond this methodological issue, it may be alleged, that some answers of the interviewees may be biased due the presence of North Korean authorities. It is a fact that the totalitarian government does not tolerate dissident opinions – even a small gesture or sentence can be interpreted as criticism against the communist regime. In that case, the person - sometimes the whole family – can be severely punished and sent to a concentration camp. Yet, this will not play any role for the anthropometric variables weight and height, which we mainly consider here. However, the socioeconomic household questionnaire may have been biased: mothers might have opted to give 'loyal' answers rather than responding accurately. Sometimes, interviewees might have exaggerated their answers to praise the communist system, whereas in other cases, they might have opted for understatement to protect themselves or their families.

5) The year-2000 survey was not conducted by the United Nations but by North Korean agencies, and is thus not very reliable.

Table 1. Cross tabulation BCG vaccination and BCG scar

		BCG scar		Total	N
		No	Yes		
BCG given	No	251	37	288	absolute
		87%	13%	100	relative
	Yes	80	2388	2468	absolute
		3%	97%	100	relative
		331	2425	2756	Total

Notes: p-values for Chi square and Fisher's exact test = 0.00;
Only mothers of children under 2 years of age were interviewed.

There are two possibilities to explore the extent of a potential interview-bias in the totalitarian context of North Korea. The first is to look for consistencies within the UN survey. We therefore resort to the variable BCG which was collected twice in the survey.6) At first, it was asked whether the child ever received a BCG vaccination (against tuberculosis). Here, the mother had to answer 'yes' or 'no.' Interviewees could have chosen to answer 'yes' in order to approve the reputation of Kim Jong Il's medical care system as one of the great achievements of communism. In a second step, the child's shoulder was visually checked for the presence of a BCG scar. As seen in table 1 where we show the cross tabulation between the physical presence of a BSC scar and the previous answer of the mother, there are no large distortions in the answers. Only 16% of the mothers gave the wrong answer. Most importantly, mothers did not exaggerate their answers because in fact, more children had a BSG scar than admitted by the mothers. This result may simply have been caused by the unawareness of some mothers that a doctor vaccinated their child against tuberculosis. Yet, we cannot rule out the interviewers bias here: mothers might not have recognized the implication of their answers as vaccination is not necessarily a politically sensitive issue.

The second possibility for detecting the effect of the presence of North Korean authorities during the interviews is to compare the UN survey to a refugee survey conducted outside of the country – notably in China. There, North Korean interviewees are not under political pressure. We compare 1995 household data which was collected from North Korean refugees residing in China and reported by Robinson (2001) to that of the UN survey carried out in 2002. In both surveys, the interviewees were asked to

6) BCG, or bacille Calmette-Guérin, is a common vaccine against tuberculosis.

identify the household's main source of food.[7] For the 2002 survey, we would expect mothers to answer more frequently that they were dependent on the government and thus the PDS, so as to give credit to the communist system. We would also expect that farmers or market sources are rather under reported, as these can be associated with capitalist and thus Western structures. However, as suggested by figure 3, we do not see large differences between North Koreans living in and outside of the country – differences found here may be due to changing patterns over time, or to the selection bias in the refugee sample. Thus, it may be assumed that the 2002 survey data seem good enough to be worth analysis even though if it is not perfect. There still may be some questions that are biased.

IV. Health determinants in North Korea

What has determined child health in the post-famine period? As mentioned above, we consider the common health indicators HAZ, WAZ and WHZ as endogenous. Each of these three variables (y) is in turn analysed using an OLS regression model with a set of socioeconomic, demographic and geographic variables (table 3). We first considered our basic model being discussed below (table 3, regressions 1 to 3), and then discarded statistically irrelevant variables by making use of stepwise selection methods (table 3, regression 4 to 6). Furthermore, as two sets of variables come out insignificant in regressions 1 to 6, we excluded these sets (regressions 7 to 12) to show the results of the basic model without these variables. When comparing regressions 7 to 12 to the basic model (regression 1 to 3), it is notable that conclusions do remain the same.

7) To compare the categories of answers within the surveys, we equalled "Buy" or "Barter" to "Farmers or markets;" "Grow" to "Own production" and "Govt. Ration" to "PDS," see figure 3.

Table 2. Summary statistics

Variable	Percent	Mean	SD	Min	Max
HAZ		-1.72	0.99	-5	4
WAZ		-1.48	0.86	-5	3
WHZ		-0.50	1.00	-4	5
Age of mother at measurement		30.76	4.11	21	45
Age of child at measurement		2.58	1.80	0	7
Household size		3.97	0.77	3	9
Male	51.94				
High education of mother	23.97				
Refrigerator	6.49				
WFP	7.38				
PDC	57.79				
Farmer	34.66				
Own production	0.15				
Markets	0.02				
Rice or maize stored	78.29				
Pulses stored	69.46				
Vegetables stored	97.81				
Fruits stored	25.50				
Rural Area	42.47				

Note : Hight education = post-secondary education

Table 3. Determinants of North Korean child health in 2002

		Basic regressions			Stepwise multiple regressions			Regressions excl. nutrition*			Regressions excl. nutrition and status*		
		HAZ	WAZ	WHZ	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ	HAZ	WAZ	WHZ
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
	(Constant)	-1.36	-1.42	-0.41	-1.52	-1.39	-0.24	-1.58	-1.42	-0.44	0.12	-1.41	-0.44
Bio-logy	Age of mother	0.01	0.01	0.01		0.01		0.01	0.01	0.01	0.00	0.01	0.01
	Age of child	-0.11	-0.07	-0.04	-0.10	-0.07	-0.03	-0.11	-0.07	-0.04	0.01	-0.07	-0.04
	Sex of child (Male=1)	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	0.02	-0.07	-0.07
Sta-tus	High education of mother (yes=1)	0.05	0.02	0.00				0.05	0.02	0.00			
	Refrigerator in household (yes=1)	0.05	0.05	0.04				0.06	0.05	0.03			
De-pendency	WFP	0.29	0.25	0.16	0.30	0.23	0.14	0.29	0.24	0.15	0.05	0.24	0.15
	PDS (ref.)												
	Farmers	0.02	-0.01	-0.02				0.02	-0.01	-0.02	0.04	-0.01	-0.02
	Own production	0.02	-0.19	-0.22				0.01	-0.20	-0.23	0.32	-0.20	-0.23
	Markets	1.83	1.09	-0.03				1.82	1.31	-0.06	0.95	1.29	-0.06
Nutrition	Rice or maize stored (yes=1)	0.01	0.02	0.02									
	Pulses stored (yes=1)	0.00	0.01	0.02									
	Vegetables stored (yes=1)	0.07	-0.02	-0.06									
	Fruits stored (yes=1)	0.03	0.01	-0.03									
	Rural area (yes=1)	-0.03	0.00	0.02				-0.03	0.00	0.02	0.04	-0.01	0.02
	Household size	-0.03	-0.04	-0.04		-0.04	-0.03	-0.03	-0.04	-0.04	0.02	-0.04	-0.04
Province	Pyongjang	0.28	0.25	0.11	0.32	0.24		0.29	0.26	0.11	0.06	0.27	0.11
	Nampo	0.39	0.39	0.19	0.44	0.38	0.14	0.40	0.39	0.19	0.06	0.40	0.20
	Kaesong	0.00	0.23	0.31		0.21	0.26	0.00	0.23	0.31	0.06	0.24	0.31
	South Pyongan	-0.01	0.05	0.11				-0.01	0.05	0.12	0.06	0.05	0.12
	North Pyongan	-0.03	-0.10	-0.11		-0.12	-0.17	-0.02	-0.10	-0.11	0.06	-0.10	-0.11
	South Hwanghae	-0.09	-0.09	-0.01		-0.12		-0.09	-0.09	0.00	0.06	-0.09	0.00
	North Hwanghae	0.18	0.16	0.07	0.21	0.15		0.19	0.17	0.07	0.06	0.17	0.07
	South Hamgyong	-0.26	-0.23	-0.09	-0.23	-0.25	-0.15	-0.25	-0.23	-0.09	0.06	-0.23	-0.09
	North Hamgyong (ref.)												
	Ryanggang	-0.19	-0.25	-0.17	-0.16	-0.28	-0.23	-0.19	-0.26	-0.17	0.06	-0.26	-0.18
	adj. R sq.	0.078	0.079	0.023	0.077	0.079	0.023	0.078	0.079	0.023	0.078	0.079	0.023
	N	5991	5991	5991	5991	5991	5991	5991	5991	5991	5991	5991	5991

Notes: Shadowed areas = signficance on the 10% level WFP = Word Food Program; PDS = Public Distribution System.

1. Human biology

We controlled for the age of the mother in years. For biological reasons especially younger and older women have less healthy babies. Thus, we first considered a nonlinear, inverted U-shaped relation between the age of the mother and the health outcome of her child. However, as seen in Table 2, the mean age of the mothers is 31 years - with a rather small standard deviation. Moreover, we find a minimum-maximum of 21-45 years of age; thus we can clearly rule out teenage and old-age pregnancies playing a biological role here. This is likely a result of the North Korean military draft in which men (and also many women) commonly serve in the army for years before they wed and raise a family. Therefore, we do not see a non-linear relation between the age of the mother and the health outcome of the child, which is why we refrained from entering a squared variable for the age of the mother in our model,[8] and just focused on a linear relation.

We consistently find a significant and positive effect of the age of the mother on the indicators HAZ and WAZ: older mothers seem to have healthier babies (table 3).[9]

We next consider the effect of sex and age in years of the child at the time of measurement. There is no evidence of gender preferences, as the communist system successfully promoted a public role for women in society (Goodkind, 1999). For all these reasons, we it seems probable that variations in health status by the age and sex of the child are largely due to the human biological effects of the famine.

Older age cohorts seem to have been more affected during the crisis years (table 3). This is plausible: in 2002, nutritional stress continued as a matter of North Korea's ongoing and considerable national food deficit - even though the extreme famine years of the mid 1990s were over by that time. Thus, the more crisis years children were exposed to, the less healthy they were. We find this cumulative effect in regression 1: stunting in body height directly reflects chronic malnutrition, and we therefore see a larger coefficient for the variable age of the child compared to regression 2, which is based on weight outcomes.

Beyond this, we see a significant and negative effect on the health of boys: they seem to be affected more in crisis times because of their genetic predisposition.

8) This result is not reported here.

9) Note that children measured are not only first births. Age of the mother refers to the age at the time of measurement.

2. Social status

Second, we control for the social status of the families. This is quite an issue, as the privileged groups in North Korean society are the military cadres and their families. Were privileged households saved from starvation because of their exclusive access to food during national crisis periods (Sen, 1981)? An alternative interpretation could be that a higher social status of the parents can be associated with an overall higher income and better general education. Either way, we consider two relevant variables. The first variable is a dummy for the education of the mother.[10) In 2002, some 24% of the mothers interviewed reported to have a higher education (Table 2). In the North Korean system, only 'loyal' citizens enter university for political reasons. These are frequently offspring of military cadres. Therefore, the fact that an individual has an academic background is a strong indicator of the present and past status of the family. In addition to this, we use a dummy variable whether the household possesses a refrigerator or not. In North Korea, a refrigerator – like a TV set or any other electronic device - is a clear status symbol, and only 6.5% of North Korean families possess one (Table 2).[11) Families who managed to obtain a refrigerator have generally direct linkages to the communist party and can be regarded as very loyal to the system. Another advantage of taking this second variable into account is that the education of the mother only indicates the wife's social background.[12)

Based on our estimations (table 3), we do find a positive but insignificant relationship between these two variables and the anthological variables. This unexpected result may be due to the fact that the survey was conducted in the post-famine period, by which the nutritional situation had largely improved due to the flow of international aid and major advancements in North Korea's agricultural sector. Another possible explanation is that these variables are unreliable on account of their potentially sensitive nature.

10) Data on the education of the father were not recorded.

11) In North Korea, electronic devices have to be imported. Thus, they are very expensive and also much desired by North Koreans. Because the variable refrigerator also has nutritional implications, we would have preferred to control for TV sets or cars. However, such data was not collected in the survey.

12) By considering the refrigerator variable, we can also control for the father's social status, as the husbands are frequently the principal earners in the family.

3. Household dependency

Third, we enter a comprehensive set of household dependency variables. Dependency is also quite debated in the North Korean context. Natsios (2001) has pointed out the basic coping mechanisms of North Koreans during the food crisis. The basic question raised is from where households received their food during the crisis. Several hypotheses will be tested here. One of these assumes that the official public distribution system (PDS), which is the basic channel through which the government supplies its people, has the most significant impact. Note that there have been reports that the PDS was abolished, but in fact, it continues to be operational even today – although the rations allocated through it declined substantially during the famine years. A diametrically opposed hypothesis is that families did not rely on governmental provisions but looked for food on private markets, which are commonly represented by farmers' grey- and black markets.[13] A further assumed coping mechanism is self-supply: home production, most likely garden farming, will make households less vulnerable as they do not have to rely on the government or spend money on private markets. Beyond this, international food donations can be supposed to have been a considerable source of food during the crisis. Most importantly, food aid distributed by the WFP might matter here, as the United Nations are by far the largest donor. Unlike European or South Korean aid, UN aid is generally not channeled through the PDS but directly allocated to child care facilities etc. Besides, its distribution is also monitored more closely (though on a rather random basis). We therefore hypothesize that households benefiting from WFP aid might be better-off.

In addition to this, it is also assumed that foraging was a common source of food during the crisis years. However, in the 2002 survey, none of the households reported foraging as a major coping mechanism. Furthermore, kinship support was also assumed to be a major source of food. In particular, support from abroad might have played a role, as it is known that relatives residing in Japan sent a lot of aid by mail. Yet again, in 2002, no household reported it – so we assume that this coping mechanism does not matter too much. Also, note that during the interviews, households were asked to identify only the primary source of stored food – which we considered as a household dependency proxy in our analysis. Therefore, we cannot rule out that kinship support and foraging might have had supplementary, yet statistically systematic effects on child

13) Farmers' markets are semi-legally and tolerated by the government. Historically, the farmers sold their extra output on local markets which were opened in every county (Savada, 1994). During the famine years, farmer's markets were assumed to become an important source of food when governmental provisions stopped.

health.

According to Table 2, the PDS (58%) and the farmers' markets (35%) seem to play by far the most important role in the supply of the households, whereas own production or (black-)markets seemed to be of less importance in 2002. WFP aid seems to play a substantial but not dominant role in the daily provisions of North Koreans, as a considerable 7.4 percent of the households depend primarily on these donations (Table 2). In our multivariate analysis where we selected the PDS as reference category, we indeed detect statistical differences between household dependencies (table 3). Households that primarily relied on WFP aid during the food crisis are generally better-off. Moreover, we find that households whose most common food source are the markets seem to be better-off than those of the reference category. However, this effect does only come out significant for the HAZ regressions. As an overall result, it may be concluded that the delivery of food aid through the United Nations can be assumed to mitigate the effects of the ongoing food crisis in North Korea.

4. Nutrition

Fourth, because health outcomes based on height or weight measurements basically indicate net-nutritional status which is largely subject to direct nutritional intake, we controlled for a number of food items that households reported to have stored. We used dummies which state whether the main North Korean staple crops (rice or maize) are stored, whether any pulse crops are found in the household, whether vegetables are stored, and if fruits are stored. Note that the variable for staple crops enables us to control for calories. Pulse crops are a close proxy for proteins, and vegetables or fruits might quite well reflect vitamin consumption. As seen in Table 2, roughly 3/4 of the households reported to have stored main staple crops or pulse crops, and almost 98% of the households reported to have stored vegetables. These seem to be quite high rates, given the ongoing food crisis in North Korea. However, let us remember that the survey was carried out during the early fall season, when the national harvest was just brought in. Thus, it is likely that the average stock of food found in the households throughout the year was most likely overestimated.

Judging from table 3, none of these nutritional variables come out statistically significant for the three weight or height-related indicators. This is somewhat surprising as one would expect that the gross and net nutritional variables, i.e. food and anthropometric health outcomes, should be highly correlated. As mentioned above, the fact that any of these food items are present in the household does not necessarily reflect food security throughout the year - we definitely cannot rule out seasonal measurement errors concerning these variables. As mentioned above, we also might consider a political bias in the answers of the mothers here.

5. Rural areas

Fifth, we wanted to see if residence in rural versus urban areas affects child health. We here consider third-level administrative units, rural Dong versus urban Ri, as a basic distinguishing criterion. According to Eberstadt and Banister (1992), even the North Korean authorities take the Dong and Ri classification as the basis for the calculation of urban and rural population figures. During the North Korean food crisis, it is argued that rural areas were better-off compared to urban ones (Schloms, 2004) due to direct access to agricultural products in villages, so we expect that cities – thus urban areas - are worse-off. All in all, we find that some 42% of the sampled children reside in rural areas (Table 2), so only a slight majority seems to live in urban districts.

As seen in table 3, we do not find a statistically significant coefficient for the rural dummies in regressions 1-3. As to the sign, we also see no consistent effect across the regressions. Beyond this, let us also consider that the abovementioned pre-selection of areas might play a role here. Thus, the survey does not account for the most isolated rural areas, where the picture might look fundamentally different.

6. Household size

Sixth, we entered the number of people living in the household into our regression. We here hypothesized that a larger household size decreases health outcomes, since more members will compete for given and scarce resources during a national food crisis. As seen in Table 2, the average household size was 3.97 persons, and the minimum household size was three. Thus, it is likely that the parents of the selected child were still alive. Otherwise, we would assume a non-linear relation, as a deceased mother or father would leave a pre-school child more vulnerable.

Based on our regression analysis, we indeed find negative and statistically significant coefficients for household size: a larger number of competing members decreases the HAZ, WAZ and WHZ of children (table 3). Thus, there seems to be a systematic intra-household effect on health. Most importantly, as mentioned above, we do not think that this is a result of allocation preferences within the family but simply a size-effect during an ongoing food crisis, when by definition, resources were scarce.

7. Provinces

Last but not least, we entered a set of province dummies into our regression model to control for unobserved regional characteristics such as the local economy, infrastructure, etc. Also, by looking at provinces, we can address three further concerns that are frequently raised. The first is that the northeastern provinces were reported to have been placed in triage in the 1990s (Natsios, 2001; Noland, 2003). As the food crisis became visible, the government decided to systematically abandon the northeastern provinces which were not really important from a military point of view. The second concern is that provinces located near China (North Hamgyong, Ryanggang, North Pyongyang) should be better-off, as people started to do (illegal) cross-border trade with ethnic Koreans living abroad. The third issue is that - even though we control for the social status of the household - it might make sense to control for city provinces, especially the capital Pyongyang: North Korean families are frequently rewarded for their loyalty to the regime by being moved to Pyongyang or other city provinces which are the showcases of the country. Note that North Korea is subdivided into nine provinces (Do) and three municipalities (Chikalsi) which are administratively equal. Therefore, we would expect to see a positive effect for the three municipalities (Pyongyang, Nampo and Kaesong) compared to the rest of the country.

Judging from our regression analysis (table 3) where we selected North Hamgyong as reference category, we can consistently support the argument that children living in municipalities are healthier in terms of HAZ, WAZ or WHZ. As to the triage and cross – border trade-hypotheses, we do not get a clear picture because significant levels and signs vary largely across the three regressions – hence let us not overemphasize the results obtained here.

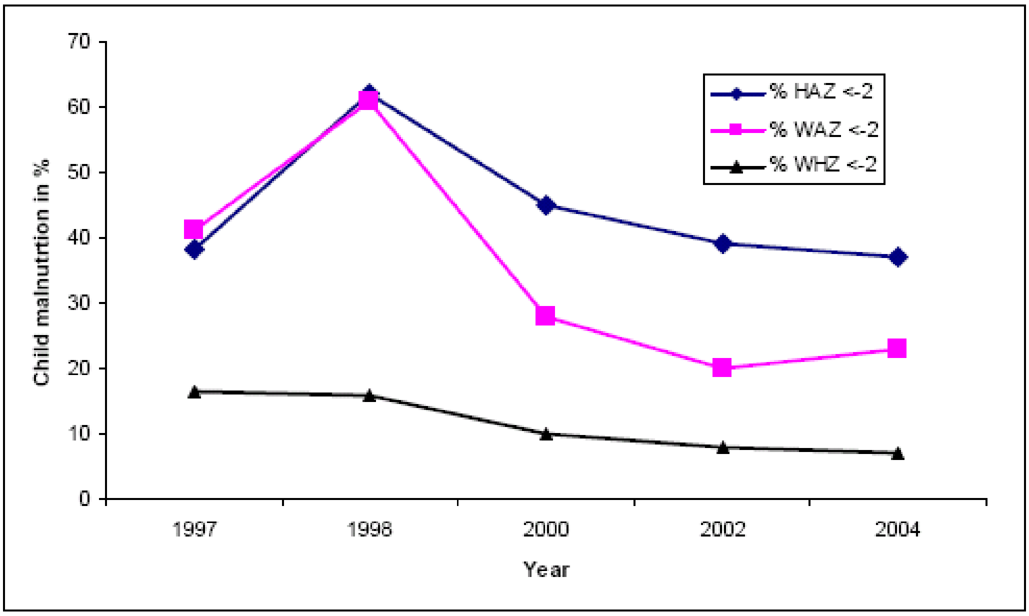
V. Conclusion

This paper aimed at investigating the determinants of the health of North Korean children brought up in the post-famine period. Specifically, the period after the famine peak might be of particular research interest, as the prevalence of child malnutrition remains alarmingly high to this day. Therefore, understanding the causes of child growth failure could help to improve the situation for future generations raised in North Korea.

We therefore resorted to a household survey carried out by the United Nations in cooperation with North Korean agencies in 2002, which measured the heights and weights of 6000 children. Along with obtaining anthropometric data which are robust against political manipulation, the mothers of the selected children were interviewed on the socioeconomic situation of the household. As North Korean authorities attended these interviews, we investigated if personal answers were politically biased. By looking at consistencies within the survey and comparing it to a refugee survey conducted among 'free' North Koreans residing in China, we did not see large distortions in the answers and concluded that the survey data are good enough to be considered for our analysis. In addition, the fact that the government systematically excluded some counties from the random sampling process will hardly matter for the overall results, as only 3.5 percent of the children in the sample had to be replaced because of this. Hence, even if the 2002 survey is not geographically representative of the whole country, it at least reflects the health status of the overwhelming majority of North Korean households.

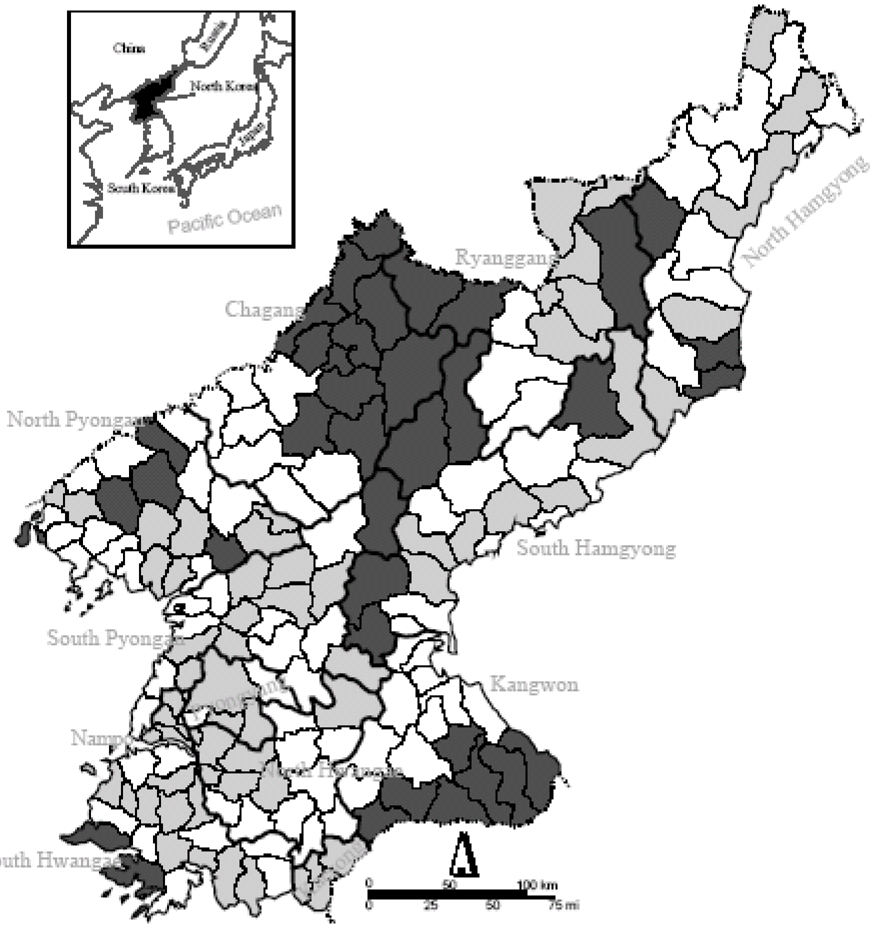
In our analysis, we paid particular attention to a comprehensive set of socioeconomic variables which were qualitatively assumed to have had an impact on the North Korean people. Moreover, we tested the biological variables sex and age, arguing that these are not likely to be subject to intra-household allocation biases like gender or birth order preference. Our main findings are that older children and specifically boys suffer more during crises, whereas the age of the mother seems to have a positive effect. Furthermore, social status, whether measured by the education of the mother or by the presence of a refrigerator in the household, does not come out statistically significant. Most importantly, we find a statistical impact for household dependency on the WFP: households primarily benefiting from international food aid seem statistically better-off than those relying on the government or farmers. Additionally, a set of food variables comes out statistically insignificant in the specified models. Controlling for rural areas, we see no effect on child health. However, household size has a negative statistical impact: a higher number of family members decreases the health status of the children. Finally, we get rather ambiguous results for the set of regional dummies for the administrative provinces. Across all regressions performed for the different height and weight-related health indicators, we find inconsistencies in the significant levels and signs. Yet it seems that Chikalsi, or city administrative provinces, are better-off than the rest of the country. We suggested that this might be a further indicator of social status, as families are frequently rewarded for their loyalty to the system by being moved to the showcase areas of the country.

Figure 1. Prevalence of child malnutrition in North Korea, 1997-2004



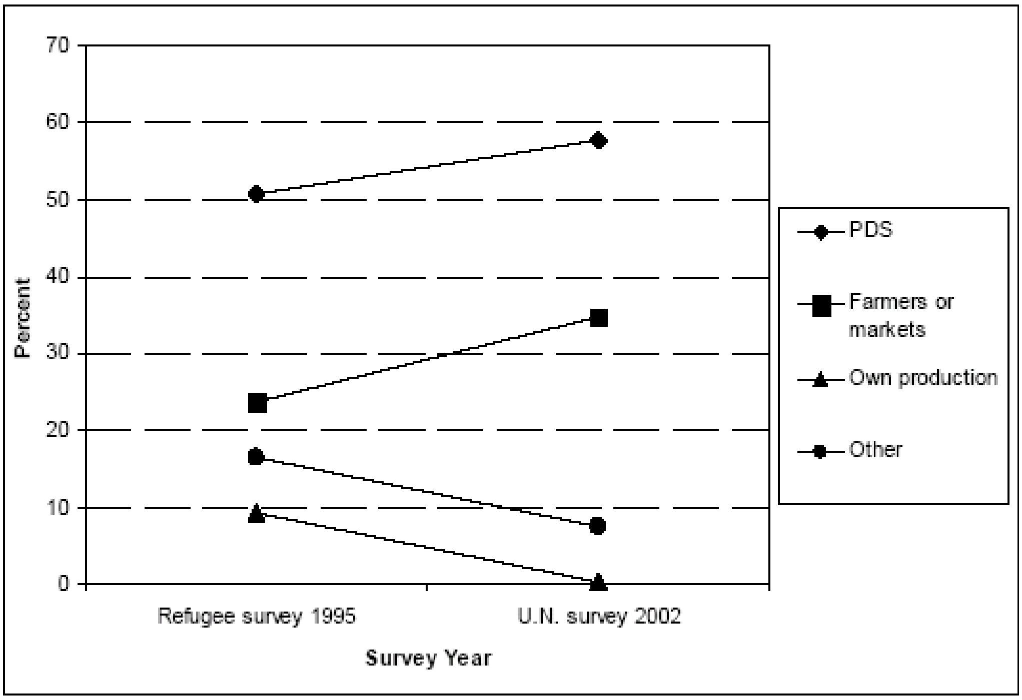
Notes: Surveys from 1997, 1998, 2000, 2002 and 2004 are based on 5, 11, 12, 10 and 8 out of 12 North Korean provinces.

Figure 2. Map of regions covered in 2002



Notes: White represents unselected counties, grey represents selected counties, black represents inaccessible counties.

Figure 3. Main source of food according to refugee and UN surveys



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Comments on 'Socioeconomic determinants of health in North Korea'

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I am very pleased to have a chance to discuss this interesting paper. When I received this paper weekㄴ ago, I was pleasantly surprised to find that this paper is using the detailed data collected by the 2002 UN nutrition survey on 6000 North Korean children. The data have not been available to any other researchers until this time. So at that time I thought this paper must be very interesting and should be a great contribution to our understanding of North Korea. I still think so. Indeed I am pretty sure that this paper will inspire many other researchers in this field in terms of its data, techniques and topics. Having said that, I would like to ask some questions. I have got many questions not only about the broad picture of this paper, but also about its technical aspects as well. But here I am going to focus myself only on its broad picture. I have got three questions.

The first one is about the reliability of the data used. The paper argues that the data are reliable for several reasons, which I basically agree with. However, what about this? According to the 2002 survey data, more than 90 percent of North Korean households reported that they had food storage in their households. Obviously the number is quite high, given that the country has been suffering immense food shortages for a long time. Of course, as the paper says, it might be because the survey was carried out in early October during the harvest season. We have to understand however that in North Korea new harvest is distributed to people not in October, but in November. To make things more interesting, this storage of food in households has proved to have no impact on the nutrition of children at all. Isn't it little bit odd? In fact it makes me wonder if the North Korean households gave the true answers to the survey or simply distorted their answers under the supervision of the North Korean authorities. There is another example as well. According to some surveys on the North Korean food refugees in China in the late 1990s, around 30-40 percent of households said that foraging and kinship support were their main food supply sources. But the 2002 UN survey data say that this number declined to zero in 2002. What should be noted here is that foraging and kinship support - for example, support from the relatives living in abroad- might be very sensitive issues to the North Korean households especially when they were monitored by the authorities. Furthermore, we have lots of anecdote evidence that such support from the relatives living abroad has increased very much since the late 1990s. So I wonder if the North Korean households really gave the true answers to the 2002 UN survey. Frankly I do not know. Nevertheless, I feel that the author must do more to convince the reader concerning the reliability of the data used.

My second question concerns the relation between health and nutrition in North Korea. The title of this paper is 'socioeconomic determinants of health in North Korea'. But practically it deals only with the nutritional status. Surely the nutrition is quite closely related to health. But still two variables are not same. For instance, health is determined not only by the nutritional factors, but also by other factors, including peoples' accessibility to medical facilities, clean water, social care system, and so on. But, I think, this paper assumes that two variables are same, making some 'interesting or funny (at least to me)' conclusions. Let me take just one example. The paper argues that the age of mother has a statistically significant impact on the children's nutritional status while other food consumption related variables have no such impact. It might be true in terms of children's health, because, as the paper says, older women gave birth to relatively weak children. But acute malnutrition such as wasting, low weight for age, is primarily dependent on food consumption level in a relatively short space of time. Imagine a 6 year old North Korean boy whose weight is very low. According to this paper, his low weight is determined not by the food consumption variables, but by the age of his mother. Might be true, but surely difficult to accept!

The final question is about the overall results of the regression or the regression variables used. According to this paper, the nutritional status of North Korean children is practically determined only tow factors: 1) biological variables such as children's and their mothers' age and their sex, and 2) their location variables. Neither their families' social status variables nor their food supply source and food consumption variables have such a impact. Frankly it does not seem quite convincing to me. So I am wondering if this paper really takes appropriate variables and analyses them in appropriate ways.

In short, this paper is quite interesting and important enough to inspire many other researchers in this field to pursue their studies on North Korea in more rigorous ways. But I think it still has many things to do in order to convince the readers of its results.

CHAPTER V-1

International Linkages of the Korean Macroeconomy: The Global VAR Modelling Approach*

by

Matthew Greenwood–Nimmo**

H. Viet Nguyen and Yongcheol Shin

Abstract

The recent development of global vector autoregressive (GVAR) modelling by Pesaran, Schuermann and Weiner (2004) and Dees, di Mauro, Pesaran and Smith (2007) represents an accessible way of incorporating country-specific models into a global framework which overcomes the typical dimensional problems associated with such large scale models. Using 33 countries (26 regions), we extend the model in a number of significant directions. We explicitly account for the trade balance by including real exports and imports, extend the sample period over 1980Q2-2006Q4, and allow for the presence of structural breaks. Focussing on a number of impulse response functions related to current headline events, we find that the impacts of each shock on six focus economies (Korea, the US, the Eurozone, China, Japan and the UK) are mostly consistent with our prior expectations. Furthermore, by focusing on the single and joint probabilities of achieving an inflation target, maintaining acceptable growth and a number of current account scenarios, we provide a great deal of interesting information of relevance to policy decisions.

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* We are grateful to Kanguk Choi, Youngil Choi, Sangpil Hwang, Heedon Kang, Chul Kong, and Yangsoo Park for their helpful comments. The usual disclaimer applies.

** Leeds University Business School, Address for correspondence: M. Greenwood-Nimmo, Room 2.38 Maurice Keyworth Building, Moorland Road, Leeds, UK, LS2 9JT. Email: bus1mjg@leeds.ac.uk I am grateful for the many helpful comments received on an earlier version of this paper presented at are search seminar at the University of Cape Town in December 2007.

Keywords: *Global (Cointegrating) VAR Modelling, Structural Breaks, Persistence Profiles, Impulse Response Functions, Probability Forecasts of Inflation, Output Growth and Current Account.*

JEL Classifications: *C32, C53, E17*

I. Introduction

The recent development of global vector autoregressive (GVAR) modelling by Pesaran, Schuermann and Weiner (2004, PSW), Dees, di Mauro, Pesaran and Smith (2007, DdPS) and Dees, Holly, Pesaran and Smith (2007, DHPS) represents an accessible way of incorporating country-specific models into a global framework which overcomes the typical dimensional problems associated with such large scale models.[1)]

We apply this modelling strategy to the same group of 33 countries (26 regions) as considered by DdPS and DHPS, although we revise and extend their research in a number of directions. Firstly, we extend the sample period from 1979Q1-2003Q4 to 1980Q1-2006Q4 to take account of more recent economic events. Secondly, we explicitly acknowledge the possibility of structural breaks among the governing economic relations of our models, the precise nature and timing of which we investigate empirically.[2)] Thirdly, given our interest in export-led Asian economies, our models include current account variables (exports and imports). Fourthly, we extend the range of uses to which the GVAR model is put beyond those of previous applications which have typically focussed on the construction of generalised impulse response functions in the analysis of the effects of various shocks on domestic endogenous variables. We compute a range of forecasts and the associated error variance decompositions and discuss the forecasting performance of the GVAR model in detail, offering some comparisons both to the existing literature and to the equivalent country-specific models where possible. Our final contribution is the construction of qualitative 'events-based' forecasts. We compute the individual and joint probabilities of the central bank achieving an inflation target while maintaining a respectable rate of growth, and also consider a number of scenarios relating to the trade balance and its relative improvement or deterioration. This type of scenario-based forecasting provides a means of presenting forecasts derived from the model in a simple, accessible and easily interpreted manner.

The compact GVAR modelling pursued in this paper represents an alternative to the new open economy macroeconomics (NOEM) paradigm which has been gathering strength in monetary policy circles. The contrast between the ease of estimation and empirical strength of VAR and the benefits of the theoretical microfoundations of DSGE

1) See also Garratt, Lee, Pesaran and Shin (2006, GLPS) for a general introduction to the global modelling approach.

2) Following Shin (2007) we account for structural breaks using one-time permanent intercept shifts. Further developments including the modelling of multiple regime shifts in a stochastic manner may prove fruitful, although the scope for pursuit of such strategies is likely to be limited in such dimensionally intensive macroeconometric modelling.

models has been well documented (c.f. Pagan, 2003), although it seems that recent advances in Bayesian DSGE modelling may have narrowed the gap in forecasting performance somewhat (c.f. Smets and Wouters, 2007, and Adolfson, Linde and Villani, 2007). A number of two country and multi–country DSGE models have emerged in recent years, notably those of de Walque, Smets and Wouters (2005) and Cristadoro, Gerali, Neri and Pisani (2006) and the IMF's Global Economy Model (GEM) and Global Fiscal Model (GFM), which are neatly summarised by Bayoumi (2004) and Botman, Karam, Laxton, and Rose (2007). This sparsity of global DSGE models reflects the complexity of the modelling that is required to deliver the rich microfoundations that are considered the principle advantage of DSGE over more empirically oriented approaches including VAR and VECM. The specification and estimation of a DSGE model where the number of countries exceeds two or three is highly computationally demanding and it is in this arena that the GVAR strategy has a decisive advantage. The principle of parsimony suggests that the relatively more simple GVAR specification should be preferred to the DSGE model in terms of out–of–sample forecasting if it can provide a similar degree of accuracy. Moreover, the relative merits of comparatively unrestricted GVAR models and highly restrictive DSGE models must be carefully considered when discriminating between these two competing approaches. If one follows the logic of Sims (1980), then the preferred strategy is that which imposes fewer restrictions, thereby letting the data 'speak for itself' : in this sense, GVAR would be preferred to DSGE[3)]

Estimation of the 26 country/region–specific models in isolation yields results which are generally encouraging. We focus our discussion on six economies of particular interest: Korea, the US, the Eurozone, China, Japan and the UK. Our estimation results for these countries are particularly promising. More specifically, we find that the estimation of the long–run cointegrating relationships, the dynamic impulse response functions and the probability forecasts are generally consistent with our prior expectations. In the case of Korea in particular, we find that our modelling is relatively robust to changes in the model specification and that the model provides qualitatively similar findings for most dynamic forecasting scenarios.

