KDI Journal of Economic Policy 2021, 43(4):45–67
http://dx.doi.org/10.23895/kdijep.2021.43.4.45

Social Welfare Analysis of Policy-based Finance with Support for Corporate Loan Interest†

By CHANGWOO NAM*

We analyze the social welfare effect when a policy-based financial system (PFS) enters a decentralized financial market. Particularly, the PFS in this case supports the interest spread for corporate loans held by firms with heterogeneous bankruptcy decisions under an imperfect information structure. Although support for capital costs through the PFS expands the economy consistently, the optimal level of PFS out of the corporate loan market is estimated to be 8.6% by a simulation model considering social welfare adjusted by the disutility of labor. This result is much lower than the recent level of PFS in the Korean financial sector.

Key Word: Social Welfare, Policy-based Finance, Default Decision, Firm Dynamics
JEL Code: E22, G32, G33

I. Introduction

Why does the Korean government want to maintain a very large policy-based finance sector? In the 1960s and 70s, when the market was not well formed, the efficient allocation of limited resources was very important. Accordingly, the government would have a role in directly intervening in the market. The Korean financial industry underwent a major restructuring after the 1997 financial crisis and thus inefficient financial companies had been winnowed out and ousted such that the financial market, mainly composed of large banks, developed more readily, especially under the control of financial holding companies. However, large-scale policy-based institutions such as the Korea Development Bank, the Export-Import Bank of Korea and the Industrial Bank of Korea (hereafter KDB, KEXIM, and IBK) still play a large role in the Korean financial market. In particular, the guarantee insurance market, including the market for credit guarantees, has not yet been opened to third parties. In this situation, KDB and KEXIM have failed to promote the restructuring of insolvent companies properly. Recently, public opinion holds that the policy-based financial system should be greatly improved to achieve financial

* Fellow, Korea Development Institute (E-mail: cnam@kdi.re.kr)
* Received: 2021. 10. 12
* Referee Process Started: 2021. 10. 15
* Referee Reports Completed: 2021. 11. 18

efficiency and for better financial market development.

However, in order for public opinion to be reflected in the financial policy, it should be verified that the current size of policy-based finance in the Korean financial sector is excessive via rigorous economic logic. From this point of view, the subject of this paper is clear. In other words, this paper analyzes how social welfare arises and what the optimal size of policy-based finance should be in the financial sector when policy-based financial institutions that support firms by supporting loan interest enter the financial sector. In particular, this paper develops a general equilibrium model. First, firms are heterogeneous because they undergo idiosyncratic shocks individually. Second, commercial banks and policy-based banks (government-owned banks) do not fully observe these heterogeneous characteristics of firms. In other words, this paper basically assumes that the financial market operates as an imperfect information system when lending to firms. In this model, firms also decide whether or not to continue operating, that is, whether or not to default, depending on their heterogeneity.[1] Finally, the analysis of social welfare does not aim to expand unconditionally the economy because the increase in the labor demand of firms by financial support is reflected in social welfare.

To summarize the results of the analysis, the level of policy-based finance that optimizes social welfare through a simulation is found to be 8.6 percent of the financial sector. This figure is much lower than the 34.4 percent average in the Korean financial market over the past three years. Furthermore, noting not only that policy-based finance is more likely to encounter moral hazard than private finance but also that policy-based finance is less efficient, it can be seen that the policy-based finance scheme implemented by the government in the Korean financial market is overabundant.

This paper is organized as follows. Section 2 explains the current state of policy-based finance in Korea, and Section 3 explains the theoretical background and how we designed the model in this paper. Section 4 explains the methodology and parameters needed for the simulation based on the theoretical model, and Section 5 explores the results of the social welfare analysis. Finally, Section 6 concludes the paper.

II. Policy-based Finance in the Korean Financial Market

In Korean policy-based finance, KDB, KEXIM, and IBK are the major financial institutions that provide financial support to firms, such as corporate loans and export credits, among other types, apart from public credit guarantee funds. These organizations were established under the "Korea Development Bank Act" of 1954, the "Export-Import Bank of Korea Act" of 1976, and the "Industrial Bank of Korea Act" of 1961, respectively. KDB and KEXIM are 100% owned by the Korean government and IBK is a listed company, but more than half of its shares are owned by the government. Accordingly, the Korean government always implements financial support for corporations through these institutions.

[1]In general, 'default' is a specific event in which a debtor refuses to make a payment, and 'bankruptcy' is a legal process by which a debtor cleans up his debts. However, this paper uses both default and bankruptcy in the same sense as an event and process.

TABLE 1—LIABILITIES AND CORPORATE LOANS OF POLICY-BASED FINANCIAL INSTITUTIONS AND THE COMMERCIAL BANKING SECTOR IN 2020

(Unit: KRW Trill.)

	KDB	KEXIM	IBK	Commercial Banks
Total Liabilities	221.4	83.1	311.3	1,779.1
Deposits	46.0	0	136.7	1,434.9
Borrowings	158.7	78.7	159.5	209.3
Debentures	139.8	72.6	90.1	118.7
Others	16.6	4.4	15.0	1347
Corporate loans (for all currencies)	151.5	71.9	195.6	624.9
LEs (except foreign currency)	71.7	17.3	6.4	75.6
SMEs (except foreign currency)	25.8	6.3	186.0	507.7

Note: This table lists the liabilities accounts and corporate loans of KDB, KEXIM, IBK and the commercial banking sector in 2020.
Source: Financial Statistics Information System (http://fisis.fss.or.kr).

Unlike commercial banks, these institutions raise funds mainly through borrowing, such as issuing bonds, rather than through deposits. For example, Table 1 shows the liabilities and corporate loans of policy-based financial institutions (hereafter PFIs) and commercial banks. Financing through borrowing for commercial banks accounts for only 11.9 percent of their total liabilities but is 64.5 percent for PFIs. In particular, PFIs issued 2.5 times the bank debentures issued by commercial banks on balance, which is possible because PFIs are guaranteed by the Korean government. Finally, most of the funds of PFIs through borrowing other than deposits are provided for corporate loans. In the table, the total corporate loans of commercial banks, including those denominated in a foreign currency, amount to 625 trillion won, while the total corporate loans of PFIs amount to 419 trillion won, which corresponds to 67.5 percent of the corporate loans of commercial banks. In fact, corporate loans from PFIs include loans to support export credit. Even when considering won-denominated loans, corporate loans for large enterprises