The GVAR model is constructed by combining the 26 country/region–specific models using carefully constructed trade–weight link matrices. Focussing on a small number of impulse responses with respect to an oil price shock, a US monetary policy

3) Of course, a number of intermediate cases obtain between the extremes of unrestricted VAR and heavily restricted DSGE, including over identified cointegrating VAR and DSGE–VAR (c.f. Del Negro and Schorfheide, 2004). Such approaches provide many interesting avenues for continuing work in the field.

shock, a positive US stock market shock and a Chinese inflationary shock, we find that the impacts of each shock on our focus economies are largely theory – consistent. Moreover, we believe that the results obtained in this manner are superior to those of country – specific modelling in the sense that they will provide a better description of most global variables. In the Korean case, at least in the short-term, we find that: (i) an oil price shock will be inflationary and will decrease output; (ii) tight monetary policy in the US will reduce both inflation and output; (iii) a positive US stock market shock (i.e. a boom) will stimulate the domestic economy, increasing output and leading to gains in the KOSPI; and (iv) elevated inflationary pressure in China will pass through to Korea relatively quickly. Furthermore, we find that the forecasts derived from the GVAR model are often consistent with recent economic developments, including the building recessionary environment in the US and the growing current account deficit in the UK.

The paper proceeds in five sections as follows. Section 2outlines the cointegrating GVAR model allowing for presence of deterministic structural breaks. The design and structure of the GVAR model are discussed in detail, and the framework for dynamic analysis is briefly described. Section 3offers a brief analysis of the dataset and discusses the results of the individual country – specific models for our focus economies. These results provide a benchmark scenario against which the performance ofthe GVAR model may be evaluated. Section 4 discusses the main empirical results of the GVAR model. Section 5 offers some concluding remarks and identifies a number of interesting avenues for further research. Details of the data construction process are provided in the Data Appendix.

II. Global Vector Autoregressive (GVAR) Modelling Approach

Given the increasing globalisation and integration of economic and financial markets, there is a growing desire to explicitly model the sources of foreign influence on domestic economies and the contributions of individual national economies to conditions in foreign economies and the broader world economy. Our interest is in modelling a small open economy (using the example of Korea) and its interactions with foreign economies, most notably the US, Japan, China and the Eurozone. Such an analysis might be used to establish the impact of shocks to the US or Chinese economies on Korea, and vice-versa. Other applications abound, including the modelling of business cycle linkages within and between countries, the consideration of stock market integration which could inform risk - diversification strategies and the analysis of financial linkages and the risk of contagion (PSW approach this issue).

The issue of how to overcome the dimensional problems associated with a large scale model is pursued by PSW and further developed by DdPS and DHPS.4) The authors develop a global VAR model to investigate global interactions and to facilitate the analysis of regional shocks on the world economy in general. The problem of modelling many economies in a coherent and consistent manner is solved by the careful construction of country-specific 'foreign' variables for use in each of the separate national models. These country - specific foreign variables are treated as weakly exogenous when estimating the national models5). The individual country/region-specific models are then combined in a consistent and cohesive manner to generate forecasts for all of the variables in the world economy simultaneously.

1. Individual Country–Specific Models

Consider a world consisting of N +1 economies, indexed by i = 0, 1,.., N, and denote the country - specific variables by an m_i x 1 vector, x_{it} and the associated country - specific foreign variables by an m_i^* x 1 vector x_{it}^* defined as6)

$$x_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt},$$

where $w_{ij} \geq 0$ are the weights attached to the foreign variables with $\sum_{j=0}^{N} w_{ij} = 1$, and $w_{ii} = 0$ for all i. The second order country–specific VARX* (2,2) model can be written as

$$\begin{aligned} x_{it} &= h_{i0} + h_{i1}t + \delta_{i0}d_{it} + \delta_{i1}d_{i,t-1} + \delta_{i2}d_{i,t-2} + \Phi_{i1}x_{i,t-1} \\ &+ \Phi_{i2}x_{i,t-2} + \Psi_{i0}x_{it}^* + \Psi_{i1}x_{i,t-1}^* + \Psi_{i2}x_{i,t-2}^* + u_{it}, \end{aligned} \qquad (1)$$

4) While it is possible to extend the national modelling strategy developed in GLPS to cover the same m core variables in each of N + 1 separate economies, this would involve the estimation of a p^{th} order cointegrated VAR in $mp(N + 1)$ parameters. Such high–dimensional modelling is clearly infeasible even when m is as small as 3 or 4.

5) Specifically, individual country/region–specific VECM models are estimated using a range of domestic macroeconomic variables and the corresponding foreign variables constructed as a weighted average of the data from the remaining countries. The weighting matrix is derived from the international trade pattern.

6) The number of variables in the different country models need not be the same.

where d_{it} is the country-specific intercept shift variable.[7] The dimensions of h_{ij}, $j = 0, 1$ and δ_{ij}, $j = 0, 1, 2$, are m_i x 1 while the dimensions of Φ_{ij}, $j = 1, 2$, and Ψ_{ij}, $j = 0, 1, 2$, are m_i x m_i and m_i x m_i^*, respectively. We assume that the error term u_{it} ~ iid $(0, \Sigma_{ii})$ where Σ_{ii} is ai m_i x m_i positive definite variance-covariance matrix.

PSW show that careful construction of the global variables as weighted averages of the other regional variables leads to a simultaneous system of regional equations that may be solved to form a global system.[8] Notice that the model (1) extends the basic model considered by PSW and DdPS, taking explicit account of the presence of country-specific structural change. the consideration of structural breaks is expected to improve estimation and forecasting results, especially for those East Asian countries most severely hit by the 1997 currency crisis, and for those South american countries that suffered hyperinflation in the 1980s. Based on careful consideration and analysis of the raw data and consultation of relevant news sources, we include break dummies in the models of Argentina, Brazil, the Eurozone, Japan, Indonesia, Korea, Malaysia, Mexico, Peru, the Philippines, Thailand and the UK (see Table 1 for details).

The individual country-specific models are estimated allowing for unit roots and cointegration assuming that country-specific foreign variables are weakly exogenous (see GLPS and Shin, 2007). Hence, the VECM associated with (1) can be written as

$$\begin{aligned}\Delta x_{it} &= c_{i0} + c_{i0}^* \Delta d_{it} + c_{i1}^* \Delta d_{i,t-1} + \Lambda_i \Delta x_{it}^* + \Gamma_i \Delta z_{i,t-1} \\ &+ \alpha_i \beta_i' \left(z_{i,t-1} - \mu_i d_{i,t-1} - \gamma_i (t-1) \right) + u_{it}, \end{aligned} \tag{2}$$

where $z_{it} = (x'_{it}, x^{*f}_{it})'$, α_i is an m_i x γ_i adjustment matrix of rank γ_i and β_i is a $(m_i + m_i^*)$ x γ_i cointegrating matrix of rank r_i.[9] Notice that (1) can be rewritten as

$$A_{io} z_{it} = h^*_{io} + h_{i1} t + A_{i1} z_{i,t-1} + A_{i2} z_{i,t-2} + u_{it}, \tag{3}$$

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7) It is easily seen that dit is also subject to the same VAR(2) lag order dynamic (see Shin, 2007).

8) They also provide theoretical arguments as well as empirical evidence in support of the weak exogeneity assumption that allows the country/region-specific models to be estimated consistently.

9) Noting that $\beta'_i(z_{it} - \mu d_{it} - \gamma_i t) = \beta'_{iz} x_{it} + \beta'_{ix^*} x_{it} - (\beta'_i \mu_i) d_t - \beta'_i \gamma_i)\ t$, it is clearly possible to rest the co-trending restrictions, $\beta'_i \gamma_i = 0$, and the co-breaking restrictions, $\beta'_i \gamma_i = 0$,

where

$$\underset{m_i\times(m_i+m_i^*)}{A_{i0}} = (I_{m_i}, -\Psi_{i0})\,; \quad \underset{m_i\times(m_i+m_i^*)}{A_{i1}} = (\Phi_{i1}, \Psi_{i1})\,; \quad \underset{m_i\times(m_i+m_i^*)}{A_{i2}} = (\Phi_{i2}, \Psi_{i1})\,;$$

$$h_{i0}^* = h_{i0} + \delta_{i0}d_{it} + \delta_{i1}d_{i,t-1} + \delta_{i2}d_{i,t-2}.$$

The parameters of (3) can be obtained from the parameters of (2) by using the following relationship:

$$A_{i0} = (I_{m_i}, -\Lambda_{i0})\,;\; A_{i1} = A_{i0} + \Pi_i + \Gamma_i;\; A_{i2} = -\Gamma_i; \tag{4}$$

$$h_{i0}^* = c_{i0} + c_{i0}^*\Delta d_{it} + c_{i1}^*\Delta d_{i,t-1} + (-\Pi_i\mu_i)\,d_{i,t-1};\; h_{i1} = -\Pi_i\gamma_i. \tag{5}$$

where $\Pi_i = \alpha_i\beta_i'.$ An extension to the general VARX* (p, q) fom is straightforward.

We follow DdPS in our selection of 26 countries/regions (as defined in Table 1) and select the following core variables fro country i = 1,..., N:10)

$$x_{it} = (re_{it}, r_{it}, m_{it}, x_{it}, q_{it}, \Delta p_{it}, y_{it})', \tag{6}$$

$$x_{it}^* = (p_t^o, r_{it}^*, q_{it}^*, \Delta p_{it}^*, y_{it}^*)'. \tag{7}$$

The core variables considered are the log of real per capita output (yit), the log of the general price level (p_i), the rate of price inflation ($\triangle p_{it}$), the log of exports (x_{it}), the log of imports (m_{it}), the short term interest rate (r_{it}), the log of the nominal l exchange rate in terms of the US Dollar (e_{it}), the log of real equity prices (q_{it}), and the log of the nominal spot oil price $(p_t^o).$ The corresponding country–specific foreign variables are defined as follows:

$$y_{it}^* = \sum_{j=0}^{N} w_{ij}y_{jt};\; p_{it}^* = \sum_{j=0}^{N} w_{ij}p_{jt};\; \Delta p_{it}^* = \sum_{j=0}^{N} w_{ij}\Delta p_{jt};\; x_{it}^* = \sum_{j=0}^{N} w_{ij}x_{jt};\; m_{it}^* = \sum_{j=0}^{N} w_{ij}m_{jt};$$

$$r_{it}^* = \sum_{j=0}^{N} w_{ij}r_{jt};\; e_{it}^* = \sum_{j=0}^{N} w_{ij}e_{jt};\; q_{it}^* = \sum_{j=0}^{N} w_{ij}q_{jt},$$

where w_{ij} is the share of country j in the trade (exports plus imports) of country i such

10) Due to the well—known measurement and comparability issues, we do not consider the inclusion of monetary aggregates in the current paper (see also DdPS). This will be addressed in a separate paper.

that w_{ii} = 0 and $\sum_{j=0}^{N} w_{ij} = 1.$ We also follow DHPS and include the log real effective exchange rate, re_{it} = ee_{it} + p^*_{it} - p_{it} = $\tilde{e}$ (where ee_{it} = $\sum_{j=0}^{N} w_{ij} e_{ijt}$ is the nominal effective exchange rate) amongst the endogenous variables.[11)]

In our application, each country-specific model includes 7 endogenous and 5 exogenous variables.[12)] However, due to the lack of reliable data, we omit equity prices, q_{it}, from the Chinese, Indonesian, Peruvian, Saudi Arabian and Turkish models. Furthermore, the Saudi Arabian Monetary Agency does not publish a reliable short-term interest rate covering our sample period and so this too is omitted.[13)]

Finally, the US, as the reference country, is treated differently. The US model is linked to the outside world through exchange rates themselves being determined in the rest of the country - specific models. Thus we have:

$$x_{0t} = (p_t^o, r_{0t}, m_{0t}, x_{0t}, q_{0t}, \Delta p_{0t}, y_{0t})', \ x_{0t}^* = (\tilde{e}_{0t}^*, \Delta p_{0t}^*, y_{0t}^*)\,. \tag{8}$$

The main difference between the US and the rest-of-the-world (ROW) is that re_{0t} is not included and p^o_t is endogenous in the US. In our application, we follow DdPS and DHPS and omit both r^* and q^* from the set of weakly exogenous variables, arguing that they are endogenous to the US economy.[14)]

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11) This follows because $\gamma e_{it} = \sum_{j=0}^{N} \omega_{ij} e_{ijt} + p^*_{it} - p_{it} = e_{it} - e^*_{it} + p^*_{it} - p_{it} = \tilde{e}_{it} - \tilde{e}^*_{it}$. PPP holds if $\gamma e_{it} = \tilde{e}_{it} - \tilde{e}^*_{it} \sim I(0)$. PSW and DdPS use $\tilde{e}_{it}$ and $\tilde{e}^*_{it}$ separately as endogenous and exogenous variables, respectively. An alternative specification adopted by GLPS uses $x_{it} = (ee_{it}, r_{it}, m_{it}, x_{it}, q_{it}, pps_{it}, \triangle p_{it}, y_{it})'$ and $x^*_{it} = (p^o_t, \gamma^*_{it}, q^*_{it}, y^*_{it})'$, where $pps_{it} = p_{it} - p^*_{it}$ and $\triangle p^*_{it}$ is dropped to avoid the collinearity problem.

12) The exogenous variables include the global oil price but omit foreign exports and imports. This omission is motivated by two considerations. Firstly, we prefer a smaller, more parsimonious model to a large and complex model. Secondly, there is a theoretical inconsistency associated with the inclusion of domestic imports and exports as endogenous variables and foreign imports and exports as weakly exogenous variables which derives from the nature of international trade. It follows that whatever is imported by one country must be exported by another country or group of countries. In such a situation, one cannot argue that imports are endogenous without conceding that foreign exports are similarly endogenous. A similar argument may made in the case of domestic exports and foreign imports.

13) Hence, for China, Indonesia, Peru, and Turkey, we have $x_{it} = (re_{it}, r_{it}, m_{it}, x_{it}, \triangle p_{it}, y_{it})'$ and for Saudi Arabia $x_{it} = (re_{it}, m_{it}, x_{it}, \triangle p_{it}, y_{it})'$. We use the same foreign variables defined above for these countries.

14) If either r^* or q^* are endogenous, the results of country—specific modelling will be biased and this will significantly affect the resulting global estimation results. In this regard we may drop either r^* or q^* or both for other financially dominant countries such as the UK, Japan and the Euro Area.

2. Long–Run Equilibrium Conditions

We shall consider the following 8 relationships as possible long-run equilibrium conditions linking the core variables of the *i*th economy to those in all other countries in the global economy:15)

$$y_{it} - \beta_{11,i} x_{it} = a_{1i} + \zeta_{1,it},\ \beta_{11} > 0, \tag{9}$$

$$r_{it} - \Delta p_{it} = a_{2i} + \zeta_{2,it}, \tag{10}$$

$$r_{it} - r^*_{it} = a_{3i} + \zeta_{3,it}, \tag{11}$$

$$ee_{it} + p^*_{it} - p_{it} - \beta_{41,i}(y_{it} - y^*_{it}) = a_{4i} + \zeta_{4,it},\ \beta_{41,i} > 0, \tag{12}$$

$$q_{it} - \beta_{51,i} y_{it} + \beta_{52,i}(r_{it} - \Delta p_{it}) = a_{5i} + \zeta_{5,it},\ \beta_{51,i}, \beta_{52,i} > 0, \tag{13}$$

$$m_{it} - \beta_{61,i} y_{it} = a_{6i} + \zeta_{6,it},\ \beta_{61} > 0, \tag{14}$$

$$y_{it} - y^*_{it} = a_{8i} + \zeta_{8,it}. \tag{15}$$

$$q_{it} - q^*_{it} = a_{9i} + \zeta_{9,it}. \tag{16}$$

The first relationship represents aggregate demand and relates the log of output to the log of exports (additional demand shifting factors could be included as appropriate). This simple specification represents export-led growth in most East Asian countries including China and Korea. the second relationship, the Fisher equation, suggests that the real interest rate is stationary and ergodic. The third relationship is long-run version of the uncovered interest parity (UIP) condition which omits $E_t\left(\Delta e^*_{i,t+1}\right)$, the expected rate of depreciation of the currency of country *i*.16) The fourth relationship Harrod-Ballassa-Samuelson effect, or, in the terms of Officer (1976), 'productivity-biased' PPP). It relates the log of the nominal effective exchange rate, $ee_{it} = \sum_{j=0}^{N} w_{ij} e_{ijt}$, to the log price ratio, p^*_{it} - p_{it}, and the per capita output gap, y_{it} - y^*_{it}.17) The

15) We allow for different long-run relations in different countries. Notice also that, for simplicity, we do not include deterministic time trends or intercept shift dummies in the above long-run relationships.

16) We describe this equation as long-run UIP as it is widely acknowledged that $E_t(\triangle e^*_{i,t+1})$, follows a stationary I(0) process and, therefore, does not belong in a long-run (cointegrating) relationship. When the exchange rate follows a random walk, the UIP condition reduces to (11).

17) Note that eeit differs from $e^*_{it} = \sum_{j=0}^{N} w_{ij} e_{jt}$. The latter is defined in terms of the US dollar exchange rates whilst the former is measured in terms of the bilateral exchange rates. Note also that the output gap as defined here differs from the typical concept of the output gap as the difference between actual and potential output. A

fifth relationship relates to equity markets and has real equity prices varying procyclically with real output and real interest rates, where the real rate is inversely proportional to the subjective rate of time preference. In the case where the real interest rate is stationary, (13) predicts a long-run relationship between real equity prices and real output only. The sixth relationship posits that the log of imports is positively related to domestic output directly via final demand and indirectly via intermediate demand. The seventh relationship postulates that domestic and foreign output are convergent in the long-run. Although the neoclassical growth model does not explicitly address the issue of cross-country output convergence, it is argued that, in an interrelated global economy, technological progress (taken to be an unobserved I(1) process) is likely to become increasingly common across countries. This may happen for a number of reasons, most notably innovation and imitation of traded goods such that the downstream economy may appropriate some (or potentially all) of the technological advantage of the innovative exporter (an example of the 'conditional convergence' literature is Barro and Sala-i-Martin, 1997). Output convergence will be complete if cross-country technological diffusion is perfect and the Solow-Swan growth process is applied to each country separately. In the case of perfect output convergence, the productivity-biased PPP relation reduces to the classical version, $ee_{it}+p^{*}_{it}-p_{it} \sim I(0)$. Similarly, the eighth relationship represents long-run convergence between domestic and foreign equity prices, derived from the increasing globalization and liberalization of the financial transactions mechanism.

3. Construction of the GVAR model

This section describes the process of combining the country specific models into GVAR. Define an (m+1) x 1 vector of the intermediate global variables with $m=\sum_{i=0}^{N} m_i$ as

$$\tilde{x}_t = \left(\tilde{x}'_{0t}, \tilde{x}'_{1t}, \ldots, \tilde{x}'_{Nt}\right)',$$

similar implementation of productivity-biased PPP may be found in GLPS.

where[18)]

$$\tilde{x}_{0t} = (\tilde{e}_{0t}, p_t^o, r_{0t}, m_{0t}, x_{0t}, q_{0t}, \Delta p_{0t}, y_{0t})', \;\; \tilde{x}_{it} = (\tilde{e}_{it}, r_{it}, m_{it}, x_{it}, q_{it}, \Delta p_{it}, y_{it})'.$$

Then, Z_{it} can be expressed as

$$z_{it} = \boldsymbol{W}_i \tilde{x}_t, \;\; i = 0, 1, ..., N, \tag{17}$$

where $\boldsymbol{W}_i$ are $(m_i + m_i^*) \times (m+1)$ link matrices defined in terms of trade-weights. Using (17) in (3) and stacking the results we obtain

$$\boldsymbol{H}_0 \tilde{x}_t = h_0^* + h_1 t + \boldsymbol{H}_1 \tilde{x}_{t-1} + \boldsymbol{H}_2 \tilde{x}_{t-2} + u_t, \tag{18}$$

where

$$\underset{m\times(m+1)}{\boldsymbol{H}_0} = \begin{pmatrix} A_{00}\boldsymbol{W}_0 \\ A_{10}\boldsymbol{W}_1 \\ \vdots \\ A_{N0}\boldsymbol{W}_N \end{pmatrix}; \;\; \underset{m\times(m+1)}{\boldsymbol{H}_1} = \begin{pmatrix} A_{01}\boldsymbol{W}_0 \\ A_{11}\boldsymbol{W}_1 \\ \vdots \\ A_{N1}\boldsymbol{W}_N \end{pmatrix}; \;\; \underset{m\times(m+1)}{\boldsymbol{H}_2} = \begin{pmatrix} A_{02}\boldsymbol{W}_0 \\ A_{12}\boldsymbol{W}_1 \\ \vdots \\ A_{N2}\boldsymbol{W}_N \end{pmatrix},$$

$$h_0^* = \begin{pmatrix} h_{00}^* \\ h_{10}^* \\ \vdots \\ h_{N0}^* \end{pmatrix}; \;\; h_1 = \begin{pmatrix} h_{01} \\ h_{11} \\ \vdots \\ h_{N1} \end{pmatrix}; \;\; u_t = \begin{pmatrix} u_{0t} \\ u_{1t} \\ \vdots \\ u_{Nt} \end{pmatrix}.$$

Notice that since $\tilde{e}_{ot}$ is not included among the US variables but is included in $\tilde{x}_t$, the total number of equations in the country-specific models is one less than the number of unknown elements in $\tilde{x}_t$. Without a further restriction, it is not possible to uniquely solve $\tilde{x}$ from knowledge of the country-specific models. This final restriction is provided by noting that $e_{0t} = 0$ and hence $e_{0t} = -p_{ot}$. We now set the following m x 1 vector of global economic variables

18) As before q is omitted for China, Indonesia, Peru, and Turkey and both q and r are omitted for Saudi Arabia.

$$\tilde{x}_t = (\tilde{x}'_{0t}, \tilde{x}'_{1t}, ..., \tilde{x}'_{Nt})', \;\; \tilde{x}_{0t} = (p^o_t, r_{0t}, m_{0t}, x_{0t}, q_{0t}, p_{0t}, y_{0t})'.$$

where the $\tilde{x}_{it}'s$ are defined as above. Note that we are now solving for the US price level as opposed to inflation, though it is inflation that is being solved for in the case of other countries (see also DHPS). It then follows that

$$\tilde{x}_t = S_0 x_t - S_1 x_{t-1}, \tag{19}$$

where S_0 and S_1 are (m+1) x m selection matrices defined by

$$S_0 = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & I_{m-m_0} \end{pmatrix}, \; S_1 = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0_{m-m_0} \end{pmatrix}$$

Hence we now have

$$F_0 x_t = h^*_0 + h_1 t + F_1 x_{t-1} + F_2 x_{t-2} + F_3 x_{t-3} + u_t, \tag{20}$$

where F_0 + H_0S_0, $F_1 = H_1S_0 + H_0S_1$, $F_2 = H_2S_0 - H_1S_1$, and $F_3 = -H_2S_1$. The reduced-form GVAR is finally obtained as

$$x_t = g^*_0 + g_1 t + G_1 x_{t-1} + G_2 x_{t-2} + G_3 x_{t-3} + \varepsilon_t, \tag{21}$$

where $G_j = F_0^{-1} F_j$, $j = 1, 2, 3$, $g^*_0 = F_0^{-1} h^*_0$, $g_1 = F_0^{-1} h_1$, and $\varepsilon_t = F_0^{-1} u_t$. Having estimated the separate national models in the form of (1), the global model in (21) can be solved recursively forward to obtain future values of all the endogenous variables in the global model, x_t.

Although the model is estimated on a country by country basis, we allow the shocks to be weakly correlated across countries. In particular, it is assumed that $E\left(u_{it} u'_{jt}\right) = \Sigma_{u,ij}$ for $t = t'$ and 0 otherwise. Global interactions take place through three distinct, but interrelated channels: (i) direct dependence of x_{it} on x^*_{it} and its lagged values, (ii) dependence of the region-specific variables on common global exogenous variables such as oil prices, and (iii) non-zero contemporaneous dependence of shocks in region *i* on shocks in region *j*, measured via the cross country covariances, $\Sigma_{u,ij}$.

As shown in DdPS, the GVAR model allows for both intra- and inter-country cointegration. The GVAR can also be derived from global factor models where there may exist one or more unobserved common factors with differential effects across countries. Finally, the cointegration properties of the individual country models are preserved in the GVAR model and thus the mean-reverting features of the individual economies carry over to the world economy.

4. Link matrices

As discussed above, careful construction of the link matrices used in (17) is critical in the development of the GVAR. In our application, the W_i's are given by[19)]

$$\underset{10\times 177}{W_0} = \begin{pmatrix} R_{00} & 0_{7\times 7} & \cdots & 0_{7\times 7} & 0_{7\times 6} & \cdots & 0_{7\times 6} & 0_{7\times 5} \\ 0_{3\times 8} & W_{01} & \cdots & W_{0,20} & W_{0,21} & \cdots & W_{0,24} & W_{0,25} \end{pmatrix},$$

$$\underset{12\times 177}{W_i} = \begin{pmatrix} R_{i0} & R_{i1} & R_{i2} & \cdots & R_{i,25} \\ W_{i0} & W_{i1} & W_{i2} & \cdots & W_{i,25} \end{pmatrix},\ i = 1, ..., 25,$$

where

and for i = 1, ..., 25,

Here w_{ij} is the weight of country *i* in the trade of country *j*, w^*_{ij} is the *i*th country's adjusted trade-weight with the *j*th country after allowing for the lack of Saudi interest rate data, and w^{**}_{ij} is the *i*th country's trade-weight with the *j*th country adjusted to accommodate the lack of reliable stock market data for China, Indonesia, Peru and

19) See Table 1 for the country order.

$$R_{00} = \begin{bmatrix} 0_{7\times1} & I_7 \end{bmatrix},\ R_{i0} = \begin{bmatrix} -w_{i0} & 0_{1\times7} \\ 0_{6\times1} & 0_{6\times7} \end{bmatrix},\ i = 1, ..., 25,$$

$$\{R_{ij}\}_{j=1}^{20} = \left\{ \begin{matrix} \begin{bmatrix} -w_{ij} & 0_{1\times6} \\ 0_{6\times1} & 0_{6\times6} \end{bmatrix} & \text{if } j \neq i \\ I_7 & \text{if } j = i \end{matrix} \right\},\ i = 1, ..., 25,$$

$$\{R_{ij}\}_{j=21}^{24} = \left\{ \begin{matrix} \begin{bmatrix} -w_{ij} & 0_{1\times5} \\ 0_{6\times1} & 0_{6\times5} \end{bmatrix} & \text{if } j \neq i \\ I_6 & \text{if } j = i \end{matrix} \right\},\ i = 1, ..., 25,$$

$$R_{i,25} = \left\{ \begin{matrix} \begin{bmatrix} -w_{i,25} & 0_{1\times4} \\ 0_{6\times1} & 0_{6\times4} \end{bmatrix} & \text{if } i \neq 25 \\ I_5 & \text{if } i = 25 \end{matrix} \right\},$$

$$\{W_{0j}\}_{j=1}^{20} = \begin{bmatrix} w_{0j} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{0j} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & w_{0j} \end{bmatrix},$$

$$\{W_{0j}\}_{j=21}^{24} = \begin{bmatrix} w_{0j} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & w_{0j} & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{0j} \end{bmatrix},\ W_{0,25} = \begin{bmatrix} w_{0,25} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & w_{0,25} & 0 \\ 0 & 0 & 0 & 0 & w_{0,25} \end{bmatrix},$$

$$W_{i0} = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & w_{i0}^{*} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{i0}^{**} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & w_{i0} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & w_{i0} \end{bmatrix},\ \{W_{ij}\}_{j=1}^{20} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & w_{ij}^{*} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & w_{ij}^{**} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{ij} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & w_{ij} \end{bmatrix},$$

$$\{W_{ij}\}_{j=21}^{24} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & w_{ij}^{*} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & w_{ij} & 0 \\ 0 & 0 & 0 & 0 & 0 & w_{ij} \end{bmatrix},\ W_{i,25} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & w_{i,25} & 0 \\ 0 & 0 & 0 & 0 & w_{i,25} \end{bmatrix}.$$

Turkey and Saudi Arabia. Notice that $\sum_{j=0}^{N} w_{ij} = \sum_{j=0}^{N} w_{ij}^{*} = \sum_{j=0}^{N} w_{ij}^{**} = 1$, and $w_{ii} = w^{*}_{ii} = w^{*}_{ii} = 0$ for all i.[20)]

20) Currently, we follow DdPS in our use of the 26 × 26 trade-weighting matrices based on trade averages over the period 1999-2001. Preliminary estimation results based on trade averages over 2001-2003 are qualitatively similar, although the more recent figures are likely to provide sharper forecasts, especially considering the recent rapid Chinese economic growth. We are considering the use of time-varying trade weights, as we believe that this will more fully reflect the changing balance of power among the world economies over the sample period. However, as DdPS note, one must be careful not to introduce an undesirable element of randomness into estimation in this manner.

5. Dynamic analysis of the GVAR model

Here we follow DHPS and provide statistics for analysing the dynamic adjustment process of the variables with respect to shocks. the persistence profiles (PP) refer to the time profiles of the effects of system or variable-specific shocks on the cointegrating relations in the GVAR model. Impulse response functions (IRF) refer to the time profiles of the effects of variable-specific shocks on all variable in the model (see Pesaran and Shin, 1996, 1998, and GLPS). Forecast error variance decomposition (FEVD) of a VAR model has been performed on a set of orthogonalised shocks where the contribution of the *j*th orthogonalised innovation to the mean squared error of the *n*-step ahead forecast of the model is calculated. In the case of GVAR, the shocks across countries, u_{it} and u_{st} for $i \neq s$ are not orthogonal. This invalidates the standard application of the orthogonalised FEVD to the GVAR model. An alternative approach invariant to the ordering of the variables is to consider the proportion of the variance of the *n*-step ahead forecast errors of x_t which is explained by conditioning on non-orthogonalised shocks, u_{jt}, u_{jt+1},..., u_{jt+n}, for $j = 1,..., m$, while explicitly allowing for the contemporaneous correlation between these shocks and shocks to the other equations in the system.[21)]

Furthermore, we follow GLPS and provide the estimation and construction of the central forecasts of the *m* global variables and the associated probability event forecasts in the context of the GVAR model, (21). The compact GVAR modelling described in this paper provides a practical framework for evaluating and measuring probability forecasts of a large variety of empirically important issues in a global context.[22)] In empirical application below we focus on the following events of particular interest to national monetary authorities:[23)]

A Achievement of the inflation target, defined as the four-quarterly moving average rate of inflation falling within the acceptable range;

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21) Detailed derivations and computational techniques of this subsection can be found in the working paper version of the paper.

22) In order to address the issue of model uncertainty we will provide the forecasting results based on the Bayesian Model Averaging (BMA) framework at a later stage.

23) See Table 4 for the declared inflation target for each individual country. In some cases, monetary policy does not formally target inflation (e.g. the US). In such cases we use a reasonable figure based on a careful consideration of the targets adopted by similar economies. Where the inflation target is defined in terms of CPI inflation we use this figure. However, in those cases where other measures are used (e.g. the Eurozone which uses HICP and South Africa which uses CPIX) we use an approximately comparable CPI figure. Where countries define a simple target as opposed to an acceptable range, we form an appropriate range centred on this target.

B Achievement of the inflation target, defined as the four-quarterly moving average rate of inflation remaining below the midpoint of the acceptable range;

C Recession, defined as the occurrence of two consecutive quarters of negative output growth;

D Poor growth prospects, identified with the four-quarterly moving average rate of output growth being less than half the historical average;

E Current account deficit, defined as $x - m < 0$; and

F Current account improvement, defined as $\Delta x - \Delta m > 0$.

Furthermore, we consider the following joint events:

- $A \cap \overline{C}$ or $B \cap \overline{C}$ (inflation target is met *and* recession is avoided):
- $A \cap \overline{D}$ or $B \cap \overline{D}$ (inflation target is met *and* growth prospects are reasonable):
- $E \cap F$ (current account deficit and improvement - we characterise this as balancing improvement);
- $E \cap \overline{F}$ (current account deficit and deterioration - unbalancing deterioration);
- $\overline{E} \cap F$ (current account surplus and improvement - unbalancing improvement); and
- $\overline{E} \cap \overline{F}$ (current account surplus and deterioration - balancing deterioration).

where $\overline{C}$, $\overline{D}$, $\overline{E}$ and $\overline{F}$ are the complements of C, D, E and F.

III. Data Analysis and Country–Specific Estimation Results

1. Data

The dataset consists of 100 quarterly observations between 1982Q1 and 2006Q4 on the variables defined above for 33 countries (26 regions). Detailed data sources and manipulations are described in the data appendix. Due to the extensive nature of the modelling presented in the paper (covering 26 countries/regions, typically with twelve variables) this section provides only a brief summary for a few selected macroeconomic variables of interest.

1.1. Real Output Growth

Table 2 provides summary statistics for real output growth. It is immediately apparent that the level and volatility of the average output growth rate varies substantially across countries/regions. The average growth rates of developed countries lie in the range 2-3.5% per annum (e.g. 2.91% for the U.S., 2.14% for the Eurozoue, 2.17% for Japan, 2.4% for the UK, 2.98% for Canada and 3.23% for Australia). The emerging economies of Asia have enjoyed considerably faster growth, typically between 5 and 7% (e.g. 6.44% for Korea, 5.89% for India, 6.66% for Singapore and 5.69% for Thailand). The two exceptions are China with the highest growth rate of 9%, aud the Philippines which exhibits slow growth at just 2.86%. Among the remaining countries, Turkey and Chile have relatively high growth rates of approximately 4.4% per annum, compared to au average of just 2%.

The growth rates of developed countries are relatively stable, with standard deviations between 2% and 4%, while standard deviations between 6% and 12% typify the emerging and developing countries. Interestingly, China has enjoyed the most rapid growth (9%) in conjunction with volatility comparable to that of a developed economy (just 3.14%).

1.2. Inflation

Historical accounts of inflation among the 26 countries/regions are summarised in Table 2. The striking feature is that average rates of inflation in almost all countries are considerably higher than those experienced in recent years. This observation is often attributed to the widespread adoption of inflation – targeting monetary policy regimes in recent years.

The developed economies have the lowest and most stable inflation rates on average, ranging from 2% to 5% (e.g. 3.5% for the US, 3.73% for Eurozone, 1.11% for Japan and 4.34% for the UK). The Japanese figure is somewhat misleading, deriving largely from the post–1990 deflationary era. The emerging Asian economies have experienced slightly higher average inflation rates, mostly of the order of 5-8%. In particular, the figure for China and Korea is approximately 5% and that of India is 7.65%. Singapore and Saudi Arabia are notable for their low inflation rates, at just 1.72% and 0.52%, respectively.

The Latin American countries and Turkey suffered hyperinflation during the sample period which is reflected in the figures which are both high and extremely volatile: 98.9% for Brazil, 71.3% for Argentina, 67.8% for Peru and 41.2% for Turkey. Inflation peaked in Argentina at 759.2% in 1989Q3, 622.61% in Brazil in 1990Q1 and 856.52% in 1990Q3 in Peru.

1.3. Real Export and Import Growth

Table 3 summarises the real export and import performance of our sample countries. Similar to the patterns observed for output growth and inflation, the industrialised countries have experienced lower and more stable average export and import growth, typically in the range 1-3%. Emerging and developing economies exhibit higher but more volatile growth rates. For example, the average export and import growth rates are 16.5% and 14.8% for China, 8.87% and 8.88% for India, 7.88% and 6.61% for Korea, 9.1% and 8.13% for Thailand, and 9.44% and 8.41% for Turkey.

Moreover, Table 3 also demonstrates the often large and persistent current account deficits that characterise many of the more developed countries. In particular, the US, UK, Canada, Australia, and New Zealand experience average current account deficits of 1.2%, 0.75%, 0.07%, 0.5% and 0.37%. However, this trend is not universal, with the Eurozone, Japan, Norway, Sweden and Switzerland all experiencing average current account surpluses of 0.57%, 0.98%, 1.61%, 0.93% and 1.15%, respectively. Almost all of the emerging and developing economies enjoy average current account surpluses. China, Korea and Singapore have relatively high surpluses of 1.72%, 1.37% and 1.02%, respectively, reflecting their export–led growth strategies.

1.4. Structural Breaks

Given our emphasis on inter temporal effects and our belief that many economies are subject to irregular shocks that fundamentally change the structure of their governing economic relations, we analyse the raw data for individual countries for signs of structural change.[24] When the impacts of structural breaks are considerable (e.g. the 1997 Asian crisis), the choice of whether or not to include break dummies in the

24) To avoid an arbitrary decision process, we only include breaks when such break points are generally regarded as significantly affecting the macroeconomic performance of individual countries/regions involved over the sample period considered. A more formal, statistical, procedure is clearly desirable but this is currently beyond the scope of the paper.

individual country models may significantly affect both the cointegrating relationships in the model and its dynamic forecasting performance. But it is also possible that the impacts of breaks will be somewhat attenuated in the global model due to co-breaking.

Table 1 summarises the cause and location of structural breaks. In general, we find substantial support for a break in either 1997Q3 or Q4 for the South-East Asian bloc relating to the financial crisis (in particular inflation and output show a noticeable perturbation). We find that many of the South American economies exhibit striking breaks associated with dollarisation (interest rates, exchange rates and inflation are typically profoundly effected). Our analysis also suggests that the departure of the UK from the ERM had significant repercussions for the domestic economy in 1992Q4 and that the real-estate and stock-market crash in Japan caused a break at 1990Q1. Lastly, we note that our composite Eurozone economy reacts noticeably to the introduction of the Euro in 1999Q1, with imports, exports and the exchange rate showing the strongest response.

2. Country–Specific Estimation Results

By their nature, global modelling exercises generate a considerable volume of statistical output. In our application, for the typical country there are an average of 3-4 PPs, 38 sheets of assorted IRF output each showing the response of 12 (11 or 10) variables and an average of 3-4 cointegrating vectors to any specific shock, the results of VECM and marginal VAR estimation and 6 different types of central forecast, not to mention the associated event forecasts. In light of this, it is obviously infeasible to discuss all of the estimation results in detail. Hence, we limit our discussion to six focus economies: Korea, the US, the Eurozone, China, Japan and the UK.[25)]

2.1. Korea

Including a structural break at 1997Q4 to account for the (slightly delayed) effects of the Asian financial crisis, the trace statistic selects 5 cointegrating vectors at the 95% level. Figure 1(a) shows that the model estimated on this basis proves stable with well behaved PPs, exhibiting some degree of persistence but no overshooting. In our

25) Detailed country-specific estimation results for all countries/regions are available from the authors on request.

discussion of the GVAR estimation results in the next section, we note that this persistence is a common trait of most of the South–East Asian economies and is probably caused by some residual effects of the 1997 financial crisis. The VECM and marginal VAR estimation results are promising. In particular, our diagnostic tests detect only minor mis-specifications in some equations, the pattern of significance is generally good and the $\overline{R}^2$s are mostly acceptable.

The SIRFs with respect to the five selected shocks (an oil price shock, a foreign interest rate shock, a foreign equity price shock, a domestic real exchange rate depreciation and a domestic monetary policy shock) are plotted in Figure 2. These SIRFs are well behaved in most cases, the notable exceptions being the large positive equity market response to a foreign interest rate shock, the negative output response to a depreciation and the current account improvement resulting from a domestic interest rate rise.

Comparison of these results with those obtained by Shin (2007) using a slightly different specification in the Korean national CVAR model,[26)] reveals that, overall, the patterns of dynamic adjustment are qualitatively similar. For example, in response to an oil price shock, inflation overshoots in the short-run in both models. After four quarters, the current model predicts that inflation stays at a slight positive value whilst it converges to zero in the Korean national model, although this difference is unlikely to be statistically significant. Similarly, the impact of an oil shock on real output is slightly more negative in the Korean national model. One potentially significant discrepancy lies in the impacts of a foreign interest rate shock on domestic inflation. The current model indicates a slight increase in inflation following tight credit conditions overseas, whereas the response of inflation to a US interest rate hike is mildly negative in the Korean national model. This difference derives, of course, from the definitions of r^* employed by each model.

The model forecasts initial low inflation at just 1.2% but which displays a mild upward trend indicating some latent inflationary pressure (see Figure 3). Output is forecast to grow steadily for four quarters before stabilising at approximately 6.4%, which is perhaps a little optimistic but remains consistent with historical experience.

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26) Shin defines xt = $(e_t, r_t, m_t, x_t, q_t, h_t, pps_t, \triangle p_t, y_t)'$ and $x^*_t = (p^0_t, \boldsymbol{\gamma}^*_t, q^*_t, y^*_t)'$, where h_t is the log of the money-output ratio and $ppst = p_t - p^*_t$ is the relative price. An additional difference lies in the construction of foreign variables. In particular, $\boldsymbol{\gamma}^*_t$ and $q^*_t$are proxied by the US interest rate and equity price index, while both p^* and y^*_t are proxied by the US interest rate and equity price index, while both p^* and y^*_t are constructed using the OECD aggregate measures. Estimation results are based on the finding that $r = 7$.

These output forecasts are somewhat similar to those of the Korean national model, while the inflation forecasts provide a significantly different profile, especially in the long-term. However, the inflation forecasts of both models remain well below 2% for the first three quarters.

Finally, in terms of probability event forecasting (Table 6), we find that the Bank of Korea has a high probability of maintaining inflation within a range of 2% to 4% while avoiding either recession or low growth in the medium-term. Compared to the results obtained from the Korean national model, the probabilities are higher in the short-term but smaller in the medium- and long-term. Indeed, after a year, the probabilities for both joint events drop well below 50%.

2.2. USA

The trace statistic supports 5 cointegrating vectors at the 95% level, which yields well -behaved PPs and good VECM results while the marginal VAR results could be improved. In particular, the $\triangle p^*$ equation shows some mis-specification and has a low $\overline{R}^2$. SIRFs all seem reasonable although our results suggest that a positive world output shock would reduce US output, although this could be attributed to some form of demand-switching behaviour. The model provides respectable inflation and output growth forecasts (Figure 3, panels (a) and (b)), indicating some reasonably strong inflationary pressure in the short-term raising inflation from 2.5% to 3.7%. It seems that inflationary pressure will ease somewhat, and will see inflation converging on a long-run value of 3.25%. Output growth is forecast to increase gradually from approximately 2%, converging at 3%. Table 6 shows that the probability of maintaining inflation between 1-3% while avoiding recession is approximately 40% in the medium- to long-term once the initial inflationary pressure has subsided. Note, however, that the model forecasts a relatively high probability (reaching 31.6%) that the economy will grow at less than half the historical average in the medium-term which tempers the optimistic growth forecasts somewhat.

2.3. Eurozone

Subject to a break at 1999Q1, the trace statistic indicates either 3 or 4 long-run relationships. Proceeding on the basis that r = 3, we achieve good PPs, and the VECM and marginal VAR estimation results are generally good with the exception of the $\triangle q$ equation which shows some evidence of misspecification.

SIRFs seem somewhat unreliable, exhibiting strange responses to p^o, r^*, re and r shocks. Growth forecasts are rather low (Figure 3(b)) and inflation forecasts are not encouraging, starting from approximately 1.5% and gradually declining until they are negative (Figure 3(a)). In light of this, the probability forecasts for output and inflation events contained in table 6 are relatively uninformative.

2.4. China

The trace statistic indicates 4 cointegrating relationships among the variables. Estimating the model on this basis yields good PPs and marginal VAR results. VECM results are encouraging, showing only a few minor misspecifications. SIRFs are mostly consistent with our prior expectations. The model forecasts output growth starting at 9%, decreasing to 7% and then recovering and converging around 9-9.5%, consistent with the historical average. Inflation forecasts are reasonable in the short-term but then gradually decrease and become negative after 5 quarters. Given this outcome, the event forecasts indicate a very high probability of maintaining inflation below 2% and avoiding low growth but these results must be interpreted with care.

2.5. Japan

Using r = 5 results in good *PP*s and good VECM results in which the break dummy is highly significant.[27] Marginal VAR results are generally good with only the r^* showing evidence of mis-specification. SIRFs are similarly promising, although the p^o, r^*, re and q^* shocks are somewhat disappointing. Iu terms of forecasting, the model predicts low inflation, starting at 0.35%, dropping to 0.1% at the second quarter and then converging at 0.65% in the long-run, below the historical average of 0.8%. Output forecasts are relatively optimistic, starting from 2.7% and climbing to 3.9% before falling and converging around 2.8%. This compares favourably to the historical average of 2.3%. Based on these results, Table 6 indicates a high probability of maintaining inflation below 2% and an initially low probability of slow growth which rises to non-negligible levels. The joint probability of maintaining inflation below 2% and avoiding low growth remains above 55% for at least 8 quarters.

27) Cointegration tests indicate either 4 or 5 long-run relationships. We find that there is a trade-off between setting r = 4 and r = 5. With r = 4, the forecasting performance is better, but the SIRFs seem less reliable and vice-versa.

2.6. UK

Including a structural break to account for Sterling's departure from the ERM the trace statistic supports5 long-run relationships, although we find that the modelling is improved by using just 4. Proceeding in this manner, the PPs show a relatively low degree of persistence and are subject to some minor over-shooting. Marginal VAR and VECM results are generally good, although some equations fail diagnostic testing. SIRFs are relatively mixed, some behaving well and others substantially at variance with our prior expectations. In particular, responses to y^* and r innovations seem unreliable. Although an exchange rate depreciation does eventually have a positive impact on output there is a substantial lag of 12 quarters.

The forecasting performance of the model is questionable. In particular, we find that the inflation forecast becomes negative within the first year and that this result is robust to changes in the cointegration rank and to the omission of the break dummy. This negativity is, however, short-lived and the forecasts rapidly return to positive values of a sensible magnitude. Output forecasts are relatively optimistic, with persistent growth prospects in excess of 3.4%. In terms of event forecasting, Table 6 reveals that the probability of the Bank of England meeting its declared inflation target (1-3% CPI) is initially relatively high (82%) but then falls rapidly to just 30%, while the probabilities of avoiding recession and low growth are high over all horizons.

IV. Main Empirical Results of the GVAR Models

1. Persistence profiles

The PPs derived from the GVAR model are generally well-behaved, converging on zero at a decreasing rate. However, we find strong evidence of regionality in the results. In particular, South-East Asian economies typically exhibit some degree of persistence of one cointegrating vector, presumably reflecting some lingering effects of the financial crisis (see Figure 1(b) for the Korean case). Figure 1(c) plots the poorly behaved cointegrating vector from each of the South East Asian countries in our sample and reveals that the overshooting and persistence can be roughly ordered in terms of severity as follows: Thailand (most severe), Korea, Philippines, Indonesia, Singapore and Malaysia (unaffected). This is generally consistent with the fact that the Asian crisis is widely believed to have originated in Thailand and that its effects were mostly concentrated in South-Eastern Asia.

Figure 1(d) presents further evidence of regionality among the Southern American countries, which tend to have one vector which briefly overshoots significantly before dying away rapidly. Brazil is the most severely affected, followed by Argentina and then Peru, with Chile being unaffected. The fact that Chile is the only South American country in our sample which did not suffer an obvious break during the hyperinflation years is unlikely to be coincidental in this regard.

2. Impulse Response Analysis

Due to the difficulties in defining au appropriate recursive ordering of variables in the global system, we focus on a small number of GIRFs with respect to a variety of interesting shocks. More specifically, we consider an oil price shock, a US monetary policy shock, a US stock market shock and a Chinese inflationary shock. Where possible we compare our results with those presented by DdPS, in which the GIRFs for the US and Eurozone with respect to the first three of these shocks are discussed.[28)]

2.1. Oil price shock

Figure 6 shows the effect of an oil price shock on inflation, output, equity prices and the current account. The inflationary impact of the oil shock is generally positive in all countries. The strongest inflationary response is seen in the Eurozone in the longer-term and Korea in the shock ou output are generally negative with the exception of the Eurozone. The observation of a positive Eurozone output response in this context is consistent with the results of DdPS, where the response is of a similar magnitude but is found to be insignificant by use of bootstrap critical values. The UK enjoys a substantial current account improvement following the shock, reflecting its position as a net exporter of oil. The remaining focus countries experience some deterioration. Lastly, the effects on the stock markets are generally negative, certainly in the medium-term. Korea shows the strongest negative reaction, reaching a nadir after 3 quarters and then gradually recovering. The GIRFs for EU and US equity prices are again relatively comparable to those contained in DdPS.

28) DdPS actually consider a negative US stock market shock, so for the purposes of comparison we exploit the linearity of the model which suggests that impulse responses should be symmetrical.

In general, these results are qualitatively similar to those derived from country-specific modelling. For example, the impacts on both Korean inflation and output are slightly smaller under GVAR than in the country-specific case, though their adjustment pattern is similar. One notable exception to this, however, is the UK. The national model suggests that output falls sharply following an oil price shock and that economic activity remains depressed. These differences may reflect the additional information used in the GVAR estimation process.

The remaining shocks that we consider are not directly comparable with those derived from the national modelling exercise. Indeed, it is one of the foremost strengths of the GVAR modelling strategy that it permits the analysis of a wider range of shocks than the corresponding national models.

2.2. US monetary policy shock

Figure 7 plots the impulse responses with respect to a positive US monetary policy shock. The output effects are mostly plausible, with the notable exception of American output which increases in clear contradiction of the accepted wisdom of monetary policymakers. This effect is also evident in the DdPS results. Japanese output increases in the short-run before falling while British output exhibits the opposite pattern. Interestingly we find that Chinese output is highly sensitive to the US interest rate, an effect which most likely derives from China's increasingly large share in US imports. Korea is initially strongly affected for approximately 6 periods, after which the effect weakens somewhat.

The inflationary consequences of the US monetary policy shock are generally slightly positive but largely negligible. The US response is similar to that reported by DdPS and is a classic example of the price puzzle which is an enduring result in the empirical literature and is, therefore, not unduly troublesome. The Chinese reaction is again strong, with a US interest rate hike causing strong deflationary pressure which does not ease for 10 quarters. The Korean inflationary response to the US interest rate rise is relatively large and positive which could potentially be attributed to cost-push explanations of inflation if Korean firms borrow extensively in dollar-denominated instruments and pass their increased costs on to their customers relatively quickly.

The impact on the US current account position is large and negative, as one would expect. The Eurozone enjoys the most substantial current account improvement, while Asian countries suffer an initial large deterioration which lasts for between 11 and 14 quarters. Stock markets are mostly positively effected, which would tend to suggest that investors move from bonds to equity as the increased interest rate drives bond prices down. The notable exceptions are the Japanese and Korean stock markets which exhibit a negative impact (substantially so in the Korean case).

2.3. US (positive) stock market shock

Figure 8 shows the impact of a positive US stock market shock. With the exception of the Eurozone, output responses are positive.[29] The results are relatively similar to those observed in the national models for q* shocks, reflecting America's position as the world's dominant financial power. The stock price boom is accompanied by universally falling inflation which is an interesting result consistent with the findings of DdPS, and which suggests that the inflationary pressure arising due to the wealth effect of stock market gains is overpowered by other factors. The responses of national stock markets to the US shock are positive in the short- to medium-term but they tend to die out after approximately 15 quarters (i.e. the impact of the shock is transitory). DdPS find that the Eurozone stock indices react significantly to the US shock for approximately 9-10 quarters before the confidence interval includes zero and in this sense our results are comparable to theirs. The current account picture is mixed with some countries enjoying sustained improvements (most notably the Eurozone and Korea) and others suffering deteriorations (e.g. the UK).

2.4. Chinese inflationary shock

Figure 9 plots the impulse responses associated with elevated Chinese inflationary pressure. Given the growing importance of Chinese exports in the world economy, such inflationary pressure has significant inflationary consequences for most of our focus countries (panel (b)). The inflationary pressure is associated with increased output in China and Korea while the US and UK suffer recessionary pressures. China enjoys a significant current account improvement (panel (c)), although the effects on the other countries are mixed. Lastly, the effects on stock markets are positive in the short-run before dying away and becoming negligible.

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29) DdPS find a negative impact of a negative US stock market shock on Eurozone output which, due to the linearity of the model, implies a positive response to a positive shock. Hence, our results disagree with those of DdPS in this instance. This could be attributed to our use of a different sample period, our inclusion of additional variables, our consideration of structural breaks or our use of different cointegration ranks in certain country models.

3. Forecast Error Variance Decomposition

Table 5 presents generalised FEVDs of inflation and real output for Korea.[30] The FEVDs are presented in terms of the top 10 determinants of error variance from all 26 countries/regions. The table shows the proportion of forecast error variance of the selected variable by conditioning on contemporaneous and expected future values of the top ten innovations, which are evaluated in terms of their respective contributions for $n = 0, 1, \ldots, 8$. The last two columns of each table provide the sums across the top ten components and across the total number of innovations (equal by definition to the number of global variables, 176). Notice that these sums may exceed 100% due to the positive correlation across country-specific shocks.

The greater proportion of the forecast variance of the Korean variables is explained by domestic variables, as one might expect. In particular, Table 5(a) reveals that the five most significant determinants of the forecast variance of Korean output are all domestic variables, in the order of real output, nominal interest rate, real exchange rate, real exports and the real equity price. Furthermore, domestic inflation has the seventh largest input. Their total contribution is 185.40% on average over 8 periods. Among the foreign variables, the real equity price in New Zealand is the largest contributor at 9.2%, while Chilean and Thai variables also prove significant. Surprisingly, the contributions of the real outputs of Korea's main trading partners (the US, Eurozone, Japan and China) are negligible at just 0.23%, 0.40%, 1.04%, and 3.15%, respectively. The contribution of the oil price is also relatively marginal at 5.41%.

For Korean inflation, five domestic variables (real imports, real output, inflation, the nominal interest rate and real exports) are among the principal contributors, totalling 47.73% on average, see Table 5(b). However, this figure is of a considerably smaller magnitude than that obtained in the real output FEVD. Among the foreign variables, the Brazilian nominal interest rate and rate of inflation dominate, with a combined contribution of 37.84%, which is even larger than the domestic counterpart. This may be a statistical artefact resulting from the high historical and average values of the nominal interest rate and inflation experienced by the hyper inflationary countries in general, and especially Brazil, over the sample period.[31] Another surprising finding is

30) Comprehensive tables of the generalised FEVDs derived from the GVAR model and orthogonalised and generalised FEVDs based on the country-specific models are available upon request.

31) We find that either Brazilian interest rates or inflation are among the main contributors to the inflation forecast error variances of the majority of countries considered despite the fact that its trade-weight with most countries is rather small (Brazil accounts for less than 1% of Korea's total trade, for example). Such results

the pattern with respect to a domestic inflation innovation: the impact contribution is the largest at 77.38% and then its contribution in the next quarter drops sharply to just 0.05%. The oil price, US real exports and the US price level also prove to be important foreign factors. Surprisingly, the total combined contribution of all variables of both Japan and China is relatively insignificant at just 17.29%.

4. Probability Forecasts of Single and Joint Events

4.1. Point and Interval Forecasts

It is worth briefly summarizing the point and interval forecasts to help place the probability forecasts in context. Figure 3 provides the point forecasts for inflation rates, output growth rates and current accounts for the 6 focus countries over a 24 quarter forecast horizon based on both the country-specific and GVAR models. We shall focus mainly on an eight quarter horizon but the additional information is provided to demonstrate the tendency of the forecasts to converge on the historical average value.

The GVAR model predicts that the average annual rate of inflation will stay between 1 and 3% over next two years for the Eurozone and China only (see Figure 3(b)). With the exception of these two countries, the GVAR model predicts inflationary pressure of sufficient magnitude to exceed the upper range of our approximate inflation targets for the remaining central banks. In particular, inflation in the UK is predicted to reach 4.9% within two years while forecasts for the US are slightly worse, starting at 2.5% at 2007q1 and reaching 5.2% at 2008q4. Furthermore, Korean inflation is forecast to start from 3.77% (still within the target range of 2-4%) and then to increase steadily, approaching 10% at the end of the forecast horizon. There results are seemingly spurious as they stand in sharp contrast against the recent experience of low and stable inflation.

The forecasts derived from country-specific modelling summarised in Figure 3(a) seem considerably more promising, indicating a significantly higher probability of the inflation targets being achieved in our focus group of countries. Focussing briefly on the Korean case, it is clear that the forecast is lower than before although some residual

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suggest that an alternative measurement of foreign financial variables (e.g. based on an appropriately constructed financial-transactions-based weighting matrix) may improve the estimation of the GVAR model. In particular, given that the contribution of Latin and South American countries to global financial markets is small if not negligible, the use of trade-weights is likely to overstate their importance in these markets.

inflationary pressure remains. In this case, it seems safe to assume that the GVAR forecasts are erroneous, particularly in light of a comparison with the Korean national CVAR model (Shiu, 2007) which indicates inflation of the order of 2.5-3.5% for the benchmark model and 1.5-2.7% for the extended model. This poor performance of the GVAR may be due to the observed excessive persistence of one of the cointegrating vectors for Korea (Figure 1(b)).

The GVAR model predicts that output growth should be reasonably healthy for all countries over the one year period although the picture is clearly dominated by a vibrant Chinese growth forecast of almost 10% (Figure 3(d)). Growth prospects start to decline for all countries except China after 4 or 5 quarters, in some cases dramatically. In particular, the US may suffer a recession toward the end of the 2 year horizon. This result is rather encouraging as, at the time of writing, many commentators are forecasting an imminent American recession. The medium-term growth forecasts are also bleak for Korea, where a sizeable contraction is forecasted. Balancing the cautionary note somewhat is the Chinese forecast which predicts growth in excess of 9% at 2008q4 whilst the economies of the Eurozone, Japan and the UK are likely to grow at a reduced although still healthy pace over 2007-2008.

Comparison with the output forecasts derived from country-specific modelling (Figure 3(c)) reveals a striking difference. The contractionary/recessionary pressures in the GVAR forecasts are largely absent. In general, the output forecasts indicate relatively stable growth at levels mostly consistent with historical experience, after some short-term adjustments at least. Interestingly China is forecast to suffer some non-negligible contractionary pressure in the short- to medium-term where no such pressure existed in the GVAR forecasts.

Figures 3(e) and 3(f) present the forecasted current account movement over next 8 quarters derived from each model. As expected, the US and the UK are notable for their substantial and consistent deficits. Closer inspection reveals that the US current account position should improve in the medium term, rather markedly according to the GVAR forecasts. By contrast, both models agree that the UK's deficit will increase significantly and at a relatively constant rate (the recent experience of the UK suggests that this forecast is being borne out). The models agree that both Korea and China will enjoy sizeable surpluses and improvements over the coming years. The only principle areas of discord between the two models in terms of current account forecasting are Japan and the Eurozone. The GVAR model forecasts a deterioration from surplus to deficit in both cases while the country-specific models indicate a growing surplus.

There are many areas of broad agreement between the country-specific and GVAR forecasts although some significant discrepancies are observed, especially concerning output forecasting in general, and some inflation forecasts.[32] However, it must be borne in mind that point forecasts are subject to a high degree of uncertainty, particularly at longer horizons. Indeed, it is difficult to evaluate the significance of these forecasts for policy analysis without more detailed information. Figure 4 provides interval forecasts for Korean inflation and output growth based on the observed empirical distributions of the variables for both the country-specific and GVAR models. It is immediately apparent that the uncertainty involved is substantial and that the interpretation of such figures is not straightforward. In light of this, a more appropriate approach is to consider probability forecasting as a method of characterising the various uncertainties that are associated with events of interest.

4.2. Predictive Distribution Functions

In the case of single events, probability forecasts are best represented by means of probability distribution functions. Here we focus simply on the estimates of the probability distribution functions of the four-quarter moving averages of inflation and output growth over threshold values ranging from -2% to 12% per annum and over 1, 2, 4 and 8 quarter forecast horizons. These estimates are computed using simulation techniques and take account of future uncertainty only. This limited focus is in the interests of brevity, especially given that our main interest lies in joint event forecasting.

Figure 5 plots the estimated predictive distribution functions for inflation and output growth for Korea derived from both the GVAR and country-specific models. In all cases, the gradient of the plots decreases as the forecast horizon increases, reflecting the increasing uncertainty. Moreover, the plots are generally shallower under GVAR than in the country-specific case, indicating that the GVAR model is subject to greater uncertainty in estimation.

In the case of inflation, inspection of the figures for the 6 focus countries (not reported) reveals that the functions at the 1 and 2 quarter horizons are relatively steep, and become flatter as the forecast horizon increases. For the US, Eurozone, Japan, the UK and China, the probability distribution functions of inflation shift further to the right around the 2-4% threshold cutoff values, as longer forecast horizons are considered. This implies that the probability of inflation falling within the target

32) It is interesting to note that we found that the point forecast results tend to be lower in those models including carefully considered structural breaks. Hence, it is possible that models taking full account of structural breaks might provide more precise forecasting scenarios for inflation and output growth. We are currently investigating this possibility.

range (about 1-3%) declines with the forecast horizon while uncertainty increases. This rightward shift to a high inflation regime is most apparent in the US, although it is also evident in a number of other countries. Turning to Korea, the predictive distribution function estimated under GVAR is reasonably steep at the 1 and 2 quarter horizons around the 3-4% cutoff threshold (still within the target range) but then shifts considerably to the right at the 4 and 8 quarter horizons, implying medium-term inflationary pressure (Figure 5(b)). A similar pattern emerges in the country-specific case, although the shift is considerably less marked implying more modest inflationary pressure (Figure 5(a)).

Figures 5(c) and 5(d) plot the estimated predictive distribution functions for output growth in Korea under both country-specific and GVAR models. These plots also become increasingly shallow as the forecast horizon increases, demonstrating once again the increased uncertainty associated with longer forecast horizons. In the GVAR case, the plots shift inward markedly, indicating a weakening of the medium-term growth prospects for Korea (a similar pattern is also observed for the US and UK, although not for China which shows robust growth at 9-10%). However, no such pattern is observed in the country-specific case.

4.3. Event Probability Forecasts

There is an increasing recognition among academic econometricians and practitioners alike of the importance of the provision of further information on the uncertainties surrounding forecasts of key macroeconomic variables (c.f. Ericsson, 2001, for au introduction to the issues and Giordani and Soderlind, 2003 for a discussion of inflation forecast uncertainty). Knowledge of the precision of forecasts enables policymakers to motivate and justify actions based on the forecasts, and helps in achieving more balanced evaluation of the forecasts by the public (the issue of the interpretation of inflation forecasts is addressed by Casillas - Olvera and Bessler, 2006). One of the many problems facing economic forecasters and policymakers is conveying to the public the degree of uncertainty associated with point forecasts. Policymakers recognize that their announcements, in addition to providing information on policy objectives, can themselves initiate responses which affect economic outcomes. This means that central bankers are loathed to discuss pessimistic possibilities lest such announcements exert a contractionary influence, and that they are similarly reluctant to make optimistic announcements for fear that they might prove inflationary. A striking example of the strength of the signalling effects of central bank announcements was Alan Greenspan's 'irrational exuberance' speech, in which he warned that caution should be exercised to avoid complacency over stock market overheating (Greespan, 1996), a remark that saw stock markets around the world drop by as much as 2% overnight. Hence there is a clear rationale for policymakers to seek methods of making unambiguous statements regarding the range and likelihood of possible outcomes for any given policy in a manner which avoids these difficulties. GLPS contend that probability forecasts provide just such a method of characterizing the uncertainties surrounding economic forecasts in a superior manner to the use of confidence intervals. The use of probability forecasts has an intuitive appeal, enabling both the forecaster and potentially the end-user to specify 'threshold values' defining an event of interest. This stands in stark contrast to the use of confidence intervals which define threshold values only implicitly through the choice of their width.

The so-called 'river of blood' forecasts produced by the Bank of England in its Inflation Report (see, for example, Bank of England, 2008, pp. 7-8) are an important step toward acknowledging the significance of forecast uncertainties in the decision making process. In the same vein, the Federal Reserve has recently adopted a similar approach to providing transparent forecasts of key macroeconomic variables including inflation and output growth over the short-, medium- and long-term. However, these approaches may suffer from two major shortcomings. Firstly, it seems unlikely that such forecasting scenarios can be replicated by independent researchers. This is largely due to the subjective manner in which uncertainty is taken into account by the central bank. Secondly, separate fan charts are provided for inflation and output growth forecasts and the usefulness of these fan charts in the analysis of uncertainty associated with joint events is thus limited. Here we address both of these issues, and present probability forecasts of the single and joint events defined above estimated using both the country-specific and GVAR models (Table 6).

Inflation Targets: Tables 6(a) and (b) show the estimated probability forecasts of inflation targets A and B defined above estimated from both the country-specific and GVAR models. Considering first the GVAR case, conditional on the information available at 2006q4, the estimated probability of the central bank achieving target A at the 1 quarter-ahead horizon is high for the US, Eurozone and Japan at 92%, 99% and 91%, respectively. The probabilities are reasonable for Korea and China at 63%. Surprisingly, the probability of the Bank of England keeping inflation within a range of 1-3% is quite low at just 13%. With the exception of the UK, the probability of achieving target A falls as the forecast horizon increases. Only for Eurozone and Japan is the probability above 50% over most horizons. For all other countries, the chance that inflation target A will be met after 2007q2 is slim. This may reflect the considerable uncertainty associated with even small-to-medium forecast horizons combined with the (individual country-specific) model uncertainty involved in the construction of the GVAR model. The probabilities of achieving inflation target B are generally lower (the exception is Japan), certainly in the short-run, which suggests that inflation is likely to be in the upper end of the targeted band or exceeding this upper limit in most countries over the forecast horizon.

The country-specific model yields significantly different forecasts. In particular, the probabilities of meeting target A are considerably higher for the UK and lower for Japan and Korea, and the probabilities of achieving target B are very high for the Eurozone, Japan and Korea, and become increasingly large for China in the longer-term. These differences reflect the heterogeneity of the central and interval forecasts discussed above. Of course, such differences have significant implications for joint event forecasting, as will be seen below.

Recession and Poor Growth Prospects: Table 6(c) shows that the probability of recession estimated under GVAR is almost zero for all countries up to 2008q1, after which time the US probability increases, reaching 54% at 2008q4. The likelihood of recession is also relatively high for Korea, at 17%. The model predicts a very slim chance of recession in the Eurozone and Japan and an almost 0% chance of a Chinese recession.

From Table 6(d), a similar pattern is observed for the prospect of poor growth. Once again, the probabilities are almost negligible for all countries up to 2008q1, after which they become more significant for the US and Korea at 2008q4. Interestingly, the probability of low growth in the UK becomes relatively significant at 30% after 8 quarters. Over all forecast horizons considered, the prospect of poor growth is slim for the Eurozone and Japan, and almost nonexistent for China.

The country-specific estimates reported in Tables 6(c) aid (d) show a low probability of recession in all countries over all horizons. Similarly, the likelihood of low growth is generally smaller with all of the focus countries having more thai a 75% chance of growing at a reasonable rate over the next two years. These figures reflect the greater optimism of the country-specific central forecasts discussed earlier.

Joint Inflation and Output Growth Events: Single events are clearly of interest but policy-makers may often be more concerned with joint events involving both inflation and output growth outcomes. Tables 6(e) add (f) provide the probability estimates of the two joint events, $A_{T+h} \cap \overline{C}_{T+h}$, and $A_{T+h} \cap \overline{D}_{T+h}$ over the forecast horizons h = 1, ..., 8.

For the event $A_{T+h} \cap \overline{C}_{T+h}$, the joint probability forecasts from GVAR are similar in magnitude to those for $\Pr(A_{T+h} \mid \Im_T)$ alone at all horizons. This is not surprising, since the probability of recession is estimated to be small at most forecast horizons and, therefore, the probability of avoiding recession is approximately one except for the US and Korea. Nevertheless, these small differences might be important if there are large and/or discontinuous differences in the net benefits of different outcomes. In fact, the probability forecasts for $A_{T+h} \cap \overline{C}_{T+h}$ are slightly less than those for $\Pr(A_{T+h} \mid \Im_T)$ alone. Turning to the probability forecasts of the joint event, $A_{T+h} \cap \overline{D}_{T+h}$, we again observe that the forecast results are somewhat smaller than those for $\Pr(A_{T+h} \mid \Im_T)$ at longer horizons, especially for the US aid Korea.

In the country-specific case, the joint probabilities $Pr(A_{T+h} \cap \overline{C}_{T+h})$ and $Pr(A_{T+h} \cap \overline{D}_{T+h})$ are again similar to the single event probabilities associated with inflation target A owing to the low probability of recession and low growth. The joint probabilities based on inflation target B reported in panels (g) and (h) are considerably lower, reflecting the smaller probability of achieving inflation target B as compared to A.

Current Account Joint Events: In terms of current account probability forecasting, it is possible to classify the countries into a number of groups. Table 6(i) reveals that the USA and UK are persistent deficit countries, Korea and China (and to a lesser extent Japan, at least in the GVAR case) are persistent surplus economies, and the Eurozone occupies an intermediate position, initially in surplus but with an increasing probability of deficit.

Turning now to Tables 6(k)-6(n), we consider the four current account joint events which we interpret as balancing improvement, unbalancing deterioration, unbalancing improvement and balancing deterioration, respectively. We find that the probability of a balancing improvement is high in the US although the probability of further unbalancing deterioration is high in the UK, certainly in the short- to medium-term. Among the surplus countries, the likelihood of a balancing deterioration is high in the Eurozone and also relatively high in Japan, while Korea and China are likely to experience unbalancing improvement.

In the country-specific case the likelihood of unbalancing improvement is also high in the Eurozone and Japan, while the probability of an unbalancing deterioration in the USA is somewhat higher than under GVAR.

V. Concluding Remarks

This paper follows the practical and transparent long-run structural VAR modelling approach advanced by GLPS and its global extension, the GVAR modelling approach pioneered by PSW and DdPS, which develops a framework for the analysis of the dynamic international linkages of a small open economy such as Korea. We apply this modelling strategy to the same group of 33 countries (26 regions) as considered by DdPS but we extend their research by explicitly incorporating the current account, extending the coverage of the data and, most importantly, by explicitly modelling inter temporal structural instability. The inclusion of deterministic structural breaks in the model is shown to be successful in the analysis of the substantial impacts of the 1997 Asian currency crisis on the macroeconomic performance of Korea during and after the crisis period (see also Shin, 2007).

We provide country-specific estimation results for 6 focus economies: Korea, the US, the Eurozone, China, Japan and the UK. Overall, these results are promising although we find a number of nonsensical estimation results even for the developed economies including the Eurozone, Japan and the UK. Based on this initial estimation, we construct the associated GVAR model, combining the country-specific estimation results by means of carefully constructed trade-weights-based link matrices. Focussing on a small number of IRFs with respect to an oil price shock, a US monetary policy shock, a US stock market shock and a Chinese inflationary shock, we find that the performance of the GVAR model is rather encouraging, in the seise that the profiles of the shocks are generally consistent with our prior expectations and with the existing empirical literature.

We consider a range of forecasting exercises which are likely to be of considerable interest in policy-making circles. In general, we find that the GVAR model predicts lower growth prospects and greater inflationary pressures than the equivalent country-specific structural VECMs. In the case of Korea, in particular, the GVAR model predicts rapidly increasing inflation over a fairly wide range of forecast horizons, which stands in contrast to the recent experience of low and stable inflation, and also to the forecasts derived from the country-specific model and the Korean national model (Shin, 2007). This seemingly erroneous forecasting is likely to derive from the excessive persistence of one of the Korean cointegrating vectors, an effect that we attribute to some lingering effects of the 1997 financial crisis. Overcoming such spurious results provides fresh challenges for subsequent revisions of our work.

We present probability forecasts based on a number of single and joint events relating to inflationary pressure, output growth and the current account position which are highly encouraging. In particular, our treatment of joint events allows the monetary authority to evaluate the likelihood of simultaneously meeting its inflation target and maintaining reasonable growth, and to investigate the potential monetary policy trade-offs. Moreover, our analysis of joint events pertaining to the level and change in the current account position allows us to classify various countries in an easily interpretable manner suitable for public reporting.

Two principal areas for further research present themselves. Firstly, the over-identification of a GVAR system is yet to be satisfactorily achieved (see also the limited progress in DHPS). In subsequent work, we hope to impose an over-identified structure based on our tentative long-run theories outlined above. If not rejected by the data, this is likely to significantly improve the performance of the impulse responses and potentially the dynamic forecasts derived from the model. Recently, Pesaran, Schuermann and Smith (2007) have divided the countries into two groups; a focus group of countries of interest, and the remainder. Such an approach allows the imposition of a theory-consistent over-identified long-run structure in the focus countries while the remainder are estimated subject to the exactly identifying restrictions. Alternatively, to further improve model performance, one could impose zero restrictions on those short-run dynamic coefficients (including the loading matrix) which prove to be statistically insignificant. This so-called general-to-specific practice circumvents the Sims critique and, therefore, may be of significant interest in refining the model to sharpen the forecasts.

Secondly, as is clear from the results adduced in this paper, there is a tendency for South American financial variables to spuriously dominate some aspects of the modelling under the current specification. As discussed in section 4.3, we attribute this effect to the use of a trade-based weighting scheme for both real and financial variables. Given that these economies trade largely in primary and low-tech commodities and have only a small presence in the financial markets, such an approach is likely to lend excessive weight to their financial variables in the global model. Hence it is likely that the construction of a more complete (potentially time-varying) weighting system which attaches weights based on financial transactions volumes to financial variables would yield substantial improvements in the performance of the GVAR model. However, the construction of the required financial link matrices and the selection of a window length which balances the improved realism against the level of undesirable randomness introduced into estimation is likely to be non-trivial to say the least, and provides an exciting and challenging avenue for further research.

VI. Data Appendix

Variables used in this paper include *y* (real GDP), *p* (consumer price index) *q* (equity price index), *e* (nominal exchange rate in terms of the US Dollar), *r* (short-term interest rate), *x* (exports), *m* (imports) and p^o (nominal spot oil price).

A1. Real GDP: Real GDP series for 33 countries are taken from the IMF's International Financial Statistics (IFS), Series 90BVRZF (Index, 2000 = 100). Where data were not available, the IFS series were completed by data from other sources: Datastream, OECD, or extrapolated growth rates (using the average growth rate of three previous years).

Where quarterly data were not available, quarterly series were generated from annual series using the interpolation procedure of DdPS (see their Supplement A for details of the interpolation procedure). Specifically, the interpolated series were used throughout the sample period for China aid Saudi Arabia aid during the following sub-periods: 1980-1989 for Argentina, 1980-1989 for Brazil, 1980-1996 for India, 1980-1982 for Indonesia, 1980-1987 for Malaysia, 1980 for Philippines, 1980-1992 for Thailand, 1980-1986 for Turkey. In these countries, quarterly data were available that covered the remainder of the sample period.

The series for Singapore were completed by Datastream data, while the series for Brazil were completed using OECD data. Extrapolated series were used during: 2006q3 & 2006q4 for India, 2006q4 for Philippines, 2006q4 for Singapore, 2006q3 & 2006q4 for Turkey, and 2006 for China.

The series for Argentina, Austria, Belgium, Brazil, Chile, Finland, India, Indonesia, Korea, Malaysia, Mexico, Norway, Peru, Philippines, Sweden, Thailand, and Turkey were seasonally adjusted using the US Census Bureau's X12 program (as implemented in EViews 5.0).

A2. Consumer Price Indices: The Consumer Price Iidex for most of the 33 countries were taken from IFS Series 64.ZF (Index, 2000 = 100), except for China, Finland and Germany. The series for China (seasonally adjusted from 1987Q1–2006Q4) and Germany (1980–2006) were provided by the Baik of Korea. The series for China were completed by IFS Series 64.XZF. Meanwhile, the source for Finland's price index was IFS Series 63EY.ZF.

A3. Exchange Rate: IFS Series RF.ZF (National currency per US$) were used for all countries. For the Eurozone, the series for 8 member countries (Austria, Belgium, France, Finland, Germany, Italy, Spain, and Netherlands) were available from 1980 to 1998, after which the Euro/US$ exchange rate was used instead.

A4. Short-Term Interest Rate: The short-term interest rate series (measured in percent per annum) were taken from IFS Series 60B.ZF (money market - interbank - rate) for 16 countries. The data for Argentina, Chile, and Turkey were taken from IFS Series 60L.ZF (deposit rate). For Sweden, IFS Series 60B.ZF was completed by IFS Series 60A.ZF from 2004q4. For Mexico and Philippines, IFS Series 60C.ZF (Treasury bill rate) were used, while IFS Series 60.ZF (discount rate) were used for China, New Zealand and Peru. For India, data covering 1998q2–2006q2 were retrieved from the Reserve Bank of India. No reliable short-term interest rate is published by the Saudi Arabian Monetary Agency.

For the Euro Area, 4 countries (Finland, Germany, Italy, and Spain) had complete short-term interest rate series (1980–2006) while the series for the 4 remaining countries (Austria, Belgium, France, and Netherlands) ended at 1998q4. For these latter countries, the series were completed by the Euro inter bank (overnight) rate, IFS Series 60A.ZF.

A5. Exports and Imports: The data sources for exports and imports (millions US$) of 32 countries were available from IFS Series 70.DZF (for exports) and IFS Series 71.DZF (for imports). The data for Belgium are from the World Bank. Extrapolated data were used for China's export and import in 1980, Belgium's export and import in 2006, Saudi Arabia's export in 2006, and South Africa's import in 2006q3 & 2006q4. The quarterly series for Belgium and Saudi Arabia were interpolated from the annual series. All the series were seasonally adjusted using Census X12.

A6. Equity Price Indices: The data source was IFS Series 62.ZF (industrial share prices, index) for 26 countries (Argentina, Australia, Belgium, Brazil, Canada, Chile, Finland, France, Germany, India, Italy, Japan, Korea, Malaysia, Netherlands, New Zealand, Norway, Philippines, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, United Kingdom, and United States). For Belgium, France, Norway, Sweden, and United Kingdom, the IFS series were completed with data from the OECD's Main Economic Indicators. For Argentina, Singapore, Switzerland, and Thailand, the IFS series were completed using Datastream. The data for Austria and Mexico are from the Main Economic Indicators. Reliable equity price indices for China, Indonesia, Peru, Turkey and Saudi Arabia could not be found.

A7. Oil Price: The UK Brent series (US$ per barrel) from IFS Commodity Price was used.

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Table 1. Countries/Regions Included in the GVAR

Order	Country	Code	Case	r	C.I. (%)	n	k	Break point (obs)	Explanation of break
0	USA	USA	4	5	90	7	5		
1	Eurozone*	EUR	6	3	95	7	5	1999Q1 (76)	Introduction of Euro
2	Japan	JAP	4	5	95	7	5	1990Q1 (40)	Real–estate/stock market crash
3	UK	UK	6	4	95	7	5	1992Q4 (51)	Departure from ERM
4	Norway	NOR	4	2	95	7	5		
5	Sweden	SWE	4	3	95	7	5		
6	Switzerland	SWI	4	4	95	7	5		
7	Canada	CAN	4	6	95	7	5		
8	Australia	AUS	4	3	95	7	5		
9	New Zealand	NZ	4	4	90	7	5		
10	South Africa	SAF	4	3	90	7	5		
11	Argentina	ARG	6	4	95	7	5	1991Q3 (46)	First major effects of Convertibility Plan
12	Brazil	BRA	6	2	95	7	5	1994Q4 (58)	First major effects of Real Plan
13	Chile	CHL	4	3	95	7	5		
14	Mexico	MEX	6	4	95	7	5	1988Q2 (33)	End of rising inflation and interest rates
15	India	IND	4	3	90	7	5		
16	Korea	KOR	6	5	95	7	5	1997Q4 (71)	S.E. Asian crisis
17	Malaysia	MAL	6	5	95	7	5	1997Q3 (70)	S.E. Asian crisis
18	Philippines	PHI	6	5	95	7	5	1997Q4 (71)	S.E. Asian crisis
19	Singapore	SNG	4	3	95	7	5		
20	Thailand	THA	6	5	90	7	5	1997Q3 (70)	S.E. Asian crisis
21	China	CHN	4	4	90	6	5		
22	Indonesia	INS	6	4	95	6	5	1997Q3 (70)	S.E. Asian crisis
23	Peru	PER	6	4	95	6	5	1991Q4 (47)	Dollarisation following 'Washington consensus'
24	Turkey	TUR	4	3	95	6	5		
25	Saudi Arabia	SAR	4	3	95	5	5		

* For our purposes, the Eurozone includes Austria, Belgium, Finland, France, Germany, Italy, the Netherlands and Spain only. Eurozone data are constructed by aggregating the contributions of these member states using a PPP－GDP weighting scheme. See the data appendix for details.

Table 2. Historical Inflation and Output Growth by Country/Region

Country	Inflation (% per annum)				Output Growth (% per annum)			
	Mean	St. Dev.	Maximum	Minimum	Mean	St. Dev.	Maximum	Minimum
USA	3.51	2.49	14.18	-3.42	2.92	2.86	8.92	-8.15
EUR	3.73	2.77	13.12	0.06	2.14	2.25	13.65	-2.72
JAP	1.11	2.76	12.52	-4.00	2.17	3.50	10.71	-8.90
UK	4.34	4.08	22.60	-2.68	2.41	2.43	8.72	-7.27
NOR	4.23	3.96	18.48	-6.71	2.82	7.15	30.29	-11.74
SWE	4.07	4.28	17.27	-4.33	2.12	4.90	15.00	-20.11
SWI	2.23	2.62	9.56	-2.62	1.54	2.64	9.04	-4.64
CAN	3.55	3.23	12.83	-3.67	2.99	4.14	31.91	-6.08
AUS	4.58	3.73	16.34	-1.67	3.24	3.25	11.49	-6.61
NZ	5.26	5.75	34.17	-3.18	2.32	3.97	13.89	-10.88
SAF	9.70	5.24	22.93	-4.81	2.29	3.42	10.02	-8.55
ARG	71.32	119.03	759.22	-4.20	1.76	9.27	21.30	-25.42
BRA	98.85	120.73	622.61	-1.42	2.35	7.47	28.47	-29.00
CHL	11.30	9.93	46.19	-1.43	4.42	8.36	33.19	-25.83
MEX	26.47	26.63	131.44	0.06	2.60	6.17	15.14	-24.73
IND	7.66	6.76	24.19	-16.01	5.89	5.36	20.52	-12.93
KOR	5.20	5.48	29.63	-2.72	6.44	6.39	26.20	-34.88
MAL	3.05	2.78	14.92	-2.43	5.89	6.17	19.94	-27.66
PHI	9.13	10.09	63.56	-14.02	2.87	6.04	17.99	-25.01
SNG	1.73	2.67	13.68	-4.63	6.66	6.84	23.78	-11.46
THA	4.11	4.10	24.39	-4.98	5.69	6.33	25.23	-20.48
CHN	5.36	7.12	33.94	-2.68	9.29	3.14	17.31	0.69
INS	10.19	12.03	73.14	-9.08	4.67	9.15	48.55	-31.51
PER	67.83	122.03	856.53	-2.38	2.40	12.94	28.01	-55.04
TUR	41.15	22.88	136.12	3.07	4.45	9.87	24.71	-47.17
SAR	0.52	3.60	17.64	-18.43	1.68	9.06	20.10	-23.03

Table 3. Historical Import and Export Growth and Current Account Position by Country/Region

	Import Growth (% per annum)				Export Growth (% per anum)				
Country	Mean	St. Dev.	Maximum	Minimum	Mean	St. Dev.	Maximum	Minimum	Current acc.
USA	3.85	12.62	50.08	-36.23	2.64	11.57	27.55	-29.30	-1.21
EUR	0.36	16.74	31.00	-97.14	0.93	16.19	35.53	-95.08	0.57
JAP	1.84	21.11	48.09	-60.94	2.83	15.79	38.97	-52.53	0.98
UK	1.95	16.83	66.17	-49.31	1.20	19.02	43.21	-86.98	-0.75
NOR	2.01	21.01	53.71	-44.72	3.63	26.25	62.19	-92.97	1.62
SWE	2.96	17.00	45.97	-57.91	3.89	18.66	66.40	-67.72	0.93
SWI	1.58	16.30	80.16	-36.70	2.74	13.40	34.50	-30.71	1.15
CAN	2.91	17.87	58.12	-50.07	2.84	18.45	101.78	-47.54	-0.07
AUS	3.81	17.61	38.86	-72.53	3.31	21.15	80.84	-50.66	-0.50
NZ	2.03	27.69	82.47	-80.16	1.65	20.87	55.45	-52.60	-0.37
SAF	5.03	32.41	83.51	-106.40	1.81	30.59	61.32	-85.16	-3.22
ARG	4.63	62.16	338.22	-178.51	6.70	70.67	391.39	-166.57	2.07
BRA	2.06	37.36	104.04	-84.20	4.62	49.71	191.46	-174.51	2.56
CHL	5.60	27.43	57.40	-92.02	7.45	32.98	114.09	-93.09	1.85
MEX	6.74	30.23	119.77	-175.89	6.81	44.78	229.15	-139.59	0.07
IND	8.89	29.84	88.39	-127.61	8.87	24.26	78.80	-58.86	-0.02
KOR	6.51	22.90	87.27	-65.47	7.89	27.49	120.76	-68.05	1.38
MAL	8.39	22.39	63.15	-65.11	8.20	21.04	71.15	-64.07	-0.19
PHI	5.38	35.48	80.41	-143.41	6.02	51.57	305.24	-150.66	0.64
SNG	6.13	17.75	40.45	-41.31	7.16	17.85	65.63	-34.38	1.03
THA	8.14	25.83	79.58	-92.76	9.10	25.86	87.53	-99.07	0.96
CHN	14.79	35.97	149.50	-139.87	16.52	26.83	119.13	-43.55	1.72
INS	8.95	54.09	163.76	-226.52	6.18	52.91	255.38	-258.03	-2.77
PER	2.43	48.80	163.08	-168.95	-0.03	54.63	218.26	-153.70	-2.45
TUR	8.41	37.37	150.38	-75.31	9.44	41.26	129.87	-119.81	1.03
SAR	3.07	18.53	34.66	-47.97	4.00	36.52	91.09	-72.13	0.93

Table 4. Definition of Forecasting Events Specific to Various Countries

Country	Official inflation target	Inflation Target 1 (% CPI)	Inflation Target 2 (% CPI)	Low Growth (%p.a.)
USA	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.46%
EUR	HICP <2% and ≈2%	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.07%
JAP	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.09%
UK	2% CPI ±1%	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.20%
NOR	2.5% CPI	$1.5\% \leq \Delta p \leq 3.5\%$	$\Delta p < 2.5\%$	1.41%
SWE	2% CPI ±1%	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.06%
SWI	<2% CPI	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	0.77%
CAN	2% CPI ±1%	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.49%
AUS	2-3% CPI	$1.5\% \leq \Delta p \leq 3.5\%$	$\Delta p < 2.5\%$	1.62%
NZ	1-3% CPI	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	1.16%
SAF	3-6% CPIX	$3\% \leq \Delta p \leq 6\%$	$\Delta p < 4.5\%$	1.14%
ARG	None	$2.5\% \leq \Delta p \leq 6.5\%$	$\Delta p < 4.5\%$	0.88%
BRA	4.5% CPI ± 2%	$2.5\% \leq \Delta p \leq 6.5\%$	$\Delta p < 4.5\%$	1.17%
CHL	3% CPI ±1%	$2\% \leq \Delta p \leq 4\%$	$\Delta p < 3\%$	2.21%
MEX	3% CPI	$2\% \leq \Delta p \leq 4\%$	$\Delta p < 3\%$	1.30%
IND	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	2.95%
KOR	3% CPI ± of 0.5%	$2\% \leq \Delta p \leq 4\%$	$\Delta p < 3\%$	3.22%
MAL	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	2.95%
PHI	4-5% CPI	$3.5\% \leq \Delta p \leq 5.5\%$	$\Delta p < 4.5\%$	1.43%
SNG	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	3.33%
THA	0-3.5% CPIX	$2.5\% \leq \Delta p \leq 4.5\%$	$\Delta p < 3.5\%$	2.85%
CHN	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	4.65%
INS	5% CPI ± 1%.	$4\% \leq \Delta p \leq 6\%$	$\Delta p < 5\%$	2.34%
PER	1-3% CPI	$1.5\% \leq \Delta p \leq 3.5\%$	$\Delta p < 2.5\%$	1.20%
TUR	5% CPI ± 2%	$4\% \leq \Delta p \leq 6\%$	$\Delta p < 5\%$	2.23%
SAR	None	$1\% \leq \Delta p \leq 3\%$	$\Delta p < 2\%$	0.84%

* Low growth is defined as half of the historical average growth rate. Where event definitions are common to all countries they are defined in the text.

Table 5. Generalised FEVDs of Inflation and Real Output for Korea

Horizon	KOR y	KOR r	KOR $e-p$	KOR x	KOR q	NZ q	KOR Δp	CHL m	CHL q	THA Δp	Sum of top 10	Sum of total
0	74.13	12.54	7.09	4.30	4.07	6.49	1.72	1.22	5.12	1.25	117.94	324.11
1	37.65	46.38	35.62	27.86	30.64	8.49	7.98	7.79	8.36	6.46	217.23	396.71
2	37.43	42.00	35.58	33.20	31.30	9.30	8.44	8.55	8.21	7.52	221.54	404.18
3	36.17	42.25	36.42	34.41	33.29	9.53	9.03	8.76	7.82	8.15	225.83	409.01
4	35.53	42.80	37.78	35.84	33.96	9.82	9.34	8.88	7.36	8.41	229.73	416.57
5	35.29	43.48	39.18	36.57	34.26	9.92	9.87	8.80	6.88	8.20	232.46	422.53
6	35.08	43.82	40.34	37.13	34.42	9.96	10.23	8.61	6.46	7.83	233.88	426.61
7	35.14	43.80	41.04	37.27	34.48	9.86	10.42	8.35	6.20	7.35	233.90	427.82
8	35.22	43.46	41.38	37.20	34.35	9.68	10.40	8.08	6.08	6.85	232.68	426.65
Mean	40.18	40.06	34.94	31.53	30.09	9.23	8.60	7.67	6.94	6.89		

(a) GFEVD of Korean Real Output

Horizon	BRA r	BRA Δp	KOR m	KOR y	US p^o	KOR Δp	US x	KOR r	KOR x	US p	Sum of top 10	Sum of total
0	0.14	0.01	9.99	2.99	3.25	77.38	0.05	21.50	10.69	4.28	130.26	395.66
1	19.68	17.98	23.68	16.91	6.56	0.07	6.35	0.00	10.07	4.06	105.35	321.20
2	29.47	25.88	15.39	10.57	13.04	0.14	11.59	3.05	5.94	3.80	118.89	336.69
3	24.68	21.43	14.59	11.62	12.59	0.12	11.98	4.67	5.03	5.03	111.74	329.73
4	21.09	18.22	13.90	12.51	10.97	0.10	10.96	5.82	4.83	6.34	104.73	328.82
5	20.52	18.05	13.78	13.00	10.91	0.12	10.28	6.73	4.59	6.60	104.57	330.37
6	21.34	19.16	13.91	12.81	9.98	0.13	9.53	7.19	4.17	6.02	104.23	329.07
7	21.88	19.70	13.32	12.21	8.88	0.12	8.57	7.09	3.83	5.46	101.07	329.74
8	21.74	19.62	12.91	11.65	8.36	0.12	7.85	6.88	3.49	5.27	97.89	331.68
Mean	20.06	17.78	14.61	11.58	9.39	8.70	8.57	6.99	5.85	5.21		

(b) GFEVD of Korean Inflation

	US		EUR		JAP		UK		KOR		CHN	
2007q1	0.96	*0.92*	0.95	*0.99*	0.11	*0.91*	0.82	*0.13*	0.19	*0.63*	0.57	*0.63*
2007q2	0.84	*0.58*	0.40	*0.90*	0.02	*0.82*	0.47	*0.14*	0.34	*0.13*	0.39	*0.36*
2007q3	0.73	*0.22*	0.44	*0.76*	0.06	*0.26*	0.27	*0.12*	0.34	*0.15*	0.26	*0.28*
2007q4	0.20	*0.00*	0.44	*0.60*	0.24	*0.02*	0.20	*0.20*	0.35	*0.03*	0.19	*0.22*
2008q1	0.27	*0.00*	0.38	*0.51*	0.36	*0.16*	0.33	*0.14*	0.32	*0.06*	0.12	*0.19*
2008q2	0.50	*0.01*	0.31	*0.44*	0.44	*0.56*	0.34	*0.26*	0.29	*0.03*	0.09	*0.15*
2008q3	0.48	*0.01*	0.28	*0.39*	0.44	*0.69*	0.30	*0.28*	0.27	*0.02*	0.08	*0.14*
2008q4	0.36	*0.01*	0.25	*0.31*	0.43	*0.65*	0.30	*0.26*	0.27	*0.02*	0.10	*0.12*

(a) Inflation Target 1 (Event A)

2007q1	0.14	*0.04*	0.92	*0.79*	1.00	*0.97*	0.17	*0.00*	0.99	*0.12*	0.22	*0.28*
2007q2	0.26	*0.04*	0.97	*0.65*	1.00	*0.07*	0.87	*0.01*	0.89	*0.01*	0.36	*0.28*
2007q3	0.22	*0.01*	0.89	*0.51*	1.00	*0.00*	0.92	*0.03*	0.82	*0.04*	0.48	*0.35*
2007q4	0.02	*0.00*	0.79	*0.42*	0.98	*0.00*	0.90	*0.07*	0.60	*0.01*	0.62	*0.48*
2008q1	0.04	*0.00*	0.79	*0.43*	0.94	*0.01*	0.64	*0.08*	0.54	*0.04*	0.71	*0.53*
2008q2	0.18	*0.00*	0.79	*0.57*	0.85	*0.14*	0.57	*0.22*	0.52	*0.03*	0.75	*0.59*
2008q3	0.18	*0.00*	0.80	*0.56*	0.82	*0.30*	0.53	*0.34*	0.53	*0.01*	0.75	*0.61*
2008q4	0.12	*0.00*	0.79	*0.51*	0.78	*0.31*	0.55	*0.42*	0.51	*0.01*	0.75	*0.62*

(b) Inflation Target 2 (Event B)

2007q1	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*
2007q2	0.01	*0.00*	0.07	*0.00*	0.02	*0.02*	0.00	*0.00*	0.01	*0.00*	0.00	*0.00*
2007q3	0.04	*0.00*	0.07	*0.00*	0.03	*0.00*	0.00	*0.00*	0.04	*0.00*	0.00	*0.00*
2007q4	0.06	*0.01*	0.06	*0.00*	0.04	*0.00*	0.00	*0.00*	0.05	*0.02*	0.00	*0.00*
2008q1	0.02	*0.05*	0.05	*0.01*	0.05	*0.00*	0.00	*0.01*	0.06	*0.09*	0.00	*0.00*
2008q2	0.01	*0.39*	0.05	*0.03*	0.06	*0.01*	0.00	*0.02*	0.05	*0.19*	0.01	*0.00*
2008q3	0.02	*0.58*	0.05	*0.05*	0.06	*0.06*	0.01	*0.05*	0.05	*0.25*	0.00	*0.00*
2008q4	0.03	*0.54*	0.05	*0.08*	0.06	*0.06*	0.01	*0.06*	0.05	*0.17*	0.00	*0.00*

(c) Recession (Event C)

Note : italicised text refers to the GVAR model while normal text refers to country-specific forecasts.

	US		EUR		JAP		UK		KOR		CHN	
2007q1	0.12	*0.04*	0.00	*0.00*	0.02	*0.05*	0.00	*0.00*	0.22	*0.03*	0.00	*0.00*
2007q2	0.24	*0.07*	0.10	*0.00*	0.04	*0.03*	0.00	*0.00*	0.15	*0.01*	0.00	*0.00*
2007q3	0.27	*0.04*	0.20	*0.01*	0.02	*0.01*	0.00	*0.00*	0.22	*0.02*	0.01	*0.00*
2007q4	0.32	*0.06*	0.30	*0.02*	0.09	*0.01*	0.00	*0.00*	0.19	*0.02*	0.09	*0.01*
2008q1	0.30	*0.25*	0.28	*0.03*	0.13	*0.00*	0.00	*0.01*	0.25	*0.15*	0.16	*0.01*
2008q2	0.28	*0.65*	0.25	*0.05*	0.17	*0.01*	0.01	*0.09*	0.27	*0.38*	0.18	*0.01*
2008q3	0.19	*0.89*	0.23	*0.13*	0.19	*0.03*	0.02	*0.20*	0.25	*0.60*	0.16	*0.02*
2008q4	0.17	*0.96*	0.23	*0.22*	0.22	*0.13*	0.04	*0.30*	0.25	*0.65*	0.13	*0.03*

(d) Slow Growth (Event D)

2007q1	0.96	*0.92*	0.95	*0.99*	0.11	*0.91*	0.82	*0.13*	0.19	*0.63*	0.57	*0.63*
2007q2	0.84	*0.58*	0.38	*0.90*	0.02	*0.81*	0.47	*0.14*	0.34	*0.13*	0.39	*0.36*
2007q3	0.71	*0.22*	0.42	*0.76*	0.06	*0.26*	0.27	*0.12*	0.32	*0.15*	0.26	*0.28*
2007q4	0.19	*0.00*	0.42	*0.60*	0.24	*0.02*	0.20	*0.20*	0.34	*0.03*	0.19	*0.22*
2008q1	0.27	*0.00*	0.37	*0.51*	0.35	*0.16*	0.33	*0.14*	0.30	*0.06*	0.12	*0.19*
2008q2	0.50	*0.01*	0.30	*0.43*	0.42	*0.55*	0.34	*0.26*	0.27	*0.03*	0.09	*0.15*
2008q3	0.48	*0.01*	0.27	*0.38*	0.41	*0.65*	0.30	*0.27*	0.25	*0.02*	0.08	*0.14*
2008q4	0.36	*0.01*	0.24	*0.29*	0.41	*0.60*	0.30	*0.25*	0.25	*0.02*	0.10	*0.12*

(e) Inflation Target 1 *and* No Recession (Events $A \cap \overline{C}$)

2007q1	0.84	*0.88*	0.95	*0.99*	0.10	*0.87*	0.82	*0.13*	0.13	*0.62*	0.57	*0.63*
2007q2	0.65	*0.55*	0.37	*0.90*	0.02	*0.80*	0.47	*0.14*	0.26	*0.13*	0.39	*0.36*
2007q3	0.53	*0.21*	0.39	*0.75*	0.06	*0.26*	0.27	*0.12*	0.24	*0.14*	0.26	*0.28*
2007q4	0.14	*0.00*	0.35	*0.59*	0.23	*0.02*	0.20	*0.20*	0.28	*0.03*	0.18	*0.22*
2008q1	0.20	*0.00*	0.32	*0.50*	0.33	*0.16*	0.33	*0.14*	0.24	*0.05*	0.10	*0.19*
2008q2	0.36	*0.00*	0.27	*0.44*	0.40	*0.56*	0.33	*0.25*	0.20	*0.02*	0.08	*0.15*
2008q3	0.40	*0.00*	0.24	*0.37*	0.38	*0.67*	0.30	*0.24*	0.20	*0.02*	0.06	*0.14*
2008q4	0.32	*0.00*	0.22	*0.26*	0.35	*0.55*	0.29	*0.19*	0.20	*0.01*	0.09	*0.12*

(f) Inflation Target 1 *and* No Slow Growth (Events $A \cap \overline{D}$)

	US		EUR		JAP		UK		KOR		CHN	
2007q1	0.14	*0.04*	0.92	*0.79*	1.00	*0.97*	0.17	*0.00*	0.99	*0.12*	0.22	*0.28*
2007q2	0.26	*0.04*	0.90	*0.64*	0.98	*0.06*	0.87	*0.01*	0.89	*0.01*	0.36	*0.28*
2007q3	0.22	*0.01*	0.82	*0.51*	0.97	*0.00*	0.92	*0.03*	0.79	*0.04*	0.48	*0.35*
2007q4	0.02	*0.00*	0.74	*0.42*	0.94	*0.00*	0.90	*0.07*	0.58	*0.01*	0.62	*0.48*
2008q1	0.04	*0.00*	0.74	*0.42*	0.89	*0.01*	0.64	*0.08*	0.52	*0.04*	0.71	*0.53*
2008q2	0.18	*0.00*	0.74	*0.55*	0.79	*0.13*	0.57	*0.22*	0.50	*0.03*	0.74	*0.59*
2008q3	0.18	*0.00*	0.75	*0.52*	0.77	*0.28*	0.53	*0.34*	0.51	*0.01*	0.75	*0.61*
2008q4	0.12	*0.00*	0.74	*0.45*	0.73	*0.28*	0.55	*0.41*	0.48	*0.01*	0.75	*0.62*

(g) Inflation Target 2 *and* No Recession (Events $B \cap \overline{C}$)

2007q1	0.12	*0.04*	0.92	*0.79*	0.98	*0.93*	0.17	*0.00*	0.78	*0.12*	0.22	*0.28*
2007q2	0.21	*0.04*	0.87	*0.65*	0.96	*0.06*	0.87	*0.01*	0.77	*0.01*	0.36	*0.28*
2007q3	0.17	*0.01*	0.70	*0.50*	0.98	*0.00*	0.92	*0.03*	0.66	*0.04*	0.47	*0.35*
2007q4	0.02	*0.00*	0.52	*0.40*	0.89	*0.00*	0.90	*0.07*	0.51	*0.01*	0.56	*0.48*
2008q1	0.03	*0.00*	0.52	*0.41*	0.81	*0.01*	0.64	*0.08*	0.43	*0.04*	0.59	*0.53*
2008q2	0.13	*0.00*	0.55	*0.53*	0.69	*0.14*	0.57	*0.21*	0.40	*0.02*	0.60	*0.58*
2008q3	0.15	*0.00*	0.58	*0.45*	0.65	*0.29*	0.52	*0.31*	0.41	*0.01*	0.62	*0.60*
2008q4	0.10	*0.00*	0.57	*0.33*	0.58	*0.26*	0.54	*0.34*	0.40	*0.01*	0.65	*0.59*

(h) Inflation Target 2 *and* No Slow Growth (Events $B \cap \overline{D}$)

2007q1	1.00	*1.00*	0.00	*0.00*	0.00	*0.00*	1.00	*1.00*	0.00	*0.00*	0.00	*0.00*
2007q2	1.00	*1.00*	0.00	*0.00*	0.00	*0.00*	1.00	*1.00*	0.01	*0.00*	0.00	*0.00*
2007q3	1.00	*1.00*	0.00	*0.04*	0.00	*0.00*	1.00	*1.00*	0.03	*0.00*	0.00	*0.00*
2007q4	1.00	*1.00*	0.00	*0.47*	0.00	*0.09*	1.00	*1.00*	0.09	*0.03*	0.00	*0.00*
2008q1	1.00	*1.00*	0.00	*0.63*	0.01	*0.18*	1.00	*1.00*	0.16	*0.11*	0.00	*0.00*
2008q2	1.00	*1.00*	0.00	*0.74*	0.03	*0.27*	1.00	*1.00*	0.18	*0.11*	0.01	*0.00*
2008q3	1.00	*1.00*	0.01	*0.80*	0.04	*0.34*	1.00	*1.00*	0.20	*0.10*	0.02	*0.00*
2008q4	1.00	*1.00*	0.02	*0.82*	0.05	*0.40*	1.00	*1.00*	0.22	*0.09*	0.03	*0.00*

(i) Current Account Deficit (Event E)

	US		EUR		JAP		UK		KOR		CHN	
2007q1	1.00	*1.00*	0.81	*0.03*	0.96	*0.11*	0.00	*0.00*	0.90	*1.00*	0.75	*0.89*
2007q2	0.97	*1.00*	0.97	*0.05*	0.84	*0.20*	0.00	*0.00*	0.71	*0.73*	0.63	*0.92*
2007q3	0.95	*1.00*	0.96	*0.10*	0.75	*0.25*	0.22	*0.00*	0.77	*0.77*	0.58	*0.93*
2007q4	0.70	*1.00*	0.81	*0.00*	0.61	*0.15*	0.47	*0.05*	0.59	*0.57*	0.54	*0.93*
2008q1	0.64	*1.00*	0.92	*0.18*	0.57	*0.34*	0.63	*0.40*	0.54	*0.29*	0.66	*0.92*
2008q2	0.60	*1.00*	0.77	*0.11*	0.62	*0.33*	0.52	*0.33*	0.60	*0.67*	0.68	*0.82*
2008q3	0.52	*1.00*	0.74	*0.15*	0.64	*0.29*	0.48	*0.48*	0.58	*0.72*	0.71	*0.73*
2008q4	0.45	*0.99*	0.63	*0.15*	0.65	*0.30*	0.31	*0.42*	0.53	*0.74*	0.66	*0.55*

(j) Current Account Improvement (Event F)

2007q1	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	1.00	*1.00*	0.00	*0.00*	0.00	*0.00*
2007q2	0.04	*0.00*	0.00	*0.00*	0.00	*0.00*	1.00	*1.00*	0.01	*0.00*	0.00	*0.00*
2007q3	0.05	*0.00*	0.00	*0.04*	0.00	*0.00*	0.78	*1.00*	0.03	*0.00*	0.00	*0.00*
2007q4	0.30	*0.00*	0.00	*0.47*	0.00	*0.09*	0.53	*0.95*	0.09	*0.03*	0.00	*0.00*
2008q1	0.36	*0.00*	0.00	*0.61*	0.01	*0.18*	0.37	*0.60*	0.15	*0.11*	0.00	*0.00*
2008q2	0.40	*0.00*	0.00	*0.72*	0.03	*0.25*	0.48	*0.67*	0.14	*0.08*	0.01	*0.00*
2008q3	0.48	*0.00*	0.01	*0.75*	0.04	*0.30*	0.52	*0.52*	0.16	*0.06*	0.02	*0.00*
2008q4	0.55	*0.01*	0.02	*0.77*	0.04	*0.35*	0.69	*0.58*	0.16	*0.06*	0.03	*0.00*

(k) Current Account Deficit *and* Deterioration (Events $E \cap \overline{F}$)

2007q1	1.00	*1.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*
2007q2	0.97	*1.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*	0.00	*0.00*
2007q3	0.95	*1.00*	0.00	*0.00*	0.00	*0.00*	0.22	*0.00*	0.00	*0.00*	0.00	*0.00*
2007q4	0.70	*1.00*	0.00	*0.00*	0.00	*0.00*	0.47	*0.05*	0.00	*0.00*	0.00	*0.00*
2008q1	0.64	*1.00*	0.00	*0.01*	0.00	*0.00*	0.63	*0.40*	0.01	*0.00*	0.00	*0.00*
2008q2	0.60	*1.00*	0.00	*0.01*	0.00	*0.02*	0.52	*0.33*	0.04	*0.03*	0.00	*0.00*
2008q3	0.52	*1.00*	0.00	*0.04*	0.00	*0.03*	0.48	*0.48*	0.04	*0.04*	0.00	*0.00*
2008q4	0.45	*0.99*	0.00	*0.05*	0.01	*0.05*	0.31	*0.42*	0.05	*0.04*	0.00	*0.00*

(l) Current Account Deficit *and* Improvement (Events $E \cap F$)

Table 6. Probability Event Forecasts Based on Country-Specific and GVAR Models (GVAR in Italics)

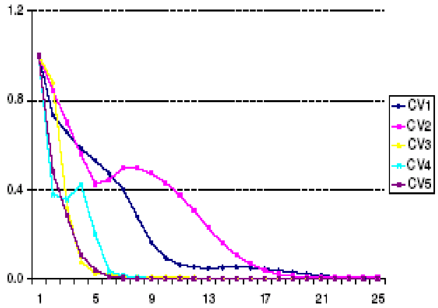
	US		EUR		JAP		UK		KOR		CHN	
2007q1	0.00	*0.00*	0.19	*0.97*	0.04	*0.89*	0.00	*0.00*	0.10	*0.00*	0.25	*0.11*
2007q2	0.00	*0.00*	0.03	*0.95*	0.16	*0.80*	0.00	*0.00*	0.29	*0.27*	0.37	*0.08*
2007q3	0.00	*0.00*	0.04	*0.87*	0.25	*0.75*	0.00	*0.00*	0.19	*0.23*	0.42	*0.07*
2007q4	0.00	*0.00*	0.19	*0.53*	0.39	*0.77*	0.00	*0.00*	0.32	*0.40*	0.46	*0.07*
2008q1	0.00	*0.00*	0.08	*0.21*	0.42	*0.48*	0.00	*0.00*	0.32	*0.60*	0.34	*0.08*
2008q2	0.00	*0.00*	0.23	*0.16*	0.35	*0.42*	0.00	*0.00*	0.26	*0.25*	0.31	*0.18*
2008q3	0.00	*0.00*	0.25	*0.10*	0.32	*0.41*	0.00	*0.00*	0.27	*0.22*	0.28	*0.27*
2008q4	0.00	*0.00*	0.35	*0.08*	0.31	*0.35*	0.00	*0.00*	0.30	*0.21*	0.32	*0.45*

(m) Current Account Surplus *and* Deterioration (Events $\overline{E} \cap \overline{F}$)

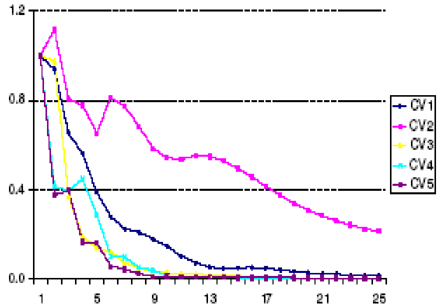
2007q1	0.00	*0.00*	0.81	*0.03*	0.96	*0.11*	0.00	*0.00*	0.90	*1.00*	0.75	*0.89*
2007q2	0.00	*0.00*	0.97	*0.05*	0.84	*0.20*	0.00	*0.00*	0.71	*0.73*	0.63	*0.92*
2007q3	0.00	*0.00*	0.96	*0.10*	0.75	*0.25*	0.00	*0.00*	0.77	*0.77*	0.58	*0.93*
2007q4	0.00	*0.00*	0.81	*0.00*	0.61	*0.15*	0.00	*0.00*	0.59	*0.57*	0.54	*0.93*
2008q1	0.00	*0.00*	0.92	*0.17*	0.57	*0.34*	0.00	*0.00*	0.53	*0.29*	0.66	*0.92*
2008q2	0.00	*0.00*	0.77	*0.10*	0.62	*0.32*	0.00	*0.00*	0.56	*0.64*	0.68	*0.82*
2008q3	0.00	*0.00*	0.74	*0.10*	0.63	*0.26*	0.00	*0.00*	0.53	*0.68*	0.71	*0.73*
2008q4	0.00	*0.00*	0.63	*0.10*	0.64	*0.25*	0.00	*0.00*	0.48	*0.70*	0.66	*0.55*

(n) Current Account Surplus *and* Improvement (Events $\overline{E} \cap F$)

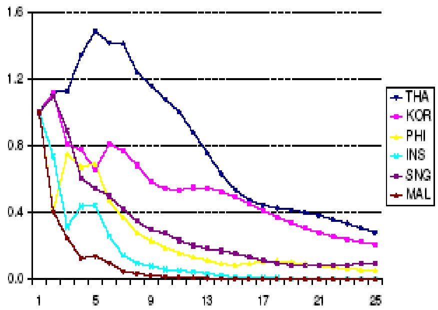
Figure 1. Persistence Profiles



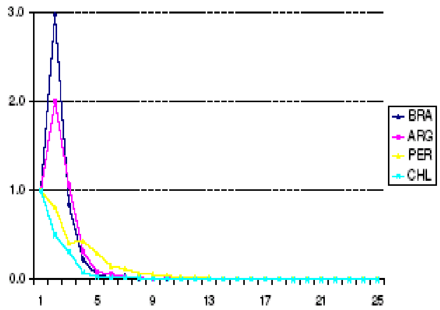
(a) Korea (Country-Specific)



(b) Korea (GVAR)

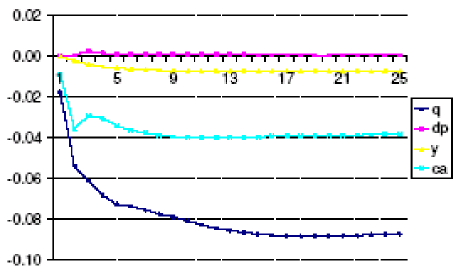


(c) Excess Persistence in South-East Asian PPs

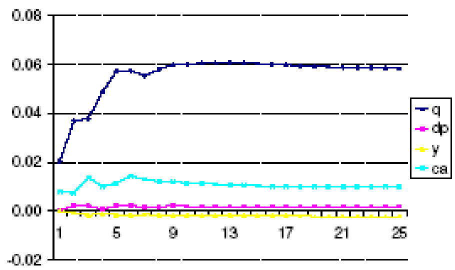


(d) Overshooting in South American PPs

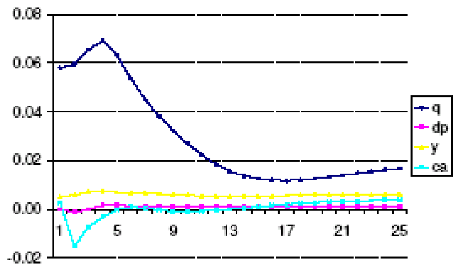
Figure 2: Various SIRs from the Korean Country-Specific Model



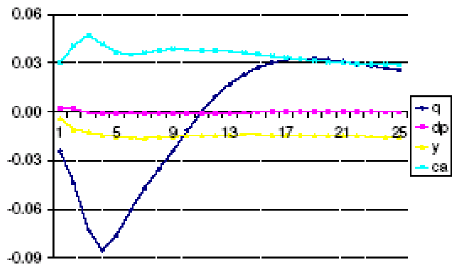
(a) Oil Price Shock



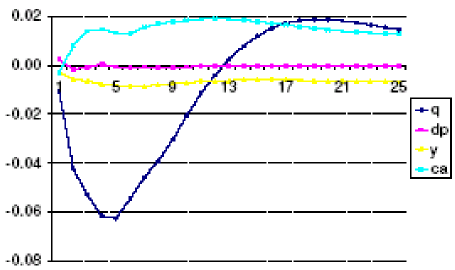
(b) Foreign Monetary Policy Shock



(c) Foreign Equity Shock

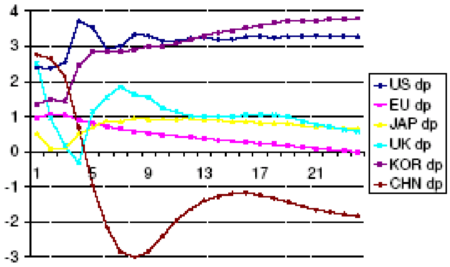


(d) Real Depreciation of the Won

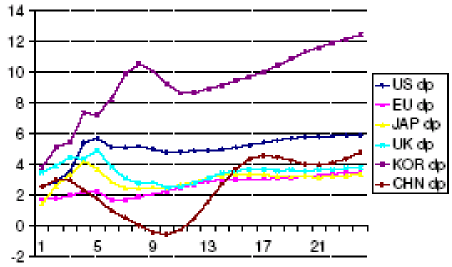


(e) Domestic Monetary Policy Shock

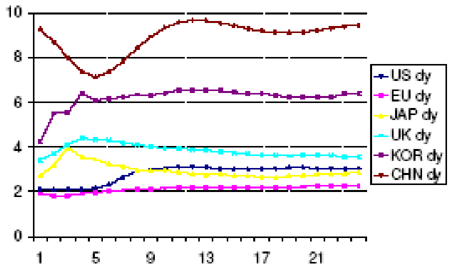
Figure 3. Four-Quarter Moving Average Central Forecasts



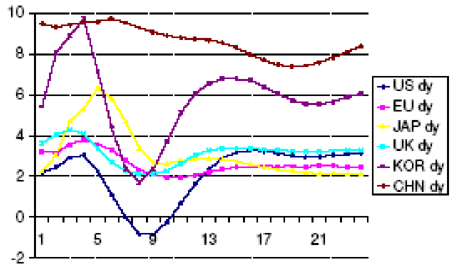
(a) Inflation (Country–Specific)



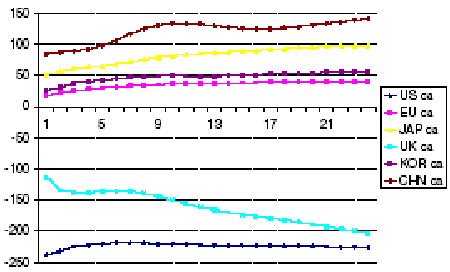
(b) Inflation (GVAR)



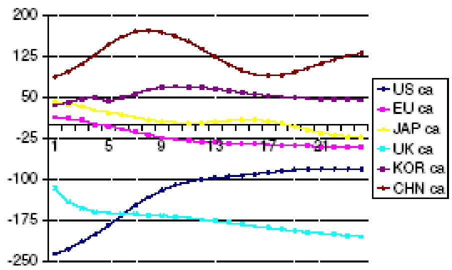
(c) Output Growth (Country–Specific)



(d) Output Growth (GVAR)

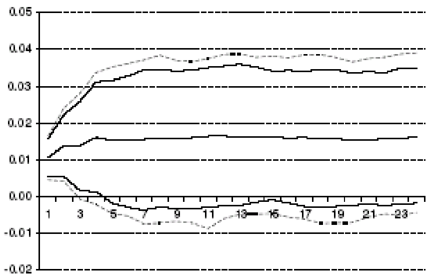


(e) Current Account (Country–Specific)

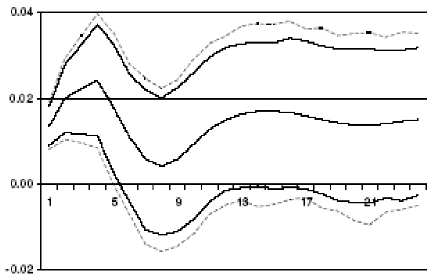


(f) Current Account (GVAR)

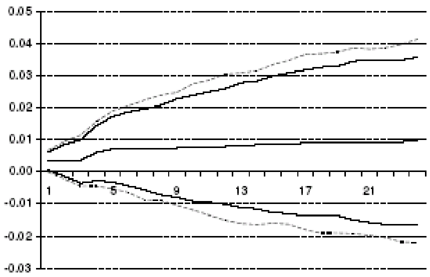
Figure 4. Korean Interval Forecasts



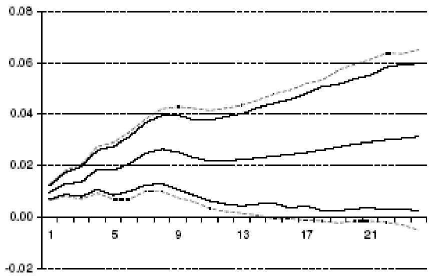
(a) Output Growth (Country-Specific)



(b) Output Growth (GVAR)

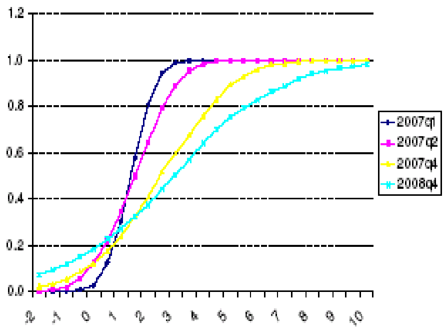


(c) Inflation (Country-Specific)

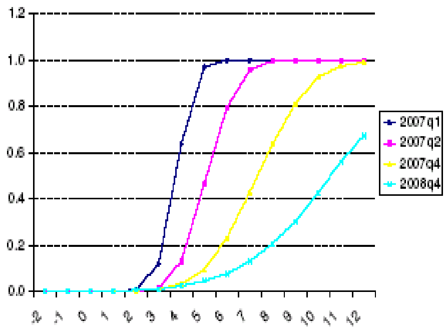


(d) Inflation (GVAR)

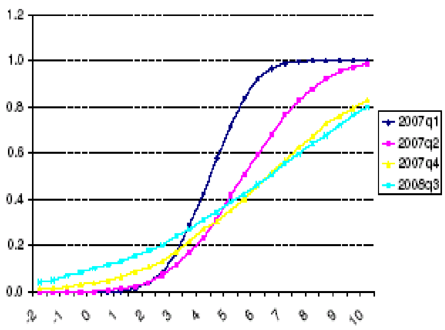
Figure 5: Predictive Distribution functions for Korea



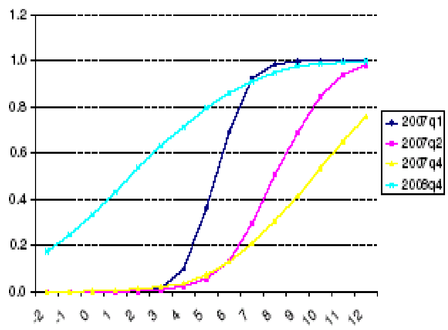
(a) Inflation (Country-Specific)



(b) Inflation (GVAR)

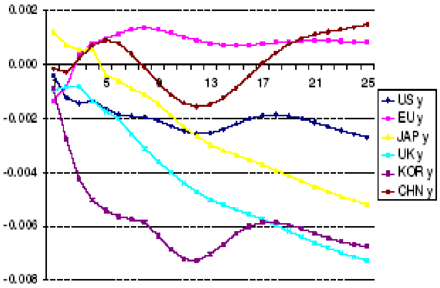


(c) Output Growth (Country-Specific)

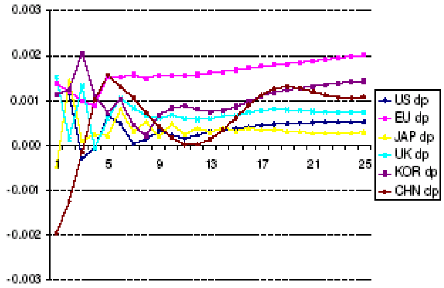


(d) Output Growth (GVAR)

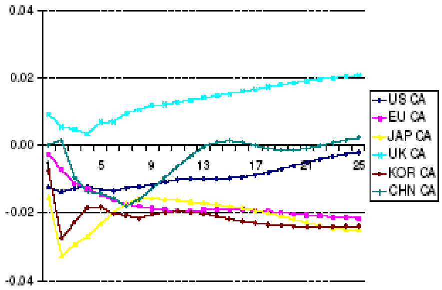
Figure 6. Various GIRs with respect to an Oil Price Shock



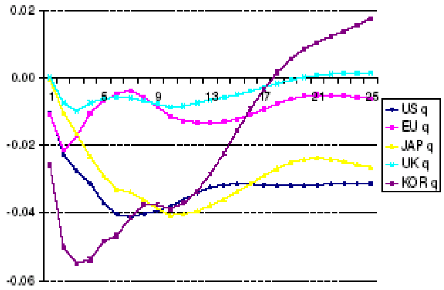
(a) Output



(b) Inflation (Price level)

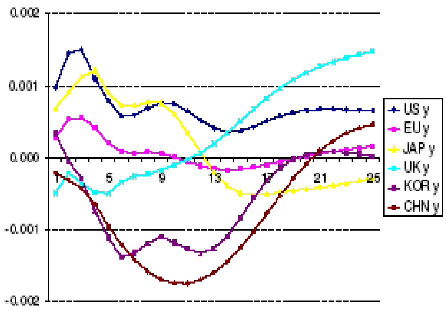


(c) Current Account

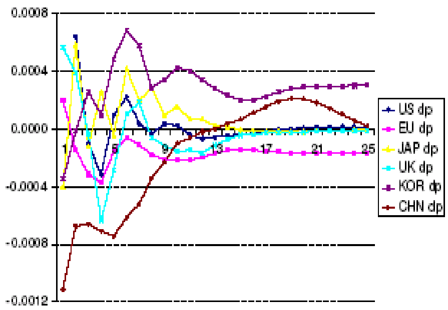


(d) Stock Market

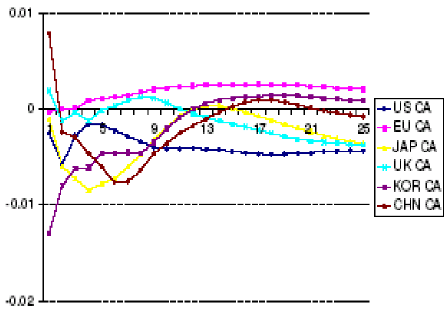
Figure 7. Various GIRs with respect to a US Monetary Policy Shock



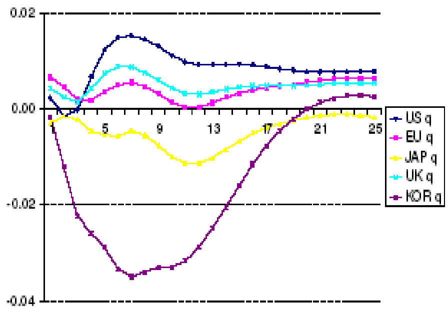
(a) Output



(b) Inflation (Price level)

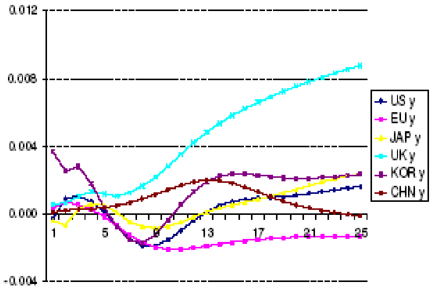


(c) Current Account

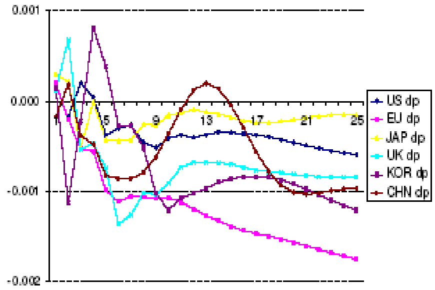


(d) Stock Market

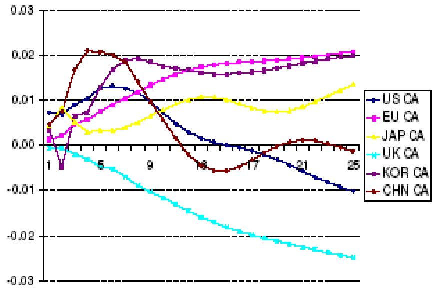
Figure 8. Various GIRs with respect to a Positive US Stock Market Shock



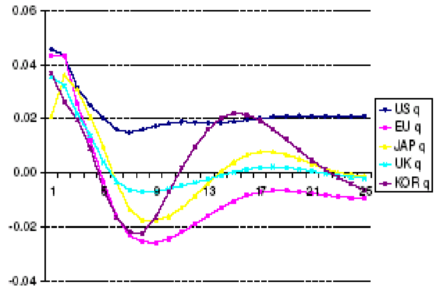
(a) Output



(b) Inflation (Price level)

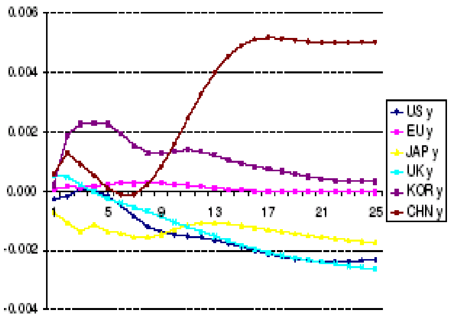


(c) Current Account

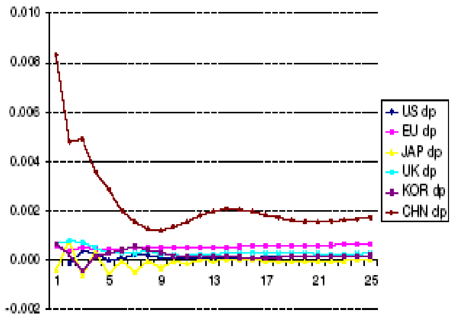


(d) Stock Market

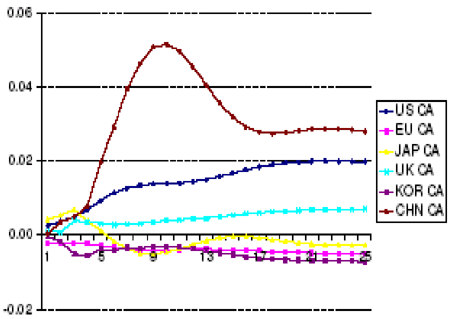
Figure 9. Various GIRs with respect to Elevated Chinese Inflationary Pressure



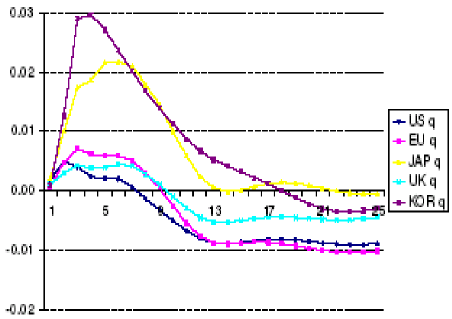
(a) Output



(b) Inflation (Price level)



(c) Current Account



(d) Stock Market

CHAPTER V-2

GMM Estimation of Hybrid Phillips Curve: A Source of Conflicting Empirical Results

by
Hae-shin Hwang*
Woong Kim*

Abstract

The New Keynesian Phillips Curve or its hybrid version are commonly estimated by the instrumental variable method. Instrumental variables are usually selected from a large number of valid instruments on an ad hoc basis. It has been recognized in the literature that the estimates are sensitive to the choice of instrumental variables and to the choice of the measurement of inflation. Such a sensitivity is reflected in the debates in recent literature on the relative role of forward-looking behavior and on the role of marginal cost as the driving force. This paper uses the L_2 -boosting method that selects the optimal instruments from a large number of valid instruments. The base for the boosting can be the observed variables, or the ordinary and generalized principal components of the valid instruments. When the optimal set of instruments boosted from the principal components is used, all conflicting conclusions in previous studies vanish. Regardless of the choice of inflation measure and estimation equation, we find the dominant role of forward-looking behavior in inflation dynamics, and the significant effect of the real marginal cost on inflation.

JEL classixcation: E31

Keywords: Hybrid Phillips curve; GMM estimation, Optimal instruments, L_2 -boosting

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I. Introduction

The New Keynesian Phillips Curve (NKPC) models are based on the microeconomic foundation that introduces nominal rigidities into the forward-looking optimizing behavior of monopolistically competitive firms. The baseline model specifies the inflation as a function of forward-looking expectations of inflation and marginal costs as the underlying driving force. Galí and Gertler (1999, GG henceforth) extend the baseline model by introducing two types of firms: forward-looking and backward-looking firms. The resulting model is a hybrid model that includes past inflation and expected inflation in addition to the marginal cost as the driving force. The presence of the past inflation in the model helps to explain the persistence of inflation. Main interests in the empirical analysis of GG's model are the degree of price rigidity, relative role of forward- and backward-looking behavior, and the relevance of the marginal cost as the driving force instead of more conventional measure of the output gap.

The model is typically estimated in a structural form or in a closed form by using the GMM. The inflation rate is usually measured by the rate of change in either the GDP deflator or the NFB deflator. The two inflation rates show very similar time paths with a high correlation coefficient, and the structural form and the closed form equations are alternative expressions of the same theoretical model. Therefore, one would expect that the estimates of underlying parameters and the tests of hypotheses will be similar regardless of the choice of the inflation measure and the estimation equation. However, recent studies find contradicting empirical results. GG and Galí, et al. (2005, GGLS5 henceforth) find the dominance of forward-looking behavior and significance of the marginal cost, while Rudd and Whelan (2007, RW7 henceforth) find the results that contradict the results of GG and GGLS5.

There can be various reasons for the contradicting results: differences in the data, sample periods, estimation equation, measurement of inflation, and the choice of instrumental variables. As we will present in more detail in the empirical section, contradicting results between the two inflation measures and between the two estimation equations arise even for the same data set covering the period of 1960:I-2003:IV.[1] For example, in the estimation of the structural form with the GDP

1) This sample period is six years longer than the sample period of GG and GGLS5, and three quarters shorter than the sample period of RW7. Four sets of instrumental variables are used in our estimation: GG, GGLS5, and two sets from RW7. GGLS5 and RW7 have differences not only in the estimation equation (different number of lead terms and inclusion of the remainder terms), but also in the data of real marginal costs. The two marginal cost data are highly correlated, but they lead to different conclusions in the estimates.

deflator, the coefficient of the marginal cost is significant when the instrument set of GG or GGLS5 is used, but it is insignificant when instrument sets of RW7 are used. Similar results hold in the estimation of the closed form equation with the NFB deflator.

A given set of instrument also gives contradictory results depending on the choice of the inflation measure and estimation equation. For example, RW7 find an insignificant coefficient of the marginal cost in their estimation of the closed form equation with the NFB deflator as the measure of inflation. If the GDP deflator is used instead, their conclusion will be reversed: the coefficient of the marginal cost becomes significant. When the instrument set of GGLS5 is used and the inflation is measured by the NFB deflator, the coefficient of marginal cost is not significant in the structural form equation, but it is highly significant in the closed form equation. As we will show in section 4 in detail, conflicting results also arise in the test of the relative role of forward- and backward-looking behavior and in the test of long-run tradeoff.

As noted in Nason and Smith (2005), GMM estimates of parameters of NKPC type models are sensitive to the choice of instrumental variables. Such a sensitivity is reflected in the differences in the estimation results between GG's instrument set and its subsets. GG's set include the variables that are intuitively reasonable for the purpose, but a large number of valid instrumental variables are left out. The number of valid instrumental variables can be large because the instrumental variables are for the rational expectation of inflation or marginal cost and the information set for the expectation can include a large number of informational variables and their lagged values. Considering the sensitivity of the GMM estimates of the hybrid Phillips curve, it is desirable to select the optimal set of relatively small number of strong instrumental variables in a systematic way.

In this paper, we use the L_2 -boosting method of Bühlmann and Yu (2003) to select the best instruments for the future inflation and marginal cost from a large number of valid instruments. This is one of the three methods that Bai and Ng (2007a) propose to use. The base set of valid instrumental variables for the boosting can be the observed variables or their principal components.[2] Many applications of principal components such as the factor augmented VAR of Bernanke, et al. (2005) use the first a few principal components which have the highest explanatory power. However, the principal components that best explain the variation of the indicator variables are not necessarily the best instruments for the endogenous regressors. The problem of selecting

2) Bai and Ng (2007b) show that principal components of a large number of weakly exogenous variables are not only valid instruments for the endogenous regressors, but also they can be more efficient than the observed variables, if weakly exogenous instruments and the endogenous regressors share common factors.

the optimal set of instruments still remains even when we use the principal components. We use the ordinary principal components (OPC) of Stock and Watson (1998, 2005) and the generalized principal components (GPC) of Forni, et al. (2000, 2005).

We find that the boosting procedure from a large number of observed variables yields different sets of instruments for the GDP and NFB inflation series, and they differ from the set of instruments in previous studies. It is interesting to note that the first instrument selected by the boosting is the NAPM (National Association of Purchasing Managers) vendor deliveries index for both inflation series, and both sets include the lagged monetary base, which is not one of GG's instrumental variables. The set of instruments selected by boosting from the principal components excludes some of the principal components of high explanatory power. More importantly, when the optimal set of instruments boosted from the principal components is used, all conflicting conclusions in previous studies vanish. Regardless of the choice of inflation measure and estimation equation, we find the dominant role of forward-looking behavior in inflation dynamics, and the significant effect of the real marginal cost on inflation. We do not find any significant difference in the results between the OPC and GPC.

The paper is organized as follows. In section 2, we briefly review GG's hybrid model of inflation and identify the hypotheses of major interest. Since previous studies did not test some of the hypotheses formally, we test them based on their estimation results. Section 3 describes the L_2 -boosting method, computational procedures of the ordinary and generalized principal components, and the methods of determining the number of static and dynamic factors. In section 4, empirical results are reported and compared across different sets of instruments. Section 5 concludes the paper with a summary of findings.

II. Specification of Hybrid Philips Curve Model

Galí and Gertler (1999) consider two models of inflation, a baseline model and a hybrid model. Both models are based on Calvo's (1983) assumption that monopolistically competitive firms face some type of constraints on price adjustment. The probability that a firm may adjust its price during any given period is $(1-\theta)$ and it must keep the current price with probability 2. Each firm faces a demand of constant price elasticity. When all firms are identical ex ante, the aggregate price level p_t is given by a convex combination of p_{t-1} and the optimal reset price p_t^*

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$$p_t = \theta p_{t-1} + (1 - \theta)\ p_t^* \tag{2.1}$$

The optimal reset price that maximizes the expected discounted profit is given by

$$p_t^* = (1-\beta\theta)\sum_{k=0}^{\infty} (\beta\theta)^k E_t(mc_{t+k}^n) \tag{2.2}$$

where mc_t^n is the nominal marginal cost, β is the subjective discount factor, and all variables are expressed as a percent deviation from their steady values. Combining these two equations, the baseline model is derived as

$$\pi_t \equiv p_t - p_{t-1} = \lambda_0 mc_t + \beta E_t\ (\pi_{t+1}) \tag{2.3}$$

where $\lambda_0 = (1 - \theta)\ (1 - \beta\theta)\ / \theta$ and mc_t is the real marginal cost. The closed form equation of (2.3) is derived by repeated substitution

$$\pi_t = \lambda_0 \sum_{k=0}^{\infty} \beta^k E_t(mc_{t+k}) \tag{2.4}$$

This closed form predicts that inflation should be determined by the discounted sum of expected future real marginal costs. To make (2.4) empirically tractable, Rudd and Whelan (2005, RW5 henceforth) truncate the infinite sum to a finite sum plus a remainder term

$$\pi_t = \lambda_0 \sum_{k=0}^{K} \beta^k E_t(mc_{t+k}) + \beta^K E_t(\pi_{t+K+1}) \tag{2.5}$$

GG generalize the baseline model by introducing two types of firms: 'forward-looking' and 'backward-looking' firms. Forward-looking firms behave like the firms in the baseline model in setting their price p_t^f as in (2.2). Backward-looking firms set their price p_t^b to the average of newly set prices in previous period plus an adjustment for the realized inflation in previous period

$$p_t^b = \bar{p}^*_{t-1} + \pi_{t-1} = [\omega p^b_{t-1} + (1-\omega)\ p^f_{t-1}\ ] + \pi_{t-1} \tag{2.6}$$

where ω is the fraction of backward-looking firms. Substituting these relationships into the aggregate price level $p_t = \theta p_{t-1} + (1-\theta)\overline{p}^*_t$, they derive a hybrid model

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t(\pi_{t+1}) + \lambda mc_t \tag{2.7}$$

where

$$\lambda = \frac{(1-\theta)(1-\omega)(1-\beta\theta)}{\phi}, \qquad \gamma_f = \frac{\beta\theta}{\phi}, \qquad \gamma_b = \frac{\omega}{\phi} \tag{2.8}$$

and $\phi = \theta + \omega\,[1-\theta\,(1-\beta)\,]$.

The closed form equation of (2.7) is given by

$$\pi_t = \delta_1 \pi_{t-1} + \overline{\lambda} \sum_{k=0}^{\infty} \delta_2^{-k} E_t(mc_{t+k}) \tag{2.9}$$

where $\overline{\lambda} = \lambda / (\delta_2 \gamma_f)$ and

$$\pi_t = \delta_1 \pi_{t-1} + \overline{\lambda} \sum_{k=0}^{K} \tau^k E_t(mc_{t+k}) + E_t[\tau^{(K+1)}(\pi_{t+K+1} - \delta_1 \pi_{t+K})] \tag{2.10}$$

where $\tau = \delta_2^{-1}$. Parameters $\overline{\lambda}$, δ_1 and τ in the equation are estimated, from which we derive the estimate of γ_b, γ_f and λ.

RW5 argue that the estimation of the structural form equation (2.7) can be sensitive to specification errors. If one of the instrumental variables is an omitted variable from the inflation equation, then the instrumental variable estimator of the coefficient of the expected inflation is likely biased upward. They argue that it is preferable to estimate the closed form equation because it is model consistent, and because it is less likely to overstate the effect of forward-looking behavior even if some relevant variables are omitted from the inflation equation.

One of the major issues in the analysis of inflation dynamics is the relative importance of backward- and forward-looking behavior. GG use the relative size of γ_b and γ_f as the measure of relative importance, and draw a conclusion that forward-looking behavior is dominant because their estimate of γ_f is greater than the estimate of r_b. Though they do not conduct a formal test, we may test GG's measure of relative importance by specifying the null and alternative hypotheses as

$$H^0_{GG} : \gamma_b - \gamma_f \geq 0, \qquad H^1_{GG} : \gamma_b - \gamma_f < 0, \tag{2.11}$$

which is equivalent to the test of $\omega \geq \beta\theta$ against $\omega < \beta\theta$.

RW7 criticize GG's measure of relative importance of price setting behavior. They argue that parameters rf and rb are "almost completely unrelated to the question ... whether there is a statistically significant role for expected future labor shares." Therefore, the comparison of the estimates of r_f and r_b is is "not useful for assessing the importance of the forward-looking component of the hybrid model." Since estimation of closed form equation (2.10) is preferable to avoid the potential adverse effects of mis-specification errors, they measure the role of forward-looking behavior by $\overline{\lambda}$ or λ in (2. 10). The null and alternative hypotheses[3] that RW7 prefer to test are

$$H^0_{RW} : \lambda = 0, \qquad H^1_{RW} : \lambda > 0 \tag{2.12}$$

In the context of GG's hybrid model with theoretical restrictions on the range of parameters ($0<\theta<1$, $0<\beta\leq1$ and $0\leq\omega\leq1$), this test can be written in two alternative forms. It is easy to see from the expression for λ in (2. 8) that $\lambda=0$ if and only if $\omega= 1$, and $\lambda>0$ if and only if $\omega<1$. Therefore, the hypotheses in (2. 12) can be written as

$$H^0_{RW} : \omega = 1, \qquad H^1_{RW} : \omega < 1 \tag{2.13}$$

The test of RW7 can thus be interpreted as a test of no forward-looking agents against a presence of forward-looking agents, and it does not consider the magnitude of the effects of forward-looking behavior on inflation. On the other hand, GG's test is testing not just the presence of forward-looking agents, but testing the presence of a sufficient number of forward-looking agents such that they influence the inflation dynamics more than backward-looking agents, i.e., $\omega \geq \beta\theta$ against $\omega < \beta\theta$.

3) RW7 seem to use two-sided tests. We specify the hypotheses as a one-sided test because 8 takes only non-negative values in the context of GG's model. This is equivalent to a test of $\overline{\lambda} = 0$ against $\overline{\lambda} > 0$ in the closed form equation.

If $\beta \neq 1$, the test of RW7 is also equivalent to a test of hypotheses[4)]

$$H^0_{RW} : \gamma_f + \gamma_b = 1, \qquad H^1_{RW} : \gamma_f + \gamma_b < 1 \qquad (2.14a)$$

This expression further illustrates that the test of RW7 is also related to parameters r_b and r_f under GG's model, and hence, their criticism on the use of these parameters in GG's test seems to be untenable. Note that $\gamma_f + \gamma_b = 1$ if and only if $\omega=1$ or $\beta=1$. Therefore, rejection of the null hypothesis $\gamma_f + \gamma_b = 1$ cannot be interpreted as a rejection of $\omega=1$ unless the null hypothesis $\beta=1$ is also rejected.[5)]

III. Choice of Instrumental Variables for GMM Estimation

The instrumental variables for the GMM estimation of the hybrid Phillips curve are the variables in the information set for the rational expectation of inflation or marginal cost. This set can contain a large number of variables as the lagged values are valid instruments and as recent advances of information technology allow agents to have an access to data on many economic variables. However, it is neither practical to include all valid instrumental variables nor desirable to include an excessive number of instrumental variables as the bias of the instrumental variable estimator increases with the number of instruments.

The conventional approach to the problem is to select lagged values of a few reasonable variables from the set of valid instrumental variables. GG selects lagged values of six distinct variables, and GGLS5, RW5 and RW7 use different subsets of GG's set.[6)] Nason and Smith (2005) use four different combinations of lagged values of inflation and marginal cost. In a study of the effect of inflation premium in the hybrid model, Gulyás and Startz (2006) use the forward and the spot inflation premium in addition to the lagged values of inflation and the driving force variable. In the estimation of Taylor rule that involves expected inflation, the instrument set in Clarida,

4) This test is equivalent to the test of $\tau=1$ against $\tau < 1$ if $\gamma_f > 1/2$, and equivalent to the test of $\delta_1 = 1$ against $\delta_1 < 1$ if $\gamma_f < 1/2$. We assume $\gamma_b \gamma_f \leq 1/4$ so that δ_1 and δ_2 are real. If $\gamma_f \leq 1/2$, then $\tau<1$, and if $\gamma_f \geq 1/2$, then $\delta<1$.

5) When the direct test of $\beta = 1$ is not feasible as in the case of estimating the closed form equation, we may concluded that $\beta = 1$ if $\lambda = 0$ is rejected and $\gamma_f \gamma_b = 1$ is not rejected.

6) GG use four lags of inflation, marginal cost, detrended real output, nominal wage inflation, commodity price inflation, and interest rate spread.

et al. (2000) includes the lagged values of the federal funds rate, inflation, the output gap, commodity price inflation, M2 growth, and the spread between the long-term bond rate and the three-month Treasury Bill rate. In a VAR model of European monetary policy, Favero and Marcellino (2004) use the instrumental variables[7)] that are similar to those in Clarida et al. (2000) and the estimates of static principal components.

Selection of these variables is intuitively reasonable for the purpose, but there is no solid theoretical or statistical basis for their selection from a large number of valid instruments. As discussed earlier, estimation of the hybrid Phillips curve is sensitive to the choice of instrumental variables and a given set of instruments can lead to contradictory results depending on the choice of inflation measure and estimation equation. It is thus important to find the best instruments which would not produce contradictory results across estimation equations and inflation measures.

In a recent paper, Bai and Ng (2007a) consider systematic procedures of selecting the best subset of instruments from a large set of valid instrumental variables. They consider two large sets: one set is the panel data of observable weakly exogenous variables, and another set is the set of unobservable factors that are estimated from a dynamic factor model. We will first review the L_2 boosting method proposed by Bühlmann and Yu (2003). This is one of the three selection procedures that Bai and Ng examine in their paper. This method can be applied to both observable panel data or the set of principal components estimated from the panel data. After the selection procedure is presented, we will review the estimation methods of ordinary (standard) and generalized principal components from the dynamic factor model.

1. Selection of Optimal Instrumental Variables

Consider a model of interest

$$y_{1t} = \boldsymbol{\beta}' Z_t + \boldsymbol{\gamma}' y_{2t} + u_t, \qquad t = 1,2, \ldots, T$$

where y_{it}, i=1,2, are the endogenous variables and Z_t is the set of exogenous regressors included in the equation.[8)] There is a set of large number of valid instrumental variables X_t that are weakly exogenous to the parameters. This set can include the lags of the endogenous variables, lags and functions (such as square) of other predetermined

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7) The set includes lagged values of the regressors, the dependent variable, a raw material price index, and the real exchange rate with the US dollar.

8) The number of endogenous regressor y_{2t} may be more than one, but we will consider the case of single y_{2t} in the following discussion.

variables. It can also be a set of principal components of a panel data on weakly exogenous variables.

The conventional first stage regression of instrumental variable estimation specifies a regression of endogenous regressor y_{2t} on the included exogenous regressors Z_t and all other instrumental variables X_t.. The L_2 boosting method for the selection of 'relevant instruments' is based on repeated first stage least squares including Z_t and one component x_{it} of X_t one at a time

$$y_{2t} = \pi_1' Z_t + \pi_{i2} x_{it} + u_{it} \equiv \pi_i' W_{it} + u_{it}, \qquad i = 1,2, \ldots, N \tag{3.1}$$

where N is the number of variables in X_t. The first relevant instrument x_{t^*} is the instrument that has the highest explanatory power in the least squares sense among all N instrumental variables, i.e., the regression with x_{t^*} yields the smallest sum of squared residuals (*SSR*). Let $\hat{v}_1 = \hat{v}_{i^*}$ be the residual vector of using instrument x_{t^*} in the first boosting iteration. Repeat the process with $\hat{v}_1$ as the dependent variable, and find the second relevant instrument and the corresponding residual vector $\hat{v}_2$ and so on. Since the search for the minimum *SSR* is always over the entire N instruments, a variable may be selected more than once.

Let P_j be the projection matrix defined by $W_{i^*} = (Z, x_{i^*})$ at the j-th boosting iteration. Then,

$$\boldsymbol{y_{2t} = \pi_1' Z_t + \pi_{i2} x_{it} + u_{it} \equiv \pi_i' W_{it} + u_{it}, \qquad i = 1,2,\cdots,N}$$

where $\hat{v}_0 = y_2$ and M is the maximum number of iterations. It is clear that $B_m y_2$ represents the estimate of the conditional mean of y_2 conditional on Z and m relevant instruments. Though B_m is not the standard projection matrix, the last expression is in the form of usual regression residuals, and B_m plays the role of standard projection matrix. Recalling that the trace of the standard projection matrix is the number of regressors, we may use the trace of B_m as an equivalent measure of the number of regressors in the selection of the number of boosting iterations. The number of total boosting iterations. The number of total boosting iterations is determined by the modified *AIC* or *BIC*:

$$IC(m) = \ln\left(\frac{v_m' v_m}{T}\right) + tr(B_m)\frac{A}{T}, \qquad m = 1,2,\cdots,M \tag{3.2}$$

where A=2 for the AIC, A=In(T) for the BIC, and $tr(B_m)$ is the trace of B_m which is a measure of the 'degree of freedom.'

The procedure presented above is the case of unitary 'step length.' When the step length τ is in the interval $\tau \in (0, 1)$, then $\hat{v}_m$ is computed by

$$\hat{v}_m = (I - \tau P_m)\hat{v}_{m-1} = \prod_{j=1}^{m}(I - \tau P_j)y_2 \equiv (I - B_m(\tau))y_2$$

Bai and Ng (2007a) suggests to set the maximum number of iterations equal to M = 10 x min [$N^{1/3}$, $T^{1/3}$]. It should be noted that the boosting procedure can be conducted with residual matrices $\tilde{y}_2 = (I-P_z)y_2$ and $\tilde{X} = (I-P_z)X$, where $P_z = Z(Z'Z)^{-1} Z'$.

2. Estimation of Principal components

Principal components have been used to reduce the dimensionality problem when panel data on a large number of variables are available. For example, in a series of papers, Stock and Watson (1998, 2002a, 2002b, 2005, SW henceforth) consider forecasting a time series using a large number of predictors. To reduce the dimensionality problem, they model the series in terms of a relatively few number of observed variables and unobserved latent factors which are estimated by the principal components of the relevant panel data. Bernanke et al. (2005) propose the Factor-Augmented VAR (FAVAR) model to overcome the dimensionality problem of standard VAR models. The FAVAR augments the standard VAR model with a few latent factors. Baiand Ng (2007b) consider the instrumental variable estimator when the number of available instrumental variables is large. They show that, if a large number of instruments and the endogenous regressors share common factors, the factors estimated from the panel are not only valid instruments for the endogenous regressors, but also they can be more efficient than the observed variables.

There are two types of factor models that have been used in the literature: static factor model and *dynamic* factor model. Let X_t be an Nx1 vector of time-series observations on N economic variables with zero means[9]. X_t is a noisy measure of the underlying unobserved dynamic factors and it admits a dynamic factor representation

9) Estimates of principal components are sensitive to the measurement units. It is therefore a common practice to standardize the data before the estimation.

$$X_t = \lambda(L) f_t + u_t \tag{3.3}$$

where f_t is the qx1 vector of unobserved common factors, the dynamic factor loadings $\lambda(L)$ is a matrix of lag polynomials of a finite order p. $\lambda(L) f_t$ is called the *common component,* and u_t is called the *idiosyncratic component.* It is assumed that $E(u_t) = 0$, $E(u_t, u_t') = \Sigma_u$, and $E(f_t, u_s') = 0$ for all t and s. If Σ_u is a scalar matrix and $E(u_t, u_s') = 0$ for all $t \neq s$, then (3.3) is the classical (strict) factor model. Approximate

factor models relax these assumptions by allowing that u_t can be serially and cross-sectionally correlated.

The dynamic representation of the dynamic factor model in (3.3) can also be written in the *static representation*

$$X_t = \Lambda F_t + u_t \tag{3.4}$$

where $F_t' = (f_t, f_{t-1}, \ldots, f_{t-p})$, λ_j is a 1xq vector of factor loadings of f_{t-j}, and Λ is an Nxr matrix, and $r=q(p+1)$. We briefly review two methods of estimating the static factor F_t: the ordinary (standard) principal component (OPC) estimator, and the generalized principal component (GPC) estimator of forni *et al.* (2005, FHLR henceforth).

The OPC estimator finds F_t and Λ as the solution to the nonlinear regression problem that minimizes the sum of all squared residuals

$$\min_{F_t, \Lambda} \sum_{t=1}^{T} (X_t - \Lambda F_t)'(X_t - \Lambda F_t) \tag{3.5}$$

subject to normalization $\Lambda'\Lambda = I$ and orthogonal conditions that $F'F$ is a diagonal matrix, where X is the TxN data matrix and F is a Txr matrix. The estimator $\hat{\Lambda}$ is the eigenvectors of X'X corresponding to its r largest eigenvalues and the estimator of the static factors F is the principal component, $\hat{F} = X\hat{\Lambda}$. Note that the OPC estimator completely ignores the dynamics among the factors.[10)]

Standard factor models in (3.3) and (3.4) do not include any observable variables as the underlying factors of X_t. The model can be extended to include observable factors Z_t

10) Stock and Watson (2005) suggest to augment a vector of distinct time series in X_t with its lagged values when F_t includes lags of the dynamic factors. This is referred as stacking X_t with its lags.

$$X_t = \Lambda F_t + \Psi Z_t + v_t \tag{3.6}$$

This is the form of factor model that Bernanke et al. (2005) use for their FAVAR model, where Z_t in their model represents the main endogenous variables in the standard VAR model. The idea is that both Z_t and F_t represent common forces that drive the dynamics of X_t. The static form of dynamic factor model in Stock and Watson (2005) also takes the form in (3.6), where $Z_t = X_{t-1}$ and Ψ is a diagonal matrix autoregressive coefficients[11)] of u_{it}.

Bernanke et al. (2005) estimate the unobservable factors F_t in (3.6) by the principal components of X_t, ignoring the presence of observable factors Z_t and excluding Z_t from X_t. Their estimator of the factors is thus an estimator of the linear space spanned by F_t and Z_t, and will be correlated with Z_t in general. Stock and Watson (2005) use an interactive procedure: starting with an initial estimator of Ψ, F_t is estimated by the first r principal components of $X_t - \Psi Z_t$; given the estimate of F_t, elements of Λ and diagonal elements of Ψ are estimated by regression of each x_{it} on F_t and Z_t. This procedure is repeated until convergence.

Alternatively, one can estimate, F_t, Λ and Ψ in (3.6) as a solution to the nonlinear regression problem that minimizes the sum of all squared residuals

$$\min_{F_t,\Lambda,\Psi} \frac{1}{T}\sum_{t=1}^{T} [X_t - \Lambda F_t - \Psi Z_t]' [X_t - \Lambda F_t - \Psi Z_t] \tag{3.7}$$

Byun and Hwang (2006) show that a solution for F is the principal components $F=U\Lambda$ where U is the matrix of regression residuals of regression residuals of X_t on Z_t, and Λ is the eigenvectors of $U'U$ corresponding to its r largest eigenvalues subject to $\Lambda'\Lambda = I$. Since the principal components are linear combinations of regression residuals, they are orthogonal to observed regressors Z.

While OPC's objective function takes a form of ordinary least squares, the GPC estimators are the solutions to the generalized nonlinear regression problem

$$\min_{F_t,\Lambda} \sum_{t=1}^{T} (X_t - \Lambda F_t)' \Sigma_u^{-1} (X_t - \Lambda F_t) = tr[(X-F\Lambda')'\Sigma_u^{-1}(X-F\Lambda')] \tag{3.8}$$

11) Let the idiosyncratic terms in (3.4) follow autoregressive processes, $u_{it} = \delta_i(L)u_{it-1} + v_{it}$. Then Ψ= diag $(\delta_i(L))$, $Z_t = X_{t-1}$, and the i-th row of Λ is specified as $[1-\delta_i(L)L]\ \boldsymbol{\lambda}_i(L)$.

subject to the normalization restriction $\Lambda'\Sigma_u^{-1}\Lambda = I$, where Σ_u is the contemporaneous covariance matrix of the idiosyncratic component. The GPC is computed by $F = X\Lambda^*$, where Λ^* is the generalized eigenvectors of $X'X$ in the metric of Σ_u corresponding to the r largest eigenvalues with normalization $\Lambda^{*\prime}\,\Sigma_u\,\Lambda^* = I$. When X_t is a demeaned time series, $\hat{\Sigma}_x = X'X/T$ is an estimator of the covariance of X_t, and hence, λ_j^* can also be computed as the generalized eigenvector of $\hat{\Sigma}_x$ in the metric of Σ_u.

To implement the GPC estimator, we need an estimator of Σ_u. FHLR estimate Σ_u by $\hat{\Sigma}_u = \hat{\Sigma}_x - \hat{\Sigma}_c$, where the estimate of covariance matrix of the common components, $\hat{\Sigma}_c$ is computed by the average of spectral density matrix of the common components $\hat{S}_c(\omega_h)$ over all frequencies ω_h. Note that the generalized eigenvectors Λ^* of $\hat{\Sigma}_x$ in the metric of $\hat{\Sigma}_u$ is equivalent to the generalized eigenvectors of $\hat{\Sigma}_c$ in the metric of $\hat{\Sigma}_u$. FHLR compute Λ^* by the generalized eigenvectors of $\hat{\Sigma}_c$ in the metric of a diagonal matrix $diag(\hat{\Sigma}_u)$. They use only the diagonal elements of $\hat{\Sigma}_u$ because this gives better results in their numerical analysis when N is large with respect to T.

This estimation procedure needs an estimate of the number of dynamic factors q. Forni et al. (2000) suggest a heuristic inspection of the averages of the eigenvalues of the spectral density matrix of X_t over the frequencies for different number of variables. Bai and Ng (2007c) propose a more systematic way to determine q. Their method is based on the fact that, when a dynamic factor model is written in a static form such as in (3.4), the static factors follow $AR(h)$ process $f_t = B_h(L)\,f_{t-1} + \epsilon_t$, where ϵ_t is an $i.i.d.$ innovation vector with a diagonal covariance matrix. Then, the static factors F_t can be written as an $AR(\tau)$ process $f_t = A_\tau(L)\,f_{t-1} + \xi_t$, where $\xi_t = R\epsilon_t$, R is a rxq matrix of rank q, and $\tau = \max(1, h\text{-}p)$. The covariance matrix of ξ_t, Σ_ξ, is a rxr matrix with a rank $q<r$. They determine q by a statistic that captures the number of nonzero eigenvalues of Σ_ξ.

Stock and Watson (2005) exploit a different implication of the static representation of the dynamic factor model. Substituting $F_t = A_\tau(L)F_{t-1} + \xi_t$ into (3.4), the model can be written as $X_t = \Lambda A_\tau(L)\,F_{t-1} + \eta_t$, where $\eta_t = (\Lambda R)\epsilon_t + u_t$. This is precisely the form of standard static factor model if data on η_t are available. They estimate η_t by the residuals of the regression of X_t on lagged values of $\hat{F}_{t-1}$, and then use the information criteria in Bai and Ng (2002) to determine the number of static factors of η_t, which coincides with the number of dynamic factors q.

3. Empirical Estimation of Hybrid Phillips Curve

The data is a quarterly panel data of 138 variables over the sample period 1960:I - 2003:IV. The data set includes Stock and Watson's (2005) 132 time series data and GG's six time series data that are not included in the former.[12] All data is obtained from the Global Insights Basic Economics Database (GIBED) except for the non-farm business (NFB) deflator, which is obtained from the Federal Reserve Economic Data (FRED)[13]. Following GG and Marcellino et al. (2003), the monthly data is aggregated to quarterly data by the quarterly averages of the monthly data. Stock and Watson (2005) transform the nonstationary series by taking the first or second differences in log or level data, while GG and GGLS5 take only the first differences of log or level data of nonstationary variables[14]. Stock and Watson (2005) adjust the outliers in some of their monthly data, but we do not adjust for the outliers in our quarterly data. The inflation is measured as the log difference in the GDP deflator (or NFB deflator) and the marginal cost is constructed as the log of labor income share in the non-farm business sector. The ordinary and generalized principal components are estimated from 135 variables, excluding the variables that appear in the inflation equation, i.e., GDP deflator, NFB

12) Data covers macroeconomic variables such as industrial production, personal income, inventories, employment, payroll, new housing starts, manufacturer's new orders, stock price index, interest rate, consumer price index, the producer price index, personal consumption expenditure deflator and average hourly earnings. GG's 7 variables are GDP deflator, NFB deflator, labor income share, the interest rate spread, output gap (quadratically detrended real GDP), wage inflation (compensation per hour of nonfarm business sector), and commodity price inflation (spot market price index of all commodities). The interest rate spread appears in both GG and Stock and Watson (2005) data sets, but they are computed differently. GG compute the spread by the difference between one year government bond yield and the three month treasury bill rate, while Stock and Watson define eight different spreads; for example, the difference between one year government bond yield or AAA corporate bond yield and the federal funds rate.

13) We found that the NFB deflator data in the GIBED, in GG's study and in RW7's study are all different. RW7's data seem to be identical to FRB's data with some recent data that may have been revised. Compared to the data that Stock and Watson posted on their web site, our data on Stock and Watson's variables reflect revisions on several variables.

14) Stock and Watson take the first difference of the commodity price inflation, but GG do not. We will follow Stock and Watson's procedure.

deflator and the labor income share.

We first examine the effects of different sets of instrumental variables that previous studies have used in the estimation of the structural and closed form equations of GDP and NFB inflation rates. Four sets of instrumental variables are described in the first four columns of Table 1: GG, GGLS5, GG-2 and RW. The last three sets are subsets of GG's set. For the structural equation, underlying model parameters (ω, θ, β) are estimated by the nonlinear GMM and the estimates of parameters $(\gamma_b, \gamma_f, \lambda)$ are derived from them. The estimation of the closed form equation follows RW7 by estimating $(\overline{\lambda}, \delta_1, \tau)$, from which the estimates of $(\gamma_b, \gamma_f, \lambda)$ are derived. Estimation results are presented in Table 2a for the structural form equation and in Table 2b for the closed form equation. For expositional brevity, we will denote the structural form equation with GDP and NFB deflator as the inflation measure by SF-GDP and SF-NFB, respectively. Similarly, CF- GDP and CF-NFB denote the closed form equation with GDP and NFB deflator as the inflation measure.

Table 2a shows a few interesting results: (a) The hypothesis 8=0 in the SF-GDP equation is rejected with the GG and GGLS5 instruments, but not with GG-2 and RW. The hypothesis is accepted with high p-values in the SF-NFB equation for all four sets of instruments. (b) There are significant differences in the estimates of T between the SF-GDP and SF-NFB equations. The estimates of ω range 40%-45% and are all statistically significant in the SF-GDP equation, while they are less than 13% and statistically insignificant in the SF- NFB equation. Similar results hold for the estimates of γ_b, except that it is significant with GG instruments in the SF-NFB equation. (c) The hypothesis $\gamma_b > \gamma_f$ is strongly rejected in both SF-GDP and SF-NFB equations with almost zero *p*-values, which is consistent with the conclusion of GG and GGLS5 that the forward-looking behavior is dominant. (d) The hypothesis $\gamma_b + \gamma_f = 1$ is not rejected in all cases, which is consistent with the acceptance of the hypothesis $\beta=1$ at 5% level of significance. However, another theoretical implication that $\lambda=0$ if and only if $\omega=1$ does not hold: $\omega=1$ is rejected in all cases, but $\lambda=0$ is rejected in only the first two cases.

Table 2b reports the estimation results of the closed form equation. The *p*-values of hypothesis $\lambda=0$ are all small except for the CF-NFB equation with GG-2 and RW instruments. The hypothesis is rejected for the CF-GDP equation regardless of the choice of instruments. A similar pattern is observed in the test of $\gamma_b + \gamma_f = 1$. The test of hypothesis $\gamma_b > \gamma_f$ also depends on the instruments: it is rejected with GGLS5 and RW, but not rejected with GG and GG-2, for both inflation measures.

These results clearly show the source of disagreements about the relative role of the backward- and forward-looking behavior in recent literature. We noted earlier the difference in the hypothesis between GG/GGLS5 and RW5/RW7 studies. The former focuses on the test of $\gamma_b > \gamma_f$ ($\omega > \beta\theta$) and the latter focuses on the test of $\lambda=0$ ($\omega=1$). The test of $\gamma_b > \gamma_f$ in the SF-GDP equation by using the instruments of GG or GGLS5 strongly rejects the hypothesis, while the test of 8=0 in the CF-NFB equation by using the instruments of GG-2 or RW easily accept the hypothesis. This leads the authors to draw opposite conclusions.

Our results indicate that, if the hypothesis $\lambda=0$ is tested in the CF-GDP equation (i.e., using the GDP deflator instead of the NFB deflator), then the conclusion of RW7 will be reversed. On the other hand, the test of hypothesis $\gamma_b > \gamma_f$ in the SF equation is robust to the choice of the inflation measure. However, the results of this test are inconsistent with the implications of GG's model when the NFB deflator is used. Since $\lambda=0$ if and only if $\omega=1$ and $\omega=1$ implies $\gamma_b > \gamma_f$ in the context of GG's model, the acceptance of $\lambda=0$ is expected to coincide with the acceptance of $\gamma_b > \gamma_f$. This is not the in the estimation of the SF-NFB equation.

Each of the four sets of instruments produces contradictory test results between the GDP and the NFB deflators, or between the structural form and the closed form equations. The differences in the results between the two inflation measures are particularly puzzling. As Figure 1 shows, the inflation rates defined by the two measures follow similar paths with a very high correlation coefficient (0.94). Cursory inspection of the figure reveals no distinctive deviations from each other. It is also difficult to explain the contradicting results between the estimation equations because the structural form and closed form equations are alternative expressions of the same GG's model. As we will show below, we find the fundamental cause of the conflicting results in the use of suboptimal instrumental variables. All conflicting results vanish when the optimal set of instruments boosted from principal components is used.

Since the estimation equation involves inflation rate and marginal cost, the information set for rational expectations must include their past values. For comparability with previous studies (GGLS5 in particular) we keep one- to four-lags of inflation and one- to two-lags of marginal cost as retained instrumental variables (Zt in equation (3.1)), and select the optimal instruments from the base set of observed variables Xt, and from the OPC and GPC of Xt. The base set consists of one- and two-lagged values of Stock and Watson's 132 variables, plus one- and two-lagged values of GG's 3 variables (detrended real output, nominal wage inflation and interest rate spread) that are not included in Stock and Watson's set.[15] The choice of two lags is

15) When the GDP deflator is used for the inflation, lagged values of the NFB deflator are not included in the base set X_t, and vice versa. The closed form equation involves more than one endogenous regressor, and the boosting is done for one-lead marginal cost mc_{t+1}. The step length in the boosting is set to $\tau=1$.

loosely based on Stock and Watson's suggestion of 'stacking up' the variables for the dynamic factor model.

Principal components are computed as the estimator of the factor model in (3.6) where Z_t represents the retained instrumental variables. All variables are standardized before computing the principal components, treating each lagged variable as an independent variable in the process. Since OPC and GPC are computed from the residuals of the regression of X_t on Z_t, they are orthogonal to the retained instrumental variables.

The boosting for π_{t+1} from observed variables Xt with the BIC criterion in (3.2) yields 25 variables for the GDP deflator and 15 variables for the NFB deflator. Two columns under the heading of structural form in Table 1 show the variables that are selected by boosting for π_{t+1}. Six of the selected variables are common to both the GDP and NFB deflators,[16] and the detrended real output gap in GG's set is not selected. The first instrumental variable selected by boosting is the lagged NAPM (National Association of Purchasing Managers) vendor deliveries index for both GDP and NFB deflators. The second instrument is the one-lagged number of building permits in Midwest region for the GDP deflator, and the one-lagged inventory to sales ratio for the NFB deflator. The third instrument is the industrial production index of durable consumer goods for the GDP deflator and the same index of fuel for the NFB deflator. One-lagged value of monetary base is in the set for both GDP and NFB deflators. Interestingly, the sixth variable selected for the NFB deflator is the one-lagged number of housing starts in Midwest region, similar to the building permit for the GDP deflator. These variables are not in GG's instrument set. Commodity price indices and interest rate spread are included in the boosted instruments, but they are defined differently from GG's variables. The list of all selected variables is provided in the Appendix[17]

Two columns under the heading of closed form in Table 1 show the variables that are selected by boosting for mc_{t+1} in the closed form equation. The number of selected variables is fewer than the case of structural form: six variables for the GDP deflator and eight variables for the NFB deflator. The output gap is the first variable selected for both deflators. The second variable selected is the IP total index for the GDP deflator

16) These are NAPM vendor deliveries index (L1), IP index - durable consumer goods (L2), P/E ratio - S&P composite common stocks (L2), IP index- Fuel (L1 for GDP and L2 for NFB), Monetary base - adjusted for RR changes (L1), PPI- intermed. Mat. Supplies & Components (L1).

17) Other variables for the GDP deflator that are intuitively reasonable include the average hourly earnings of production workers(L2), employees on nonfarm payrolls (L1), personal income (L1), wage inflation (L2), consumer credit outstanding (L2), capacity utilization (L2), real consumption (L1 & L2), unemployment duration, manufacturers' new orders in durable goods industries.

and the number of non-farm employees for the NFB deflator. The third variable is the interest rate spread for the both deflators. Other variables common for both deflators are the net changes in commercial and industrial loans of large commercial banks, the average weekly working hours in manufacturing, and Moody's corporate bond yields.

The traditional usage of principal components for the reduction of data dimension takes the first a few principal components that explain a certain percentage (e.g., 40%) of the total variation of indicator variables. Instead of following this tradition, we first determine the number of static factors $\hat{r}$ by using Bai and Ng's (2002) information criterion $IC_{P2}(k)$. This procedure selects the first 10 and 7 OPCs out of total 169 principal components for the GDP and NFB deflators, respectively, and they explain about 60% and 51% of the variations in indicator variables X_t after partialling out the effects of retained instruments Z_t. These sets of principal components in addition to the retained instrumental variables Z_t. are used in the estimation of the structural and closed form equations.

As mentioned earlier, the principal components that best explain the variation in X_t may not be the best instrumental variables for the endogenous variable. Therefore, we select the best instruments from OPC and GPC by L_2 -boosting. Bai and Ng (2007a) use the entire set of principal components as the boosting base and set the maximum number of boosting iteration to M=10xmin[$N^{1/3}$, $T^{1/3}$]. This procedure gives an excessive number of instruments in our data set: four out of eight cases select the maximum number of iteration.

Since such an excessive number of instruments increases the bias, we limit the size of the boosting base by considering two factors. The first factor is the percentage of the variation of X_t explained by the principal explain more than 98% of the variation of X_t. The second factor is the effect on the joint precision of key parameters (γ_b, γ_f, λ), measured by their generalized variance (i.e., the determinant of estimated covariance matrix). Starting with a small number of principal components as the boosting base, instrumental variables are selected and the generalized variance of the estimates of (γ_b, γ_f, λ), is computed. This is repeated by adding one additional principal component to the boosting base. The joint precision increases significantly at the beginning, but the improvement of the precision becomes negligible by the time we reach 100 principal components. Therefore, we set the size of the boosting base to 100.[18]

The number of principal components selected by boosting varies from 8 in the CF-NFB-GPC case to 24 in the SF-GDP-GPC case. The first principal component is the first instrument selected by boosting in all cases. The fourth principal component is also

18) The exception is the estimation of the structural form of GDP deflator with instruments boosted from the GPC. There is a significant increase in the joint precision from 100 to 102 GPC.

selected in all cases. The second principal component is selected in all cases except for the SF-GDP cases which select the third principal component instead. We showed that the estimated dimension $\hat{r}$ of the factor space is 1- in the SF-GDP case, but only five of the first 10 OPCs are selected by boosting. In the SF-NFB case, the estimated dimension is 7, and only 3 of the 7 first OPCs are selected by boosting. These results confirm the Bai-NG argument that principal components that best explain the variation in the indicator variables are not necessarily the best instrumental variables for the endogenous variable.

Tables 3a and 3b report the estimation results for the structural form and the closed form equations, respectively. Columns under the headings OBS, OPC and GPC show the results of GMM estimation with instruments boosted from observed variables, OPC and GPC, respectively. The column under the heading $\hat{r}$ -OPC shows the estimation results with first $\hat{r}$ number of OPCs as the instruments. The most striking result in Table 3a and Table 3b is the similarity in the estimates of parameters, the *p*-values of test statistics, and the number of selected instruments across the OBS, OPC and GPC in each case. The only exception is the *p*-value of the test statistic for $\gamma_b \geq \gamma_f$ in the CF-NFB equation, where the hypothesis is not rejected with instruments boosted from OBS while it is rejected strongly with instruments boosted from OPC and GPC.

We noted earlier that the instrument sets in previous studies generate contradictory results in the tests of hypotheses. The instrument sets boosted from OPC and GPC, on the other hand, lead to consistent test results regardless of the choice of the inflation measure and the estimation equation. As noted above, however, the boosted instrument set OBS gives a contradictory test result of $\gamma_b \geq \gamma_f$ between SF-NFB and CF-NFB. Estimates of parameters and the *p*-values of hypothesis tests with the first $\hat{r}$ number of principal components ($\hat{r}$ -OPC) as instruments very similar to the results of using the instruments of GG and GGLS5, and it has a few contradictory results. We may thus conclude that using the first $\hat{r}$ number of principal components as instruments is not as good as using the boosted instruments from the OPC or GPC.

We also noted earlier that, when instrumental variables in previous studies are used, there are significant differences in the estimates of parameters between the SF-GDP and SF-NFB and between the SF and CF equations. These differences are much smaller when the boosted instruments are used. For an easy comparison of the estimates, Figure 2a shows the differences between the GDP and NFB deflators, and Figure 2b shows the differences between the SF and CF equations. The estimates of λ do not vary much across the inflation measures and the estimation equations. However, differences in the estimates of ω, γ_b and γ_f are quite noticeable for the instrument sets in previous studies, and they tend to be smaller when the instrument set boosted from OPC is used.

Instrument sets boosted from the observed variables (OBS) and the GPC also perform well, but the overall performance seems to be better with the OPC-boosted instruments.

We showed earlier that $\lambda=0$ is equivalent to $\omega=1$ in GG's hybrid model. If GG's model is the true data generating structure, then one expects to find the same test results for $\lambda=0$ and for $\omega=1$. Estimates based on the instruments boosted from principal components support this implication of GG's hybrid model in both SF-GDP and SF-NFB cases. However, all four sets of instruments in previous studies in the SF-NFB equation, and GG-2 and RW instruments in the SF-GDP equation, do not support the implication of GG's model. Other two implications of GG's model, i.e., the equivalence of $\lambda=0$ and $\gamma_b + \gamma_f = 1$ if $\beta \neq 1$, and $\gamma_b + \gamma_f = 1$ if $\beta = 1$, are supported by all sets of instruments.

IV. Conclusion

The New Keynsian Phillips curve or its hybrid version includes the rational expectation of inflation as one of the explanatory variables. Instrumental variables for the future expectation can include all variables in the current information set, but only a relatively small number of instruments are used in the estimation of the hybrid inflation equation. Instrumental variables are usually selected on an ad hoc basis though they are intuitively reasonable candidates for the instruments. It has been recognized that the estimates of the parameters are not robust to the choice of instruments and the effects of the choice of instruments can be substantial across different measures of inflation and different form of estimation equation. Such a sensitivity has been detected in recent literature. We also showed that each set of instruments in previous studies can lead to conflicting conclusions, depending on the choice of the inflation measure and the estimation equation.

This paper uses the L_2 -boosting method of Bühlmann and Yu (2003) to select the optimal set of instruments in the estimation of the structural form and the closed form equations of GG's hybrid model. Three sets of boosting base are used. The first boosting base is the lagged values of a large number of observed variables that have been used widely in the study of forecasting. The other two sets are the ordinary and generalized principal component estimators of underlying factors. Bai and Ng (2007a) show that principal components can be more efficient instrumental variables than the observed variables.

We find that the set of optimal instruments from observed boosting base is quite different from the sets used in previous studies. The first instrumental variable selected by boosting for inflation is the lagged NAPM (National Association of Purchasing Managers) vendor deliveries index for both the GDP and the NFB deflators. One-lagged value of monetary base is also in the set for both GDP and NFB deflators. These variables are not included in the set of instrumental variables of previous studies. In boosting for the marginal cost, the output gap is the first variable selected for both GDP and NFB deflators, and the selected set includes the spread between 90 day commercial paper rate and federal funds rate, and net changes in commercial and industrial loans of large commercial banks. Estimates of GG's model with these instruments lead consistent conclusions across the inflation measures and estimation equations, except for the test of $\gamma_b > \gamma_f$ in the CF- NFB case.

Principal components that best explain the variation of indicator variables are not necessarily the best instruments. The boosting procedure selects only five of the first ten OPCs in the SF-GDP case and selects only three of the first seven OPCs in the SF-NFB case. We find negligible differences between the OPC and GPC as the boosting base. Estimates of the model by using the instruments boosted from OPC and GPC give consistent results in all cases for all hypotheses under consideration. That is, the results of hypothesis tests are the same regardless of the choice of inflation measure and estimation equation. Furthermore, differences in the estimates of parameters between the SF-GDP and SF-NFB and between the SF and CF equations are much smaller when the boosted instruments are used than when instruments in past studies are used.

Boosted instruments also support the implications of GG's hybrid model, while all four sets of instruments in previous studies do not support the equivalence of $\lambda = 0$ and $w = 1$ in some cases. Therefore, the estimation based on previous sets of instruments can cause the controversy about the validity of GG's hybrid model. Estimation based on the boosted instruments will validate the model and will lead to the same conclusions no matter which measure of inflation or estimation equation is used. Estimation of GG's hybrid model by using the optimal set of instruments shows the dominant role of forward-looking behavior in inflation dynamics, and the significant effect of the real marginal cost or the present value of future real marginal cost on the inflation regardless of the measurement of inflation by the GDP deflator or NFB deflator.

Figure 1. Comparison of Inflation Rates

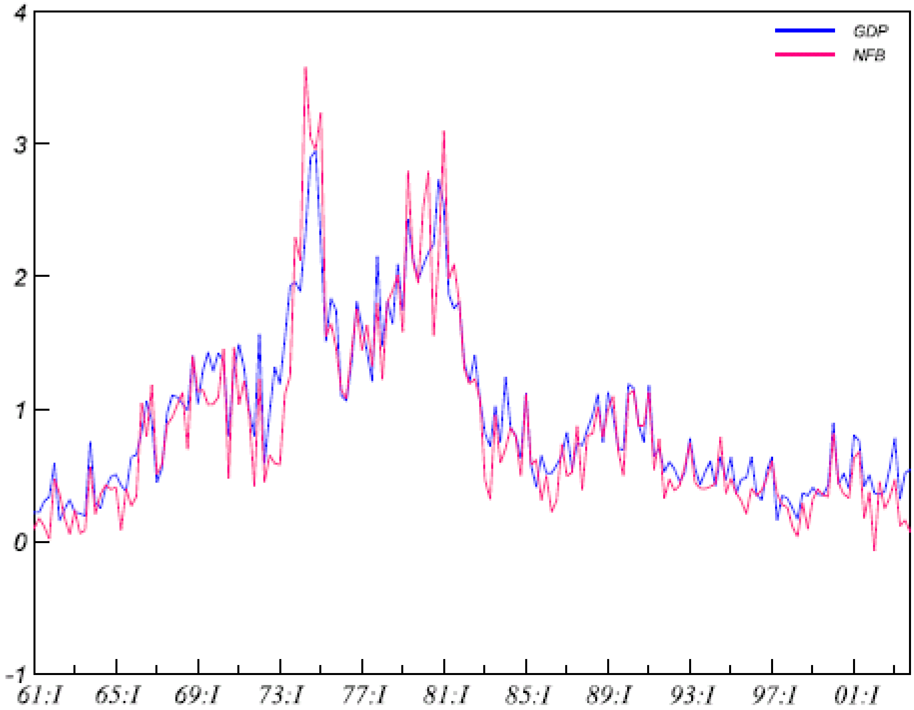

Figure 2a. Differences in Estimates of Parameters between GDP and NFB Deflators

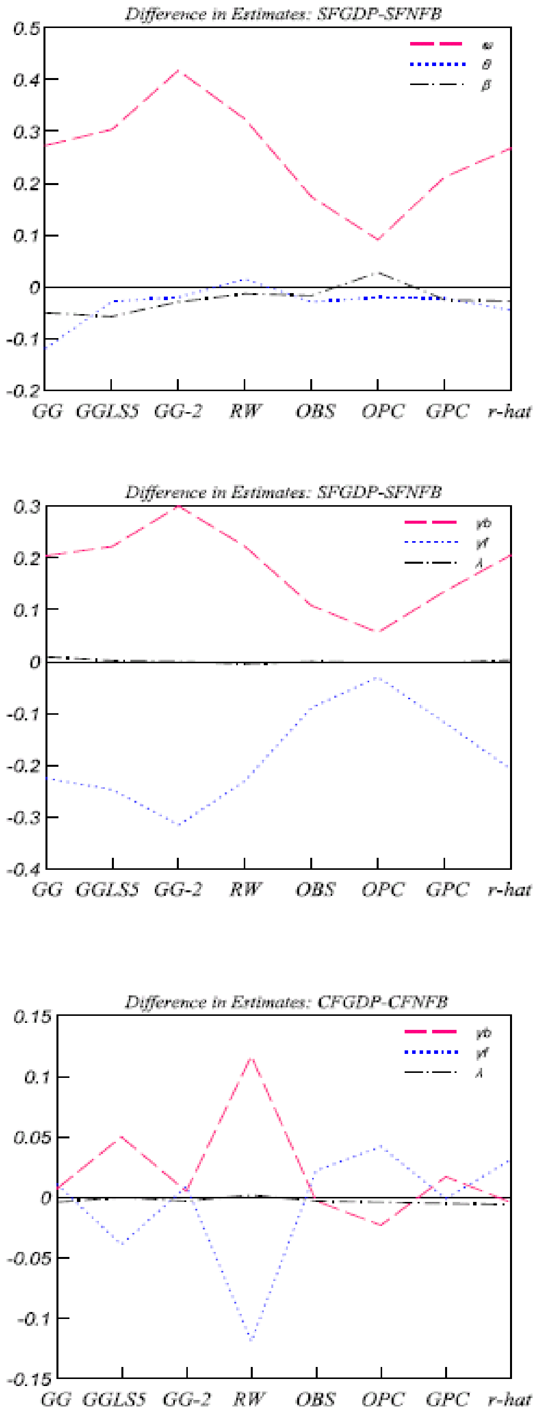

Figure 2b. Differences in Estimates of Parametes between SF and CF Equations

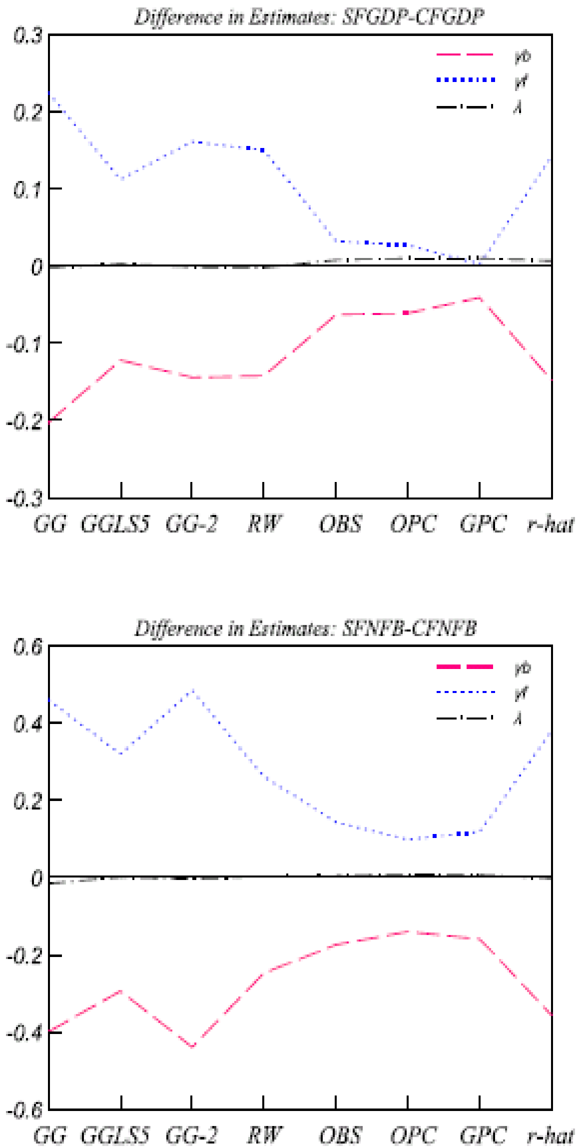

Table 1. Set of Instrumental variables

Both Structural and Closed Form Equations				Structural Form (π_{t+1})		Closed Form (mc_{t+1})	
GG	GGLS5	GG-2	RW	GDP-L2	NFB-L2	GDP-L2	NFB-L2
inflation lag 1-2	T	T	T	T	T	T	T
inflation lag 3-4	T			T	T	T	T
Marginal cost 1-2	T	T	T	T	T	T	T
Marginal cost 3-4							
Real output 1-2	T	T	T			lag 1 only	lag 2 only
Real output 3-4							
Nominal wage 1-2	T	T	T	lag 2 only			
Nominal wage 3-4							
Comm. price 1-2[a]		T		lag 1 of two related comm. prices	lag 1 of three related comm. prices		
Comm. price 3-4[a]							
Interest rate spread 1-2[b]		T			lag 2 of one related spread	lag 1 of one related spread	lag 1 of one related spread
Interest rate spread 3-4[b]							
Additional instruments not in GG and GGLS5				15 real, 3 inflation, 4 monetary variables	8 real, 3 monetary variables	2 real, 2 monetary variables	4 real, 2 monetary variables

(a) GG use the spot market price index of all commodities L_2-boosting selects the CPI-durable and PPI-material goods for the GDP deflator, and the CPI-medical care, PPI-material goods and PPI-finished goods for the NFB deflator.

(b) GG define the interest rate spread as the difference between one year government bond yield and the three month treasury bill rate. The NFB deflator in the structural form equation selects two-lagged value of interest rate spread defined by the difference between AAA corporate bond yield and the federal funds rate. The interest rate spread selected in the closed form equation is the difference between CP rate and the federal funds rate.

Table 2a. Comparison of Alternative Instrumental variables Structural From Equation (1960:I - 2003:IV)

	SF-GDP				SF-NFB			
	GG	GGLS5	GG-2	RW	GG	GGLS5	GG-2	RW
T	0.400 (0.038)	0.402 (0.085)	0.448 (0.078)	0.408 (0.103)	0.127 (0.252)	0.098 (0.077)	0.030 (0.068)	0.084 (0.085)
2	0.882 (0.021)	0.874 (0.033)	0.916 (0.047)	0.926 (0.060)	1.001 (1.949)	0.902 (0.051)	0.936 (0.054)	0.911 (0.051)
$	0.950 (0.030)	0.948 (0.038)	0.980 (0.039)	0.992 (0.034)	1.000 (0.021)	1.005 (0.030)	1.009 (0.031)	1.005 (0.034)
γ_b	0.316 (0.022)	0.320 (0.051)	0.331 (0.038)	0.306 (0.056)	0.112 (0.046)	0.098 (0.070)	0.031 (0.068)	0.084 (0.079)
γ_f	0.663 (0.017)	0.659 (0.025)	0.662 (0.023)	0.690 (0.024)	0.888 (0.188)	0.906 (0.030)	0.977 (0.030)	0.920 (0.031)
8	0.009 (0.004)	0.010 (0.006)	0.004 (0.004)	0.003 (0.005)	0.000 (0.005)	0.008 (0.010)	0.004 (0.007)	0.007 (0.009)
p-Values of Hypothesis Tests								
8=0	0.006	0.033	0.213	0.282	0.500	0.207	0.307	0.218
$\gamma_b \geq \gamma_f$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\gamma_b + \gamma_f = 1$	0.190	0.304	0.425	0.475	0.501	0.528	0.547	0.523
GV	0.066	1.364	0.414	1.002	0.908	17.887	17.185	33.541
J-stat	10.844 (0.966)	7.864 (0.345)	3.869 (0.920)	3.321 (0.651)	9.930 (0.980)	6.623 (0.469)	4.510 (0.875)	3.387 (0.641)

GV: Generalized variance (i.e., determinant of covariance matrix) of ($\hat{\gamma}_b$, $\hat{\gamma}_f$, $\hat{\lambda}$) times E-11.

Table 2b. Comparison of Alternative Instrumental Variables Closed Form Equation (1960:I - 2003:IV)

	CF-GDP				CF-NFB			
	GG	GGLS5	GG-2	RW	GG	GGLS5	GG-2	RW
$\bar{\lambda}$	0.017 (0.006)	0.011 (0.005)	0.008 (0.005)	0.009 (0.005)	0.022 (0.010)	0.011 (0.005)	0.013 (0.010)	0.004 (0.005)
δ_1	0.798 (0.026)	0.747 (0.049)	0.781 (0.039)	0.757 (0.049)	0.756 (0.024)	0.611 (0.061)	0.737 (0.048)	0.489 (0.094)
τ	0.673 (0.107)	0.925 (0.040)	0.824 (0.081)	0.913 (0.048)	0.631 (0.166)	0.913 (0.042)	0.773 (0.170)	0.972 (0.027)
γ_b	0.519 (0.032)	0.442 (0.021)	0.475 (0.027)	0.448 (0.022)	0.512 (0.046)	0.392 (0.029)	0.470 (0.050)	0.331 (0.044)
γ_f	0.438 (0.046)	0.547 (0.024)	0.501 (0.035)	0.540 (0.025)	0.427 (0.077)	0.586 (0.034)	0.492 (0.075)	0.659 (0.044)
8	0.011 (0.005)	0.007 (0.003)	0.005 (0.003)	0.005 (0.003)	0.015 (0.008)	0.007 (0.003)	0.008 (0.007)	0.003 (0.003)
p-Values of Hypothesis Tests								
8=0	0.008	0.016	0.053	0.034	0.033	0.019	0.119	0.195
$\gamma_b \geq \gamma_f$	0.854	0.010	0.336	0.027	0.756	0.001	0.427	0.000
$\gamma_b + \gamma_f = 1$	0.007	0.025	0.016	0.032	0.033	0.011	0.091	0.158
GV	0.028	0.005	0.007	0.006	0.231	0.031	0.283	0.144
J-stat	14.300 (0.856)	8.474 (0.293)	9.357 (0.405)	4.881 (0.431)	13.152 (0.903)	10.122 (0.182)	10.181 (0.336)	9.257 (0.099)

GV: Generalized variance (i.e., determinant of covariance matrix) of ($\hat{\gamma}_b$, $\hat{\gamma}_f$, $\hat{\lambda}$) times E-11.

Table 3a. GMM Estimation of Phillips Curve with Boosted IV Structural Form Equation (1960:I - 2003:IV)

	SF-GDP				SF-NFB			
	L2 Boosting			r-OPC	L2 Boosting			r-OPC
	OBS	OPC	GPC		OBS	OPC	GPC	
T	0.511 (0.040)	0.450 (0.041)	0.488 (0.038)	0.365 (0.057)	0.337 (0.049)	0.359 (0.044)	0.276 (0.046)	0.097 (0.059)
2	0.857 (0.017)	0.848 (0.019)	0.854 (0.018)	0.862 (0.026)	0.886 (0.031)	0.868 (0.031)	0.876 (0.030)	0.907 (0.044)
$	0.848 (0.034)	0.872 (0.026)	0.859 (0.028)	0.946 (0.034)	0.864 (0.036)	0.844 (0.037)	0.884 (0.032)	0.973 (0.026)
γ_b	0.393 (0.020)	0.360 (0.021)	0.380 (0.019)	0.302 (0.035)	0.285 (0.033)	0.304 (0.028)	0.245 (0.033)	0.097 (0.055)
γ_f	0.558 (0.016)	0.592 (0.014)	0.572 (0.014)	0.674 (0.021)	0.647 (0.026)	0.622 (0.026)	0.689 (0.024)	0.881 (0.026)
8	0.015 (0.004)	0.017 (0.005)	0.016 (0.004)	0.013 (0.005)	0.015 (0.007)	0.019 (0.009)	0.018 (0.008)	0.010 (0.009)
p-Values of Hypothesis Tests								
8=0	0.000	0.000	0.000	0.007	0.018	0.014	0.014	0.148
$\gamma_b \geq \gamma_f$	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$\gamma_b + \gamma_f = 1$	0.018	0.019	0.009	0.222	0.006	0.003	0.015	0.315
GV	0.054	0.081	0.050	0.630	1.157	1.135	1.442	6.488
# of Base	270	100	102	169	270	100	100	169
# of IV	25	23	24	10	15	11	11	7
J-stat	12.056 (0.996)	11.641 (0.993)	12.004 (0.994)	10.399 (0.661)	12.056 (0.996)	9.886 (0.770)	10.066 (0.757)	9.780 (0.460)

GV: Generalized variance (i.e., determinant of covariance matrix) of $(\hat{\gamma}_b, \hat{\gamma}_f, \hat{\lambda})$ times E-11.

Table 3b. GMM Estimation of Phillips Curve with Boosted IV Closed Form Equation (1960:I - 2003:IV)

	CF-GDP				CF-NFB			
	L2 Boosting			r-OPC	L2 Boosting			r-OPC
	OBS	OPC	GPC		OBS	OPC	GPC	
$\bar{\lambda}$	0.011 (0.005)	0.011 (0.004)	0.010 (0.004)	0.010 (0.003)	0.015 (0.006)	0.018 (0.004)	0.016 (0.005)	0.018 (0.008)
δ_1	0.760 (0.043)	0.690 (0.047)	0.700 (0.049)	0.746 (0.030)	0.719 (0.041)	0.700 (0.039)	0.630 (0.049)	0.699 (0.046)
τ	0.877 (0.045)	0.926 (0.028)	0.945 (0.020)	0.882 (0.028)	0.790 (0.099)	0.826 (0.043)	0.889 (0.034)	0.771 (0.112)
γ_b	0.456 (0.019)	0.421 (0.018)	0.421 (0.019)	0.450 (0.012)	0.459 (0.032)	0.444 (0.020)	0.404 (0.023)	0.454 (0.035)
γ_f	0.526 (0.022)	0.565 (0.018)	0.569 (0.019)	0.532 (0.012)	0.504 (0.046)	0.523 (0.023)	0.570 (0.025)	0.501 (0.052)
8	0.007 (0.003)	0.007 (0.002)	0.006 (0.002)	0.006 (0.002)	0.010 (0.004)	0.011 (0.003)	0.011 (0.003)	0.012 (0.006)
p-Values of Hypothesis Tests								
8=0	0.012	0.003	0.003	0.003	0.006	0.000	0.001	0.019
$\gamma_b \geq \gamma_f$	0.042	0.010	0.000	0.000	0.283	0.000	0.001	0.293
$\gamma_b + \gamma_f = 1$	0.008	0.000	0.005	0.001	0.015	0.032	0.000	0.025
GV	0.007	0.003	0.001	0.001	0.058	0.012	0.028	0.569
# of Base	270	100	100	169	270	100	100	169
# of IV	6	10	10	10	8	13	8	7
J-stat	10.515 (0.310)	11.288 (0.587)	12.535 (0.484)	11.980 (0.529)	10.383 (0.496)	12.862 (0.683)	11.628 (0.392)	11.508 (0.319)

GV: Generalized variance (i.e., determinant of covariance matrix) of $(\hat{\gamma}_b, \hat{\gamma}_f, \hat{\lambda})$ times E-11.

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Appendix A. Variables Boosted from Observed Instruments Structural Form GDP (π_{t+1})

var. #	lag	Variable name	Category
63	1	NAPM Vendor Deliveries Index (Percent)	Real
58	1	Houses Authorized by Build. Permits: midwest(thou.u.)S.a.	Real
142	2	Industrial Production Index - Durable Consumer Goods	Real
261	2	Average Hourly Earnings of Production or Nonsup Workers on Private nonfar	Inflation
44	1	Employees on Nonfarm Payrolls - Financial Activities	Real
1	1	Personal Income (Ar, Bil. Chain 2000 $)	Real
267	2	GGIV-wage Inflation	Inflation
212	2	Consumer Credit Outstanding - Nonrevolving(g19)	Monetary
246	2	NAPM Commodity Prices Index (Percent)	Inflation
217	2	S&P's Composite Common Stock: Price-earnings Ratio (%,Nsa)	Real
79	1	Wkly Rp Lg Com'l Banks:net Change Com'l & Indus Loans(bil$,Saar)	Monetary
135	2	Real Consumption (Ac) A0m224/gmdc	Real
18	1	Industrial Production Index - Fuels	Real
120	1	CPI-U: Durables (82-84=100,sa)	Inflation
260	2	Pce,impl Pr Defl:pce; Services (1987=100)	Inflation
152	2	Capacity Utilization (Mfg)	Real
75	1	Monetary Base, Adj for Reserve Requirement Changes(mil$,Sa)	Monetary
47	1	Average Weekly Hours of Production or Nonsup Workers on Private Nonfar	Real
3	1	Real Consumption (Ac) A0m224/gmdc	Real
110	1	Producer Price Index: intermed Mat.supplies & Components(82=100,sa)	Inflation
163	2	Unemploy.by Duration: Persons Unempl.27 Wks + (Thous,sa)	Real
66	1	Mfrs' New Orders, Durable Goods Industries (Bil. Chain 2000 $)	Real
15	1	Industrial Production Index - Nondurable Goods Materials	Real
22	1	Employment: Ratio; Help-wanted Ads:no. Unemployed Clf	Real
225	2	Bond Yield: Moody's AAA Corporate (% per Annum)	Monetary

Appendix B. Variables Boosted from Observed Instruments Structural Form NFB (π_{t+1})

var. #	lag	Variable name	Category
63	1	NAPM Vendor Deliveries Index (Percent)	Real
70	1	Ratio, Mfg. And Trade Inventories to Sales (Based on Chain 2000 $)	Real
150	2	Industrial Production Index - Fuels	Real
236	2	Foreign Exchange Rate: Switzerland (Swiss Franc per U.s.$)	Monetary
233	2	Fyaaac-fyff	
53	1	Housing Starts:midwest(thous.u.)S.a.	Real
142	2	Industrial Production Index - Durable Consumer Goods	Real
108	1	Producer Price Index: Finished Goods (82=100,sa)	
117	1	CPI-U: Transportation (82-84=100,sa)	
217	2	S&P's Composite Common Stock: Price-earnings Ratio (%,Nsa)	Real
75	1	Monetary Base, Adj for Reserve Requirement Changes(mil$,Sa)	Monetary
218	2	Interest Rate: Federal Funds (Effective) (% per Annum,nsa)	Monetary
110	1	Producer Price Index:intermed Mat.supplies & Components(82=100,sa)	
9	1	Industrial Production Index - Consumer Goods	Real
23	1	Civilian Labor Force: Employed, Total (Thous.,Sa)	Real

Appendix C. Variables Boosted from Observed Instruments Closed Form (mc_{t+1})

var #	Lag	Variable name	Category
GDP Inflation			
265	1	GGIV-output Gap	
138	2	Industrial Production Index - Total Index	Real
95	1	Cp90-fyff	
79	1	Wkly Rp Lg Com'l Banks:net Change Com'l & Indus Loans(bil$,Saar)	Monetary
49	1	Average Weekly Hours, Mfg. (Hours)	Real
94	1	Bond Yield: Moody's Baa Corporate (% per Annum)	Monetary
NFB Inflation			
265	2	GGIV-output Gap	
166	2	Employees on Nonfarm Payrolls - Goods-producing	Real
95	1	CP90-fyff	
217	2	S&P's Composite Common Stock: Price-earnings Ratio (%,Nsa)	Real
79	1	Wkly Rp Lg Com'l Banks:net Change Com'l & Indus Loans(bil$,Saar)	Monetary
49	1	Average Weekly Hours, Mfg. (Hours)	Real
225	2	Bond Yield: Moody's Aaa Corporate (% per Annum)	Monetary
40	1	Employees on Nonfarm Payrolls - Service-providing	Real

Comments on "GMM Estimation of Hybrid Phillips Curve: A Source of Conflicting Empirical Results"

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The theoretical implications of short-run inflation dynamics for monetary policy analysis are frequently reviewed through the so-called New Keynesian Phillips Curve (NKPC). The NKPC is based on the microeconomic foundation that introduces nominal rigidities of Taylor (1980) and Calvo (1983) into the forward-looking optimizing behavior of monopolistically competitive firms and describes the inflation as a function of forward-looking expectations of inflation and marginal costs as the underlying drive force. Gali and Gertler (1999) develop a hybrid NKPC model in which two types of firms, backward-looking and forward-looking firms, exist and thus past inflation and expected inflation in addition to the marginal cost are included as the driving force of inflation. The regression model of the NKPC can be written as follows:

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda y_t, \tag{1}$$

where π_t is inflation at time t, E_t is conditional expectation given information at time t, y_t is marginal cost, and $\gamma_b, \gamma_f, and\ \lambda$ are estimated coefficients on the backward-looking component, on forward-looking component and on marginal cost respectively. Under the assumption of rational expectations, $E_t\pi_{t+1}$ in equation (1) can be replaced with realized inflation π_{t+1} and it can be estimated by instrumental variable estimations due to endogenous regressor.

There, however, has been little consensus about the empirical validity of the NKPC. Gali and Gertler (1999), Gali, Gertler and Lopez-Salido (2001, 2005) argue that the forward-looking behavior and the marginal cost are significant driving components in the NKPC, while Rudd and Whelan (2007) find an insignificant coefficient on the marginal cost. Various reasons for the contradicting results include difference in the data and sample periods, estimation equation, measure of inflation and the choice of instrumental variables. What is a true insight for the empirically disjointed results?

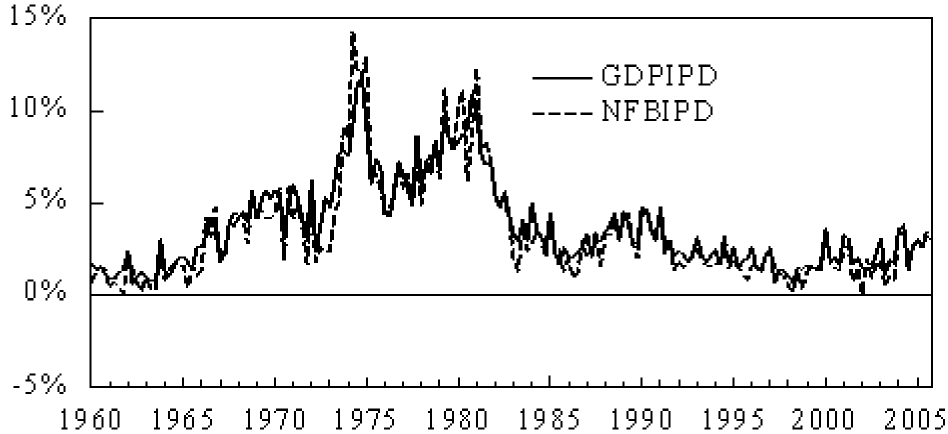
This paper by Hwang and Kim is looking for an answer from the choice of instrumental variables because GMM estimates of parameters of NKPC models are sensitive to the set of instruments and thus the instrument set and its subsets can produce conflicting results. Given the sensitivity of the GMM estimates of the hybrid NKPC, the paper starts with selecting the optimal set of relatively brief number of strong instrumental variables from a large number of valid instruments in a systematic way. This is a quite desirable initiative since the information set for the expectation can include a large number of informational variables and only best instruments have a possibility to produce more credible estimation results than just valid instruments.

Hwang and Kim apply the L_2-boosting method of Buhlmann and Yu (2003) to select the best instruments for the future inflation and marginal cost from various valid instruments. This methodology uses principle components of Stock and Watson (1998, 2005) and Forni et al. (2000, 2005) to make the base set of valid instrumental variables for the boosting. Hwang and Kim show that when the optimal set of instruments boosted from the principle components is used, all conflicting results in previous studies vanish and find the dominant role of the forward-looking behavior and the significant effects of real marginal cost in inflation dynamics regardless of the type of inflation measure and the form of estimation equation.

This paper, I think, is a fairly good application of recently developed methodology to controversial issue and tries to show in a systematic way what the true story is in this literature. However, I feel that it would be more convincing for the paper to need to consider following points further.

First of all, the inflation seems to have substantial fluctuation over the sample which the paper uses. <Figure 1> shows U.S. inflation from the first quarter in 1960 to the fourth quarter in 2005.

GDPIPD and NFBIPD denote the annualized inflation based on GDP deflator and based on Non-farm business sector price respectively. The inflation seems to be fairly volatile until 1982 but seems to be stable after the mid-1980s. In line with this inflation dynamics, Zhang, Osborn and Kim (2008a) investigate the possibility of structural break for U.S. inflation and find the evidence for structural break and Kim and Kim (2008) find the evidence for endogenous structural break in U.S. inflation. From this point of view, this paper needs to consider sub-sample analysis and thus examine whether the concrete result of the paper based on the optimal set of instrumental variables is robust to the sub-sample.



Secondly, output gap is still significant driving force in inflation dynamics in Neiss and Nelson (2005), and Zhang, Osborn and Kim (2008a, 2008b) while it is not in Gali and Gertler (1999). Nevertheless, this paper does not tell us about this issue at all. Since modern monetary policy analysis generally includes output gap in the specification of inflation dynamics it would be interesting for the paper to address whether the output gap is a valid inflation driving force based on new methodology for the optimal set of instrumental variables.

Thirdly, this paper selects the NAPM (National Association of Purchasing Managers) vendor deliveries index as the first instrument and the one-lagged number of building permits in Midwest region as the second instrument by the boosting method. Usually, a valid instrument is meaningful variable and reflects good information about macroeconomy in the NKPC estimation. From this point of view, this paper does not describe economic intuition or background for such selected instruments at all. It would be desirable for the paper to discuss this point briefly.

To summarize, in macroeconomic literature, to produce a unified story for specific issue seems not to be easy because macroeconomics might be subject to various issues such as Lucas critique, structural break, simultaneous equation bias, non-stationary series, misspecification, etc. Even so, this paper tries to show a significant contribution in the recent debate about the NKPC in a systematic way. Even though the results of this paper reconfirm those of existing literature, the application of new methodology to the NKPC must attract many interests from macroeconomic scholars and monetary policymakers and thus should be a good contribution.

Thank you.

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CHAPTER VI-2

House Prices and Monetary Policy: A Dynamic Factor Model for Korea

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Abstract

This paper investigates the relative importance of national, regional, and city- specific factors on explaining the movement of housing prices across Korean cities. For this purpose, I employ a dynamic factor model using the Bayesian approach proposed by Otrok and Whiteman (1998) to measure the contribution of each factor. The variance decomposition analysis illustrates that most of the movement of Korean housing prices are ascribed to the national factor which accounts for 56% of housing price variations on average and over 70% in 5 cities including Seoul and Pusan. This demonstrates the existence of the comovement of housing prices in Korean cities, which has been discussed in both academics and real estate industry without providing any solid evidence so far. This paper also finds that the contribution of city-specific factors range from 20% to 70%. However, the regional factors have negligible impacts on housing price fluctuations in all cities.

I also study the effects of monetary policy shocks on national-level housing prices measured by the national factor. For this purpose, I use a structural VAR model to disentangle the structural monetary shocks. Based on this, I conduct a counterfactual exercise which restricts the structural monetary shocks equal to zero after 2003. This experiment finds that the effects of monetary policy shocks on national-level housing prices are trivial. This finding reveals that the hike in housing prices observed in recent periods are mostly likely attributable to macro fundamentals rather than mitigating structural monetary shocks.

I. Introduction

House prices in Korea have been on the constant rise since 2001 due to the expansion of fluctuation and home-backed loans caused by low-interest rate policy, price deregulation, permits for the re-sale of new houses, and temporary exemption on the capital gains tax. The price of apartments in Kangnam (a part of Seoul located south of the Han River) rose more than 40 percent in 2002 compared with the same month a year ago. During the early stage of the Participatory Government, its real estate policy to regulate the reconstruction of apartments had contributed to maintaining stabilized house prices to some degree. However, the government strategy, which includes the creation of new administrative city, innovation cities, and enterprise cities under the umbrella of pursuing a balanced national development, brought severe consequences such as soaring land prices of local areas and weakening of the government's reliability in sustaining the real estate stabilization. In addition, coinciding with the building of new apartments in Pangyo new town, the housing prices reversed its course and began to soar again in the second half of 2005. The prices continued to rise so dramatically that in 2006 there were even widespread debates over a possible real estate price "bubble" in Korea. Entering 2007, helped by the strengthened government regulations on taxation and finances, house prices have shown signs of stabilization again, but a lock-in effect had made the property transactions fall, leading to the overall sluggishness in the housing market.

Looking into the trends in house prices by city, it shows that all the cities have not experienced a sharp rise in prices. According to [Figure 1] showing the average growth rate of Korean house purchase price composite index by city from the first quarter of 2000 to the fourth quarter of 2007, the average growth rate of Seoul and Gyeonggi province recorded 9.8 percent, far higher than that of other cities. But, it shows that the house prices in other cities like Masan, Mokpo, and Sooncheon had dropped as well. This means that factors affecting house prices could be different across areas and cities. In other words, when house price changes are disintegrated by nationwide factors, regional factors, and the city's own factors, the recent steep rise in Korean house prices could be explained mostly by local or specific factors relating to respective cities. Therefore, when analyzing the recent data alone, it is possible that the housing business cycle[1] does not appear to exist in Korea. But, reasoning like this does not hold up in

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1) Generally, business condition means the expansionary and contractionary phenomena that take place in the process of economic activity. The business cycle generally tends to have comovement between auto-correlation and other variables. In this report, housing business cycle refers to the business cycle of housing prices by city.

the long-term time series data.

Among domestic studies regarding housing business cycle, Kim (1992) used the residential building permit as a proxy variable of housing business cycle. He classified elements affecting the housing business cycle of Korea into two variables; a macroeconomic variable, represented by the national income and the aggregate money supply, and a housing policy variable, represented by the regulation on home construction permit. His analysis finds that the house policy variable had more influence than the macroeconomic variable. According to Hur (1991), the changes in house purchase price were significantly affected by housing investment scale, inflation, land price, construction business, and income level, but not by the aggregate money supply. He analyzed that the government's housing policy had the greatest influence on house prices. On the other hand, Lee (1992) used VAR model and analyzed that the changes in house prices were affected by the aggregate money supply in a short-term period and by inflation factors in a long-term period. Tcha (2004) finds that the house prices were insignificantly affected by income.

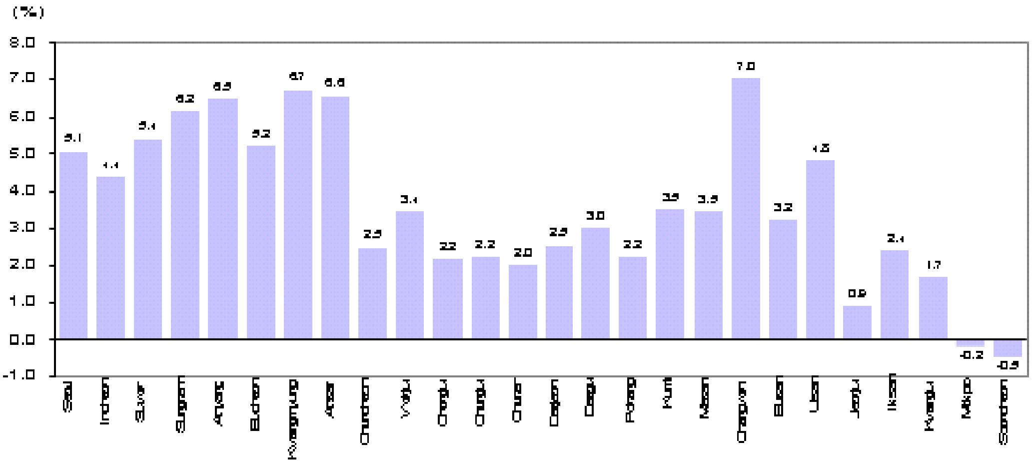
A common feature in most preceding studies is that their analyses use the aggregate indicator relating to houses. This type of method does not take into account the heterogeneity of different areas and cities in the housing market, and only adopts the aggregate indicator of the national total, which would not fully consider heterogeneity and local characteristics in the housing market. A house needs to be considered differently from other assets in that it has expensive searching cost because of its high heterogeneity and that the geographic location is critical to the house price determination due to difficult mobility. Using the aggregate indicator means no consideration was taken on such characteristics, and also when totaling, the hosing indicators are likely to be determined by a few large housing markets in large cities with relatively large proportion. Therefore, it is highly likely that the empirical analysis based on the aggregate indicator will fail to reflect the true condition of the nationwide housing market.

Understanding the housing business cycle is considerably significant not only in setting a model relating to the housing market, but also in establishing government policy. If the sharp rise in house price in certain areas is attributable to the characteristics of the housing market of the area or city itself, justification for the central bank's interest rate policy or the central government's taxation policy in stabilizing the housing market would be hard. This is because the government's policy on the interest rate, finances, and taxation is applied nationwide, which is not enough to control the rise of house prices in certain areas and cities. In order for the government's housing policy to be rationalized and be applied to the whole nation, and not just to certain areas or cities, by applying macroeconomic variables, the house price swings of cities need to have some common features. To put it simply, finding out whether a housing business cycle exists or not is a one way to rationalize the government's macroeconomic policy for a stabilized housing market through interest rates and taxation.

This study conducts an empirical analysis on whether the Korea's housing business cycle by city—which considers the characteristics in local areas—has the comovement and then it attempts to ponder which macroeconomic variable exerts an influence on this comovement. As a way to look into the comovement of the housing business cycle, the analysis disintegrates the factors behind the changes in the house purchase price by city and province into the nationwide, local, and city's own factors. Then, the study adopts a factor model, taking into account the dynamic aspects of these factors and analyzes the each factor contribution in the housing business cycle by city through the impulse response analysis and variance decomposition. In addition, this study, by identifying which macroeconomic variable is good enough to explain a nationwide factor particularly, intends to improve the understanding of its relation with the house price. As mentioned earlier, macroeconomic variables mainly have an impact on the nationwide factors but limited one on local or city factors. Therefore, in order to closely look at the degree of impact of each macroeconomic variable of the policy authority, it would be appropriate to focus on the house price's national factor alone, excluding its regional and city factors. To that end, the study uses the structural VAR and analyzes the effect of monetary policy in dealing with the recent house price swings, which will help to find out what kind of impact was made on the rise in house prices by the monetary policy.

The remainder of the paper is organized as follows. Section 2 lays out the dynamic factor models and the choice of priors used in the Bayesian estimation. Section 3 describes the data set and the empirical results followed by variance decomposition to disentangle the relative importance of the derived factors. Section 4 discusses whether the monetary policy has any bearings on the recent hike in housing prices. Section 5 concludes.

Figure 1. Housing Price Inflation by City



Note: Average House Price Inflation between 2000:Q1 ~2007:Q4.
Source: Kookmin Bank.

II. Model

Let Σ be the variance-covariance matrix of y_t = $[y_{1t}, y_{2t},....y_{Qt}]'$ with the following structure:

$$\Sigma = \Gamma\Gamma' + U$$

where Γ denotes a Q x K $(K<Q)$ matrix and U is a Q x Q diagonal matrix which has positive entries on the diagonal. This structure implies that y_t can be explained by k factors and idiosyncratic noise, i.e.:

$$y_{it} = \beta_{i1} f_{1t} + \ldots + \beta_{iK} f_{Kt} + u_{it}, \qquad i = 1,\ldots,Q, \quad t = 1,\ldots, T$$

$$= \beta_i' f_t + u_{it}$$

Representing in matrix from:

$$y_t = \beta f_t + u_t$$

where β represents a Q x K $(K<Q)$ coefficient or factor loading matrix, f_t imlies a K x 1 stochastic latent factor vector, and u_t is a Q x 1 idiosyncratic noise vector with the following stochastic properties:

$$E(u_t) = 0$$

$$E(f_t u_t') = 0$$

$$E(u_t u_t') = U = diag(\sigma_1^2,\ldots,\sigma_Q^2)$$

Under this setting, the variance-covariance matrix of y_t takes the following form:
$E(y_t y'_t) = \boldsymbol{\beta} \boldsymbol{\Omega} \boldsymbol{\beta}' + U$

where
$\boldsymbol{\beta} \boldsymbol{\Omega} \boldsymbol{\beta}' = T\ T'$

The dynamic factor model is composed of a K -dimensional stochastic latent factors and noises. The factors and noises are generally modeled to be serially correlated to characterize the persistence of the series. The static counterparts of the dynamic factor models usually ignore the serial correlation hence, they are more popular in the cross-sectional analysis. In general, factor models identify latent factors which describe the best statistical properties of the data but they do not explicitly describe the causal relations between variables. Also, the derived factor in itself does not characterize any economic variables. To make any meaning out of the factor, one needs to find economic variables with statistical properties that are close to the factor.

In this study, however, my interest lies more in finding the factor which affects the house price on national level rather than in characterizing the macroeconomic variables. More specifically, this paper decomposes housing prices explained by three factors: national, regional and city. The national factor is the global factor which affects housing prices across the country. The regional factor is the common factor influencing the housing prices in the same administrative region. Finally, the city factor is the unique factor associated with individual cities. Among those factors, the national factor can be considered as the main driving force to generate the comovement of housing business cycle.

Consider the following dynamic factor model:

$$y_{i,t} = \boldsymbol{\alpha}_i + \boldsymbol{\beta}_i^{nation} f_t^{nation} + \boldsymbol{\beta}_i^{region} f_{r,t}^{region} + \varepsilon_{i,t}, \qquad E[\varepsilon_{i,t}\varepsilon_{j,t-w}] = 0, \text{ for } i \neq j \tag{1.1}$$

where i denote the city γ the region, and $\boldsymbol{\alpha}_i$ the average growth rate of house price, which is allowed to differ across cities. One needs to note that the city-specific factors are not modeled explicitly in eq. (1.1) as the city factors are denoted by the error terms implicitly.

Let the evolution of error terms be given by the following auto-regression of order p_i :

$$\varepsilon_t = \phi_{i,1}\varepsilon_{i,t-1} + \phi_{i,2}\varepsilon_{i,t-2} + \dots + \phi_{i,pi}\varepsilon_{i,t-pi} + u_{i,t} \tag{1.2}$$

$$\mathrm{E}[u_{i,t}u_{j,t-s}] = \begin{cases} \sigma_i^2 & \text{if i=j and s= 0} \\ 0 & \text{elsewhere} \end{cases}$$

Notice that the innovations, $u_{i,t}$, are assumed to have zero mean, serially uncorrelated. However, they are allowed to be heteroskedastic. Likewise, the law of motions of the factors are assumed to be governed by auto-regressions of order qk, and their innovations have the same stochastic properties described in the above equation, i.e.:

$$f_{k,t} = \phi_{k,1} f_{k,t-1} + \phi f_{k,2} f_{k,t-2} + \ldots \phi f_{k\text{-}qk} f_{k,t-qk} + u f_{k,}^{\;t} \tag{1.3}$$

$$\mathrm{E}[u_{f_k,t} u_{f_k,t-s}] = \begin{cases} \sigma^2_{f_k} & \text{if s= 0} \\ 0 & \text{elsewhere} \end{cases}$$

where k implies both nation and region accordingly.

Regarding to the identification of the model, one should note that neither the sign nor the size of the latent factors and the factor loadings are separately identified. In the literature, signs are identified by imposing one of the factor loadings to be positive in each factor. I follow this convention and require the factor loadings of each of the factors associated with Seoul metropolitan city to be positive. To fix the scale problem, each σ^2_{fk} is normalized to one.

To estimate the dynamic factor models, most researchers choose one of the following two methods. The first method is the maximum likelihood employing either EM[2] or Kalman filtering applied in Gregory et. al. (1997), Stock and Watson (1992, 1993). The alternative uses Bayesian technique via data augmentation process on the latent factors which are treated as missing data used in Kose, Otrok and Whiteman (2003).

Considering the number of parameters in the model, I employ Bayesian method which is regarded to have comparative advantage in estimating models with a large set of parameters. The dynamic factor analysis can be thought of as a statistical specification of a joint density for the data conditional on a set of parameters and a set of latent factors. The Bayesian method is a sequential process of estimating a certain set of parameters given the rest of parameters or factors. The typical processes of applying the Bayesian method to dynamic factor models are the following. The first step is to estimating the conditional probability density of the parameters given the starting values of factors and data. The second step is to generate a set of factors from the conditional distribution of the parameters and data. Repeating this procedure, it is

2) EM process can be decomposed into two parts. First, given the initial guess of factors, estimate the factor loading to maximize the likelihood function (M-step). Second, given the estimated factor loading from the M-step, derive the factor via Kalman smoothing (E-step). These steps are repeated until the likelihood function is maximized.

possible to generate random samples from the joint posterior distribution for the unknown parameters and factors using a MCMC (Markov Chain Monte Carlo) method.

Detailed procedures to implement the estimation are in order. Given initial values of the parameters and factors, I first sample the posterior distribution of parameters conditional on the factors. Then, the country factors are drawn from the distribution conditional on the parameters and regional factors. Taking the distribution conditional on the parameters, country factors and regional factors are sampled. This completes one step of the Markov chain. It is well known that the joint posterior distribution of the parameters and latent factor from this sequential sampling converges to its limiting distribution under regularity conditions satisfied in the above model.

The prior distributions used in the model are similar to those employed in Kose, Otrok, and Whiteman (2003). The lag orders for the error term and latent variables are set to three. The priors for the factor loadings (β_i^{nation}, β_i^{region}) are $N(0, 1)$ and the priors for the latent factors are $N(0, \Sigma)$, where Σ takes the following form:

$$\Sigma = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0.75 & 0 \\ 0 & 0 & 0.75^2 \end{pmatrix}$$

The variance of house price of each city (σ_i^2) has the inverse gamma distribution of the form $iG(a,b)$, where a = 6, b = 0.01[3] These priors are regarded quite standard in the literature. The total number of parameters to be estimated is 209. α_i, β_i^{nation}, β_i^{region} *and* σ_i^2 should be estimated for 26 cities, 3 autoregressive coefficients for the national factor[4], 3 autoregressive coefficients for the regional factors for 8 regions (3x8=24), and 3 autoregressive coefficients for the error terms for 26 cities (3x26=78). Estimating this size of parameter using the classical statistical techniques is quite a daunting task. However, one can easily do such a task using the appropriate Bayesian technique. To assure the convergence of the posterior distribution, I first derive the posterior distribution after 5,000 repetitions of Monte Carlo sampling. Then, I extend the length of repetitions to 10,000 and compare this posterior with the previous one to see any significant differences between the two. No major differences between these distributions are found after the chain length becomes 50,000, hence the empirical results reported in this paper are based on the sampling size of 50,000.[5]

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3) Relating to Bayesian estimation, it is quite standard to assume that the prior of parameters takes beta distribution when the parameter values are confined between 0 and 1, and gamma or inverse gamma when the parameter values are bigger than 0.

4) To test robustness of the model, I employ different lag orders, 2 and 4, and still find the similar results.

III. Empirical Results

1. Data

The housing price data is collected from the Kookmin Bankwebsite (http:\\est.kbstar.com). Despite the criticism on the bank's data for its construction, it is publicly available and most widely quoted in Korea. The Kookmin Bank, then the Housing Bank, began to collect the house price data of 26 cities in 1986 on a monthly basis. It also publishes House Purchase Price Composite Index (HPCI) based on the collected city-level data. Since September 2003, more cities have been added to the Index totaling around 150 cities. In the empirical work, I convert the data into quarterly frequency to mitigate the volatile feature of original data. Due to the limitation on the length time series, I include only 26 cities. Hence the sample ranges from 1986Q1 to 2007Q4. The data is then transformed into growth rates over a year ago. <Table 1> reports selected statistics for the sample. The average growth of house prices during the sample period records 4.2%. The house prices of Gyeonggi province including Seoul metropolitan city exceed the national average, reflecting that the majority of price hikes in the country are led by this region. In the case of other cities, they are well below the national average except for Changwon and Ulsan. In particular, for Mokpo and Sooncheon, the average house prices have even decreased. In order to examine the comovement of house prices in all cities, simple correlations across the cities are reported in <Table 2>[6]. By reviewing this table, one can witness the correlation between cities within the same region classified by the administrative areas. For example, the correlations between any two cities in Gyeonggi province are higher than 0.7, while most of the correlations between these cities and any other cities outside this region are far below 0.7. One can infer from this finding that the regional factor has a significant influence on explaining the price comovement within the region. However, this may not always be the case when one takes into account the global factor. Suppose all the cities in a certain region are strongly affected by the global factor, then the correlations among those cities become large not because of regional influences but because of the global factor which affects the house prices in a similar manner.

5) For further discussion regarding Bayesian estimation, see Kim and Nelson (1999).
6) To save the space, I report only 15 selected cities.

To clarify the above argument, consider the following factor model:

$$y_i = \alpha_i f_1 + \beta_i f_2 + \gamma_i f_3$$

where f1 impies national factor, f2 regional factor, and f3 city factor. Then the correlation between two cities i, j with the same region can be expressed as follows:

$$\frac{\alpha_i \alpha_j var(f_1) + \beta_i \beta_j var(f_2)}{\sigma_{y_i} \sigma_{y_j}}$$

If the correlation between two cities is explained mainly by $\alpha_i \alpha_j var(f_1)$, regional factors will have a limited power in characterizing the comovement of house prices with the region. One needs to come up with sophisticated tools to disentangle the mixed effects from the national and regional effects. In the following, the growth of house prices is decomposed into three factors: national, regional and city, and relative contributions of each factor on price growth will be discussed in due course.

Table 1. Selected Statistics on House Price Growth in 26 Cities

(YOY, %)

Region(8)	City(26)	Average	Std. Dev	Min	Max
All nation		4.20	7.84	-12.80	20.81
Kyunggi	Seoul	5.07	9.09	-14.23	23.97
	Incheon	4.36	8.60	-12.86	23.82
	Suwon	5.40	11.04	-18.37	33.50
	Sungnam	6.16	11.26	-14.93	29.20
	Anyang	6.47	9.98	-17.78	35.15
	Bucheon	5.20	9.41	-10.74	31.37
	Kwangmyung	6.74	11.68	-14.37	34.37
	Ansan	6.57	12.11	-16.72	44.60
Kwangwon	Chuncheon	2.46	9.41	-16.34	33.21
	Wonju	3.44	9.44	-15.00	31.63
Chungbuk	Chungju	2.18	6.53	-11.57	16.17
	Choongju	2.23	7.12	-14.95	28.56
Chungnam	Chunan	2.00	8.87	-12.35	23.13
	Daejeon	2.54	6.14	-10.42	19.73
Kyungbuk	Daegu	3.01	9.16	-15.35	38.67
	Pohang	2.21	7.89	-9.58	34.60
	Gumi	3.48	9.36	-13.68	33.41
Kyungnam	Masan	3.46	11.35	-12.69	50.26
	Changwon	7.05	11.85	-18.72	55.39
	Busan	3.24	9.42	-13.08	29.93
	Ulsan	4.81	9.69	-15.55	31.98
Jeonbuk	Jeonju	0.91	5.84	-14.34	15.33
	Iksan	2.39	7.64	-8.38	34.78
Jeonnam	Kwangju	1.67	7.58	-15.67	29.85
	Mokpo	-0.16	7.28	-9.49	33.24
	Sooncheon	-0.46	6.90	-13.20	19.28

Note: The sample period is 1987:Q1~2007:Q4.

Source: Kookmin Bank.

Table 2. Correlation among Selected Cities

		All	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	All	1.00															
	A	0.96	1.00														
	B	0.93	0.92	1.00													
	C	0.85	0.89	0.80	1.00												
Gyunggi	D	0.82	0.89	0.79	0.77	1.00											
	E	0.80	0.86	0.78	0.75	0.88	1.00										
	F	0.87	0.93	0.88	0.93	0.81	0.79	1.00									
	G	0.83	0.88	0.83	0.84	0.79	0.71	0.84	1.00								
	H	0.89	0.84	0.91	0.73	0.70	0.76	0.79	0.68	1.00							
Kwangwon	I	0.72	0.61	0.57	0.63	0.50	0.37	0.55	0.66	0.52	1.00						
Chungbuk	J	0.72	0.67	0.67	0.54	0.61	0.51	0.49	0.74	0.51	0.78	1.00					
Chungnam	K	0.69	0.69	0.63	0.69	0.69	0.47	0.65	0.73	0.51	0.58	0.54	1.00				
Kyungbuk	L	0.80	0.66	0.68	0.45	0.51	0.58	0.50	0.44	0.75	0.55	0.57	0.44	1.00			
Kyungnam	M	0.89	0.75	0.77	0.64	0.55	0.51	0.66	0.61	0.80	0.71	0.63	0.60	0.87	1.00		
Jeonbuk	N	0.80	0.67	0.66	0.63	0.55	0.54	0.58	0.54	0.76	0.74	0.58	0.47	0.75	0.81	1.00	
Jeonnam	O	0.73	0.58	0.61	0.47	0.51	0.53	0.41	0.49	0.71	0.72	0.68	0.32	0.74	0.75	0.84	1.00

Note: To save space, we use the following abbreviation: S(Seoul), B(Incheon), C(Suwon), D(Sungnam), E(Anyang), F(Bucheon), G(Kwangmyung), H(Ansan), I(Chuncheon), J(Chungju), K((Deajeon), L(Daegu), M(Busan), N(Jeonju), O(Kwangju).

2. Dynamic Factors

The median and 10th and 90th percentiles of the posterior distribution of the autoregressive coefficients of the national factor are presented in <Table 3>[7]. The median value of the coefficient on the first lag marks 0.87, indicating high persistence of the national factor. [Figure 3] plots the median of the national factor along with the national house sales price composite index. The dotted lines show the 80 percent posterior confidence band.

7) The estimates of factor loadings are presented in Appendix.

One can see that the confidence band gets wider at the peak or trough of the national factor, while the band is quite tight in other periods. This implies that the growth of house prices becomes more volatile around turning points. The national factor seems to track well at both the up-period when the housing prices increase across the nation in 1987~1989, 2001-2002, and 2006, and the down-period in 1992~1993, and 1998.

Table 3. Autoregressive Coefficients on National Factor

$\phi_{f\text{nation},1}$			$\phi_{f\text{nation},2}$			$\phi_{f\text{nation},3}$		
10%	Median	90%	10%	Median	90%	10%	Median	90%
0.75	0.87	0.97	0.14	0.21	0.27	-0.22	-0.18	-0.13

Another feature observed in [Figure 2] is the similar moving patterns of the growth rate of the national house purchase price composite index and the national factor. Given the fact that the national index is the weighted sum of the nationwide, local, and city's own factors, the gaps between these indicators are mostly the ups or downs driven by the local and city's own factors. Based on this figure, the periodical trends in house price changes caused by housing factors can be described as follows. In 1987, due to a series of bullish factors, such as the "three low periods—the low oil price, the low value of the US dollar, and the low interest rate," the increased money supply, and 1988 Seoul Olympic, the house prices across the country had climbed sharply. After 1988, as several regulations and the plan for the supply of 2 million houses during the Roh Administration's kick-off, the house prices driven by the nationwide factor began to fall, but as shown in the case of the overheated subscription for new houses in the five new towns including Bundang and Ilsan in a capital region, the upward trend driven by local or city's own factors had continued, pushing the national house purchase price composite index up to over 13 percent. Later, as the public concept of land ownership[8] was carried out on a full scale, house price dropped rapidly. Considering the movement

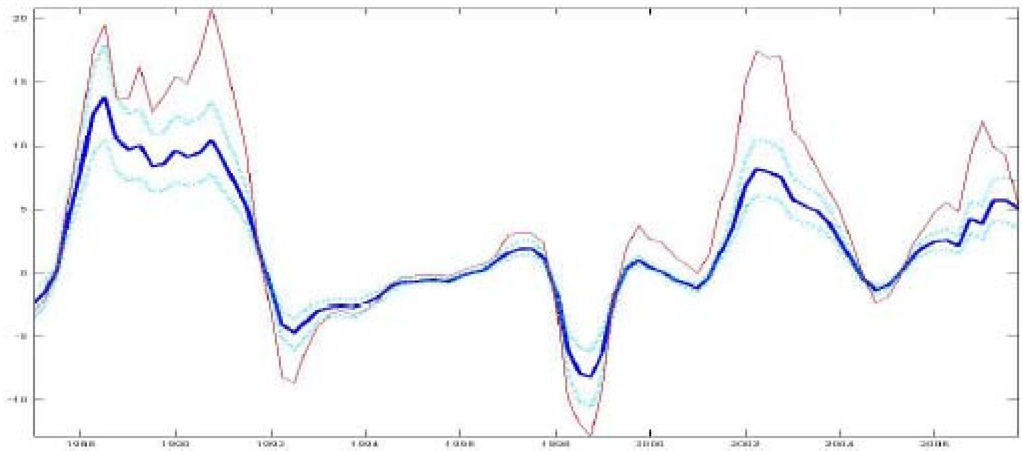
8) Systems related to the public concept of land ownership include the residential land ceiling, the excessively increased valuable land tax, and the contribution system for development. The residential land ceiling was abolished in Dec. 1998, and the excessively increased valuable land tax was also abolished in Dec. 1998, after the Constitution Court ruled it unconstitutional. The contribution system for development was suspended in 2004, but reinstated in 2005 after the 31 August 2005 package was announced.

of the national house purchase price composite index and the nationwide factor, it is assumed that the public concept of land had a nationwide influence. After the Kim Young-sam Administration in 1993, the house prices across the country had continued to stabilize. It seemed that the effect of supply of 2 million houses, in particular, contributed to the downward stabilization of house prices in certain areas. During this period, the gap between the growth rate of house prices driven by a nationwide factor and the national house purchase price composite index in real terms had widened, which seemed because of the expanded explanatory power driven by the local factor of supply of 2 million houses. In 1998, with the launch of Kim Dae-jung Administration, the government encouraged the revitalization of the real estate business as a way to help the Korean economy recover from the financial crisis. Then, the house prices began to recover. A number of policies implemented in the early stage of the Kim Administration include the deregulation of the price ceiling policy, a temporary exemption on the capital gains tax, the elimination of the period limit on re-acquiring the right to buy new apartments offered by the private sector, and the alleviated requirements for rental housing business. These policies served to slow down the downward trend in the house prices, which can be explained by a nationwide factor. The rise in house prices after 2002 led by the reconstruction of apartment complex in Kangnam is largely attributable to the city's own factor rather than by a nationwide factor. This could be presumed from the fact that since 2002 the gap between the growth rate of the national house purchase price index and the nationwide factor has widened. The house prices fell again in 2003, as the new Roh Administration pushed for strengthened real estate regulations, including heavier capital gains tax, the newly launched Comprehensive Property Tax (CPT), and the loan-to-value (LTV) and the debt-to-income (DTI) regulations. However, in 2006, the house prices turned to rise again due to the overheated purchase orders for new houses in new towns including Pangyo and the soaring prices of local lands and the land compensation cost's reflux into the capital region, brought by the plan for creating new administrative city, innovation cities, and enterprise cities. But, the rise of house prices during this period is considered to be driven by bullish factors of certain areas and cities, not by a nationwide factor.

[Figure 3] is made by the growth rates of house prices by the city, nationwide, and local factors. One thing that needs to be pointed out here is that local factors have made almost no contribution to the growth rate of house prices. For instance, with the local factor of province, there are few to explain the rise of house prices in Daegu, Pohang, and Gumi in the northern province of Gyeongsang. This means that since these cities are located far from each other, there is no appreciable mutual effect on the house prices. If a phenomenon like this is observed in one particular area, this could be considered as the characteristics of the house prices in that area. However, given the fact that such trend is observed in all subject areas, it can be analyzed that when it comes to the rise in house prices, its comovement by city within each eight province is insignificant.

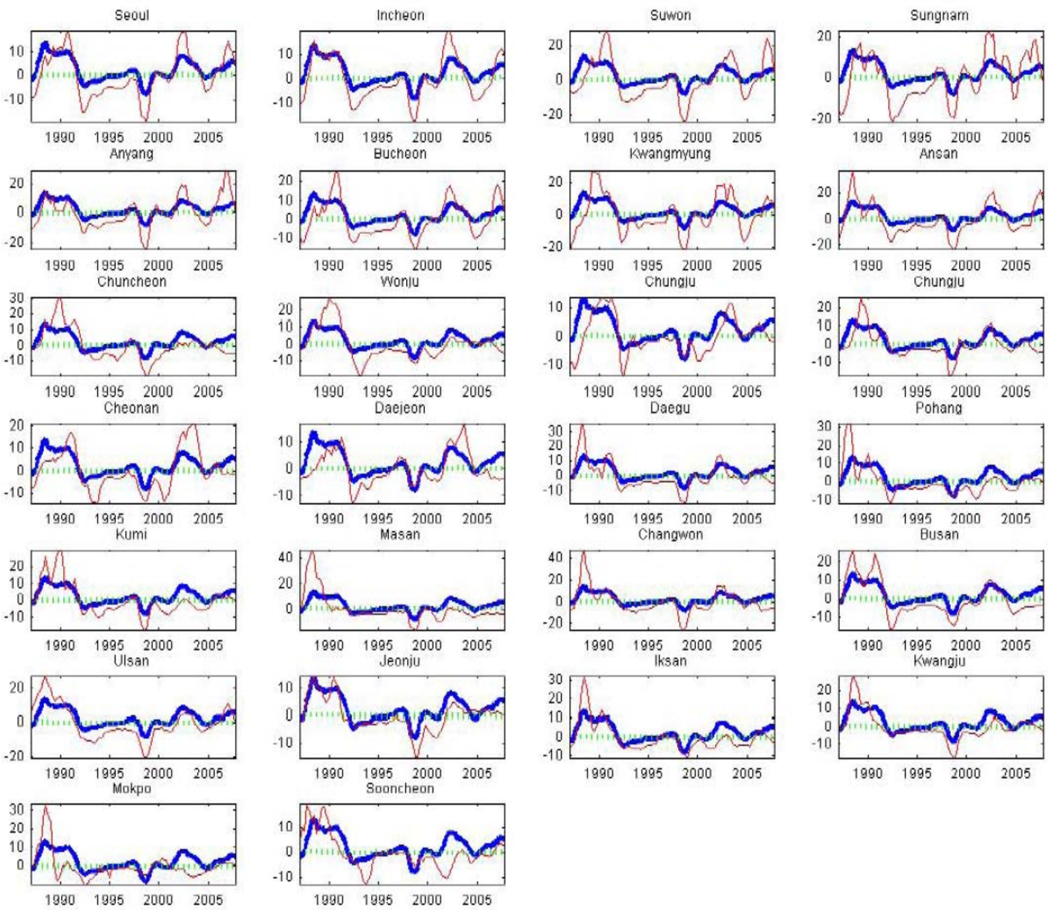
Along with that, [Figure 3] suggests a high possibility that the soaring house prices observed in 2006 was probably a local bubble, not a nationwide one. During the same period, the growth rate of the house price in the cities of Gyeonggi province rose above a nationwide factor, while most other cities showed a similar pattern or fell. This means that the house price rise in cities of Gyeonggi province was largely driven by the city's own factors.

Figure 2. National Factor and Housing Price Composite Index



Note: The bold line indicates the median values of the posterior distribution of the national factor, the dotted lines are 80% of the confidence band and the thin line is the growth rate of housing price of composite index.

Figure 3. National, Regional Factor and Growth of House Price by City



Note: The bold line indicates the national factor, the dotted line is regional factor and the thin line is the growth rate of house price of individual city.

3. Variance Decomposition

To measure the relative contributions of the national, regional and city factors to variations in the growth rate of house price, the shares of the variance of each factor to the house price are estimated. I decompose the variance of house price into the fraction of each factor. With orthogonal factors, the variance of the growth of house price of city i can be decomposed as follows:

$$var(y_{i,t}) = (\beta_i^{nation})^2\, var(f_t^{nation}) + (\beta_i^{region})^2\, var(f_{r,t}^{region}) + var(\varepsilon_{i,t})$$

Then, the variance contributions due to the national and regional factors can be written:

$$\frac{(b_i^k)^2 var(f_t^k)}{var(y_{i,t})}, \qquad k = nation, region$$

and the of variance explained by city specific factors will be defined as:

$$\frac{var(\varepsilon_{i,t})}{var(y_{i,t})}$$

<Table 4> displays the variance shares of each factor in 26 cities. The average median share of the national factor stands at 56 percent, indicating the existence of comovement of housing business cycle in Korea. Especially, the fraction of volatility due to the national factor on Seoul, Incheon, Ansan, Busan and Ulsan is more than 70 percent, accounting for the high correlation observed in [Table 2]. Note that the contribution of the national factor to house prices in Daejeon is relatively small compared to other big cities. Looking at [Figure 3], the house prices of Daejeon tend to be isolated from the national factor in periods after 2003. In particular, house prices of this city increase while the national factor points to decline in 2004. This might be related with the construction of new administrative city under which project a total of 49 government institutions are planned to be relocated near Deajeon area. While the variance shares attributable to the regional factors are minuscule, the contributions from the city specific factors range from 20 to 70 percent. This suggests that housing-related policies of local governments have a significant influence along with those of the central government.

Identifying the sources of changes of house prices is quite important in the following sense. When house price hikes are caused by the policy imposed by the local government, macroeconomic policies by the central government to unwind the course of the house prices will have limited effects. Macroeconomic policy interventions to fend off soaring house prices could be rationalized only when the changes in house prices are nationwide.

Table 4. Variance Decomposition

	National			Regional			City		
	10%	Median	90%	10%	Median	90%	10%	Median	90%
Seoul	0.689	0.715	0.738	0.001	0.002	0.003	0.258	0.281	0.307
Incheon	0.702	0.729	0.748	0.001	0.002	0.003	0.248	0.268	0.294
Suwon	0.535	0.560	0.581	0.002	0.003	0.004	0.413	0.435	0.459
Sungnam	0.504	0.530	0.551	0.002	0.003	0.005	0.443	0.464	0.489
Anyang	0.465	0.488	0.507	0.002	0.003	0.005	0.487	0.506	0.529
Bucheon	0.536	0.563	0.587	0.002	0.003	0.004	0.408	0.431	0.458
Kwangmyung	0.533	0.559	0.580	0.002	0.003	0.004	0.414	0.435	0.460
Ansan	0.705	0.729	0.747	0.001	0.002	0.003	0.249	0.267	0.292
Chuncheon	0.542	0.563	0.579	0.002	0.004	0.006	0.411	0.428	0.448
Wonju	0.608	0.629	0.646	0.002	0.003	0.005	0.346	0.362	0.383
Chungju	0.391	0.411	0.427	0.002	0.004	0.006	0.564	0.581	0.600
Choongju	0.496	0.513	0.526	0.002	0.003	0.005	0.468	0.481	0.497
Cheonan	0.497	0.516	0.532	0.002	0.004	0.006	0.458	0.473	0.492
Deajeon	0.380	0.397	0.411	0.003	0.005	0.007	0.578	0.592	0.608
Daegu	0.613	0.639	0.660	0.001	0.002	0.004	0.335	0.356	0.382
Pohang	0.403	0.426	0.446	0.002	0.004	0.006	0.545	0.565	0.589
Gumi	0.613	0.637	0.656	0.001	0.002	0.004	0.339	0.358	0.381
Ansan	0.364	0.389	0.410	0.003	0.004	0.007	0.578	0.600	0.624
Changwon	0.638	0.661	0.680	0.001	0.002	0.004	0.315	0.334	0.357
Busan	0.744	0.772	0.792	0.001	0.002	0.003	0.204	0.225	0.252
Ulsan	0.669	0.704	0.734	0.001	0.002	0.004	0.261	0.290	0.324
Jeonju	0.669	0.695	0.713	0.002	0.003	0.006	0.277	0.294	0.319
Iksan	0.572	0.596	0.615	0.002	0.004	0.006	0.374	0.393	0.417
Kwangju	0.600	0.624	0.645	0.002	0.003	0.005	0.347	0.367	0.392
Mokpo	0.258	0.275	0.291	0.003	0.006	0.009	0.694	0.711	0.728
Sooncheon	0.300	0.322	0.344	0.003	0.006	0.009	0.639	0.660	0.683

4. National Factor and Macroeconomic Variables

Because the factors are unobservable and extracted based on the statistical relationships to time series I observe, it is hard to describe what the factors are. However, one can rightly conjecture that the national factor should be related with underlying macro variables. In factor models, it is more of a rule rather than an exception to track the seemingly related economic variables with derived factor to characterize the economic contents of the factor. In the same vein, I try to relate a set of underlying macroeconomic variables to the national factor. Simple regressions with different lags are employed to characterize the factors with proper macroeconomic variables. The regression equations are modeled as:

$$f_t^{\text{nation}} = \beta_0 + \beta x_{t-k} + \eta_t, \qquad k = 0, 1, 2$$

where x_t denotes growth rates of monetary bases, interest rates and incomes and k is the lag order of explanatory variables.

<Table 5> presents the regression results. Among monetary bases, M_1 and M_2 have low correlation with the national factor in terms of determination coefficients (R^2). The highest R^2 is 0.08 and the lowest is 0.04 in all lags. However, L_f, measure of total liquidity, has a higher correlation with statistically significant coefficients at a 1% significance level. L_f is the measure of liquidity including deposits from non-bank financial institutions. This finding can be interpreted to mean that a significant portion of construction sectors' financing are channeled through those non-bank financial institutions. Overall, the determination coefficients are relatively smaller than other macroeconomic variables.

Once the interest rates are used, we have a different picture. Among the interest measures, call, CD and 3-year Treasury bond rates have higher correlations with the national factor. The determination coefficients range from 0.08 to 0.40. One can notice that lagged interest rates have higher correlations with the national factor, suggesting national housing prices response to the change in interest rates one or two periods later. The signs of coefficients are negative which is exactly what we expect. What is interesting is that 1-year Treasury bonds have insignificant coefficient and low $R^{2'}$s compared to those of 3-year treasury bonds. As 3-year treasury bonds are the benchmark issues, prices reflect market conditions due to high transactions on these bonds. On the contrary, the market transactions on 1-year Treasury bonds are not frequent and their prices are less affected by underlying macroeconomic situations. Also, the interest rate on corporate bonds with credit rating of AA- turns out almost no correlation with the national factor. This can be understood as the interest rate levied on corporate bonds reflects more of the credit availability of a firm rather than the general economic activities.

The R^2s when a set of income measures are used as regressors are distributed between 0.08 and 0.17. In contrast to the case of interest rates, contemporaneous measures of income show higher R^2 than lagged ones except for the real GDP. This indicates that the contemporaneous relations between nominal GDP and the national factor are convoluted by GDP deflator, suggesting the contemporaneous correlation between general price and the national factor.

Summing up, the growths of house prices explained by the national factor are characterized better by lagged macroeconomic variables than contemporaneous ones. It is widely known that asset prices are regarded as leading indicators. However, it is not the case when the asset is a house. This might be caused by the different nature of housing asset which is not shared by many other assets: high transaction costs, non-divisibility of the asset, minimum holding period to avoid heavy sales taxes, etc.[9]

Table 5. National Factor and Macroeconomic Variables

		Lag (k)					
		0		1		2	
		β_1	R^2	β_1	R^2	β_1	R^2
Money	M_1	0.09*	0.04	0.12**	0.08	0.12**	0.07
	M_2	0.10*	0.04	0.12**	0.05	0.13**	0.06
	L*f*	0.18***	0.10	0.20**	0.12	0.20	0.12
Interest rate	Call	-0.21**	0.08	-0.33***	0.23	-0.43***	0.40
	CD	-0.22**	0.10	-0.33***	0.24	-0.42	0.39
	TB(1 year)	-0.32	0.02	-0.37	0.02	-0.39	0.03
	TB(3 year)	-0.43***	0.19	-0.54***	0.29	-0.61***	0.37
	CB(AA-)	0.08	0.01	-0.03	0.00	-0.11	0.01
Income	GNP	0.30***	0.16	0.27***	0.13	0.22***	0.08
	GNI	0.31***	0.17	0.28***	0.15	0.23***	0.10
	Real GDP	0.37***	0.13	0.43***	0.18	0.42***	0.17

Note: The sample period is 1990:Q1~2007:Q4. *, **, and **** indicate the statistical significance at 10%, 5%, and 1%, respectively.

9) Tax policies have a huge impact on house prices inarguably. But, I omit this line of study for two reasons. First, the national factor is a continuous variable while tax policies are discrete. Second, the timing of the effect of tax policies are obscure. Besides, even within the same policy, minor changes have been made time to time to make it difficult to measure the impact of the original policy.

IV. House Prices and Monetary Policy

Of macroeconomic variables, the fact that the explanatory power of the interest rate indicator is high on a nationwide factor means that the interest rate policy of the central bank which has the right to make decisions on short-term interest rates is closely related to the rate of the house price rise. The central bank's interest rate policy can be divided into two parts: one equivalent to the reaction function that is determined depending on the market condition; and the other equivalent to a pure monetary shock. What brings our attention here is the actual effect that the pure shock, one of the low interest rate policies of the central bank, has made on house prices nationwide. The preceding studies on house prices and the interest rate mostly focused on knowing the relation between the two through regression analysis. However, these analyses have a problem of not properly considering the response function that exists in the interest rate. Besides, since the response function is endogenous, a problem could occur in the econometrics side as well, and the coexistence of endogenous and exogenous functions makes it difficult to accurately analyze the effect of the interest rate policy which is recognized as an external shock.

In this regard, this study uses the structural vector auto-regression model and attempts to identify a pure monetary shock. Based on the identified monetary shock, the study intends to answer the following question:

Question: If there had not been an exogenous monetary shock of the central bank what would have happened to the growth rate of the house prices which are explained by a national factor after the second quarter of 2003? In other words, to what degree does the central bank's exogenous monetary policy had contributed to the rise in house prices represented by a national factor after the second quarter of 2003?

In order to find the answer to this question, a counterfactual historical simulation needs to be conducted. This simulation is carried out by making the central bank's monetary policy determined purely by the endogenous function, after eliminating the structural monetary shock later than the second quarter of 2003. In this case, the difference between the growth rate of house prices by a national factor and the counterfactual historical simulation can be understood as the growth rate of house prices caused by a purely exogenous monetary shock. The reason for using the growth rate of house prices by a national factor instead of the national growth rate of house prices is because the growth rate of house prices driven by the local and city's own factors has no significant relation with the monetary policy since the effect of monetary policy occurs across the nation.

To answer this question, I construct the following 4-variable structural VAR:

$$A(L)\,y_t = u_t$$

where y_t = [real GDP growth, CPI inflation, national factor, Call rate]. To identify monetary shocks, I employ sign restriction methods introduced by Faust (1998), Uhlig (1999), Canova and De Nocolo (2002). In many structural VARs, the identification problems are tackled either by introducing restrictions on covariance matrices or imposing zero restrictions on contemporaneous relations. Under sign restrictions, identification problems are tackled by letting impulse responses restricted to match the stylized facts under a given structural shock. To be concrete, I simulate impulse responses from a multivariate normal random draw based on the covariance of the residuals estimated after Bayesian VAR. Then, I record the draw to be structural when the corresponding impulse responses meet the sign restrictions and discard it otherwise. I repeat this process for 10,000 times to identify technological and monetary shocks.

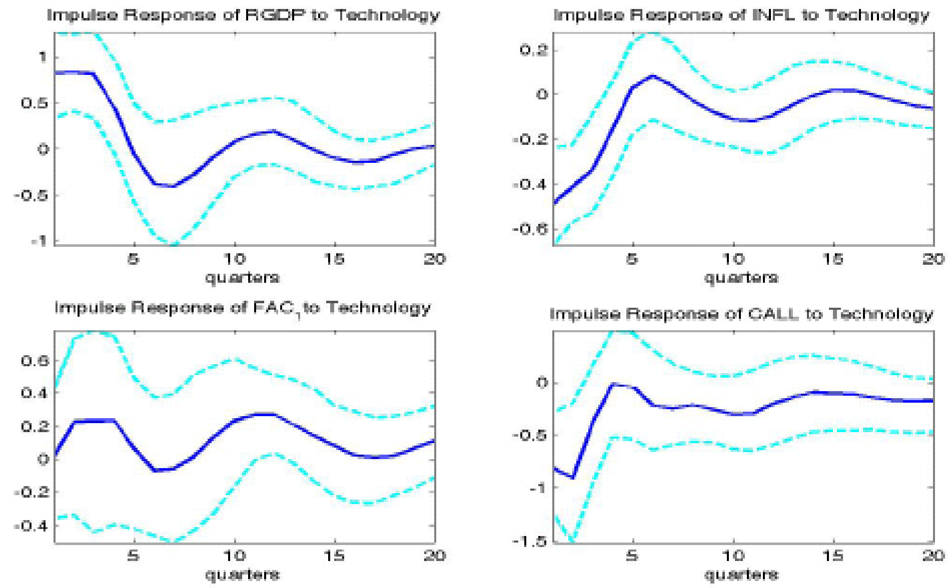
The sign restrictions imposed to identify technological shocks are as follows: real GDP growth should be non-negative and CPI inflation should be non-positive at least after the first 2 quarters after the shock.[10] [Figure 4] exhibits the impulse responses up to 20 quarters after technological shocks. Here, I show the median as well as the 10% and the 90% quintiles for the sample of impulse responses. The technology shock drives up house prices denoted by the national factor for 3 quarters, its impact seems to be limited considering confidence bands, though. Call rate declines after the shock which is consistent with earlier findings.

In order to identify monetary shocks, I impose the following sign restrictions: real GDP growth and CPI inflation should be non-positive at least for 2 quarters after the shock.[11] The impulse responses as well as the 10% and the 90% confidence bands are presented in [Figure 5]. The results show that contractionary monetary shocks affect the house prices explained by the national factor negatively for around 8 periods and lower inflation for about 5 periods. The results are fairly reasonable in that they confirm the stylized facts illustrated in undergraduate textbooks.

10) Regarding the lag structures on sign restrictions, I adopt those used in Uhlig (1999).

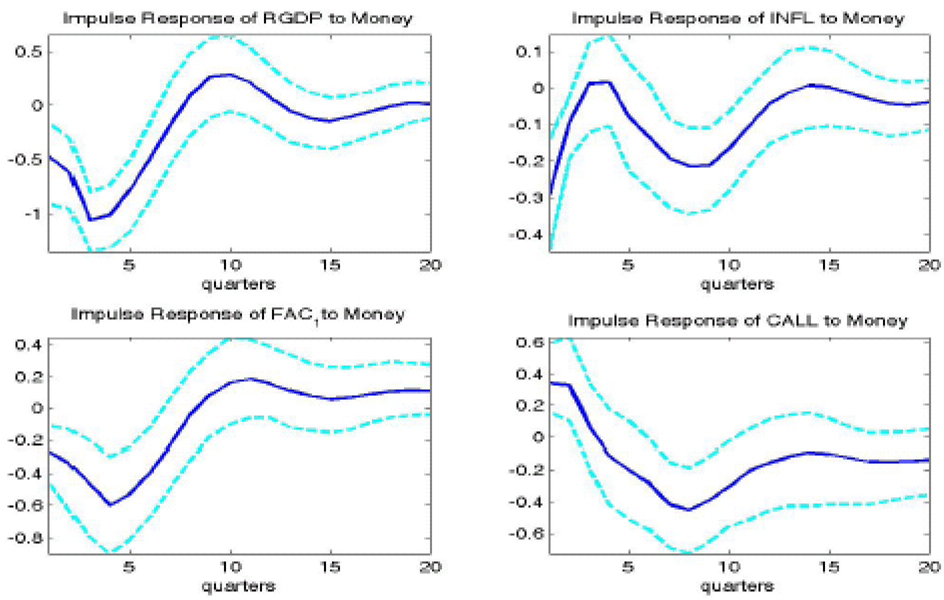
11) These restrictions are considered to avoid price puzzle problems known as perverse in VAR literature. Directed by AIC, the time lag is set to 3.

Figure 4. Impulse Responses to Technology shocks



Note : The dotted lines denote the 10% and the 90% confidence bands.

Figure 5. Impulse Responses to Monetary shocks

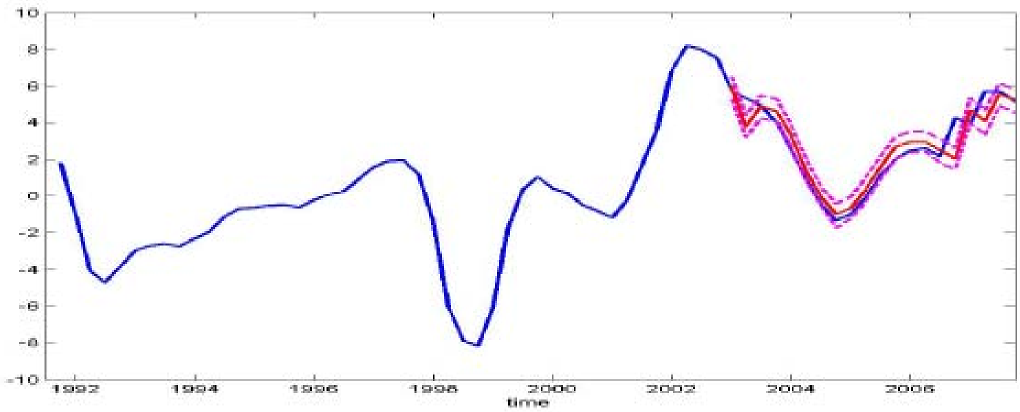


Note : The dotted lines denote the 10% and the 90% confidence bands.

Based on the monetary shocks identified under the sign-restricted VAR, [Figure 6] presents the results of a historical counterfactual exercise to answer the question laid out at the beginning of this section. According to results, the house prices would have lowered by around 1 percentage point during 2003:Q2~2003:Q3, had there not been an exogenous monetary shock of the monetary authority. Afterwards, its impact on house prices becomes weak until the mid 2006. During this period, the house prices under the counterfactual experiment moves almost in tandem with the historical prices, suggesting monetary policy shocks have little contribution on the house prices.

As the house prices rebounded at the end of 2005, the monetary authority became more contractionary and started to raise benchmark interest rates, rendering the actual prices move below the counterfactual prices. Despite the continued contractionary policy of the central bank, its impacts are contrary to what we expect under purely exogenous monetary policy shocks after the second half of 2006. If the contractionary monetary policy shocks had been exogenous apart from the feedback from the underlying economic conditions, the actual prices should have been below the counterfactual prices. This finding gives a weak footing on the argument that the monetary tightening observed after 2006 is purely exogenous. Rather, it seems to be more reasonable to claim that the contractionary policy in this period is based on its feedback rule of the central bank, i.e. endogenous responses to the underlying macroeconomic fundamentals such as CPI inflation, real estate taxes, and real GDP, etc. Rounding up, the counterfactual experiment reveals that the tightening of the monetary policy witnessed since 2006 is the result of accommodating the economic status rather than purely exogenous monetary shocks.

Figure 6. Actual and Counterfactual House Prices Induced by the National Factor



Note : The dotted lines indicate the 10% and the 90% confidence intervals.

V. Conclusion

Of the national wealth, the proportion of the real estate such as houses is significantly larger than that of stocks, bonds, or foreign reserves. In particular, the house price has potentially much higher ripple effect than general macroeconomic policy since it directly exerts an influence on the resource allocation within the national economy and people's quality of life through the residential service. In this regard, looking into which macroeconomic variable brings the most significant impact on the determination of house prices, and making efforts to identify whether the changes in house prices are local phenomenon or nationwide are of great importance in terms of establishing a real estate-related model or policy stance.

This paper investigates the relative importance of national, regional, and city- specific factors on explaining the movement of housing prices across Korean cities. For this purpose, I employ a dynamic factor model using a Bayesian approach to measure the contributions of each factor. The variance decomposition analysis illustrates that most of the movement of Korean housing prices are ascribed to the national factor which accounts for 56% of housing price variations on average and over 70% in 5 cities including Seoul and Pusan. This demonstrates the existence of comovement of housing prices in Korean cities, which has been discussed in both academics and real estate industry without providing any solid evidence so far. This paper also finds that the contribution of city-specific factors ranges from 20% to 70%. However, the regional factors have negligible impacts on housing price fluctuations in all cities.

The analysis on specifically which economic variable affects the nationwide factor out of latent factors deducted from a dynamic factor model shows that the interest rate and the incomes are closely related. Lastly, according to a counterfactual historical simulation on the effect of the low interest rate since 2003 on the house price, which uses the structural VAR, it is found that the exogenous monetary shock in the late 2003 affected the rise in house prices, but later until the late 2005 the monetary shock had not made a notable impact on house prices. In particular, it is found that the high interest rate situation after 2006 was driven more by the response function of the interest rate determined based on the economic status at that time than by the central bank's exogenous monetary tightening policy. Therefore, it is concluded that the changes in house prices at that time were more affected by other macroeconomic variables, such as CPI inflation, real estate taxation, and real GDP than by exogenous monetary shocks.

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Appendix Estimation Results of Dynamic Factor Model

Model: $y_{i,t} = \alpha_i + \beta_i^{nation} f_t^{nation} + \beta_i^{region} f_{r,t}^{region} + \varepsilon_{i,t}$

	α_i			β_i^{nation}			β_i^{region}		
	10%	Median	90%	10%	Median	90%	10%	Median	90%
Seoul	0.41	0.65	0.89	0.48	0.60	0.73	0.03	0.04	0.05
Incheon	0.57	0.81	1.04	0.30	0.38	0.46	-0.01	0.00	0.02
Suwon	0.38	0.63	0.89	0.16	0.26	0.37	-0.01	0.00	0.02
Sungnam	0.22	0.46	0.72	0.53	0.67	0.80	-0.02	0.01	0.04
Anyang	0.42	0.68	0.94	0.56	0.70	0.85	-0.02	0.01	0.04
Bucheon	0.52	0.75	0.99	0.36	0.45	0.55	-0.01	0.01	0.02
Kwangmyung	0.35	0.60	0.85	0.56	0.69	0.83	-0.02	0.01	0.04
Ansan	0.39	0.65	0.90	0.58	0.73	0.89	-0.02	0.01	0.03
Chuncheon	-0.12	0.12	0.36	0.24	0.29	0.36	-0.02	0.01	0.04
Wonju	0.07	0.32	0.56	0.22	0.27	0.33	-0.03	0.01	0.06
Chungju	0.23	0.44	0.65	0.11	0.15	0.19	-0.02	0.00	0.04
Choongju	0.11	0.32	0.52	0.36	0.44	0.53	-0.04	0.01	0.07
Cheonan	-0.02	0.22	0.45	0.18	0.23	0.29	0.00	0.00	0.01
Deajeon	0.22	0.44	0.67	0.23	0.29	0.36	0.00	0.00	0.02
Daegu	0.15	0.38	0.61	0.40	0.49	0.58	-0.03	0.01	0.05
Pohang	0.14	0.36	0.58	0.20	0.25	0.31	-0.02	0.01	0.04
Gumi	0.06	0.28	0.52	0.40	0.50	0.60	-0.06	0.01	0.08
Masan	-0.07	0.16	0.42	0.41	0.50	0.61	-0.03	0.01	0.05
Changwon	0.44	0.69	0.93	0.67	0.83	0.99	-0.05	0.02	0.09
Busan	0.06	0.29	0.52	0.36	0.45	0.54	-0.02	0.01	0.04
Ulsan	0.06	0.29	0.53	0.10	0.15	0.21	-0.03	0.00	0.03
Jeonju	-0.19	0.02	0.22	0.15	0.19	0.23	-0.02	0.02	0.08
Iksan	0.20	0.41	0.63	0.15	0.20	0.25	-0.04	0.02	0.08
Kwangju	-0.07	0.14	0.36	0.15	0.19	0.24	-0.03	0.01	0.06
Mokpo	-0.51	-0.29	-0.08	0.17	0.23	0.29	-0.04	0.02	0.09
Soonchеon	-0.42	-0.19	0.03	0.14	0.19	0.24	-0.05	0.02	0.09

Comments on "House Prices and Monetary Policy: A Dynamic Factor Model for Korea"

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In the first part of the paper, the author attempt to decompose the housing price index into national, regional, and city-specific factors to find that most of the fluctuations in housing price is ascribed to the national factor. Then the author find that the estimated national factor is strongly correlated with current and lagged macroeconomic variables such as monetary aggregates, interest rates, and income variables. In the second part of the paper, the author conduct a counterfactual simulation exercise in which the estimated monetary policy shocks from a structural VAR model are restricted to be zero. The results show that the monetary surprise have only trivial effects on national factor of housing price.

Overall, I believe that the author addresses an interesting and important issue regarding housing price and monetary policy. Nevertheless, as the title of the paper suggests, the author needs to focus more on the second part of the paper. Readers may expect more detailed discussion on the implication of monetary policy actions on housing price fluctuations. It seems to me that the first part of the paper is essentially a preparatory stage for the analysis in the second part. Here are some specific comments.

1. It is possible that not only the national factor but also regional and/or city-specific factor is correlated with macro variable. To confirm the validity of the national factor in the analysis of the second part of the paper, the author may want to see whether the regional and city-specific factor are also correlated macro variables.

2. In fact, to estimate the monetary policy shocks in structural VAR model, the composite index of housing price itself is more appropriate because 1) national factor is not observable to policy-makers implying that it is not in the information set of policy-makers, and 2) the national factor is subject to estimation error. I believe

replacing national factor with the composite index would not change the results qualitatively.

3. Table 5 shows that interest rate seems to be the most important determinant of housing prices, suggesting that anticipated change in interest rate (or monetary policy stance) is important to explain housing price fluctuations. In fact, a simple deterministic model can predict that (anticipated) low interest rate can raise housing price. Thus, the author needs to discuss the effects of anticipated and unanticipated changes in interest rates when discussing counterfactual simulation results.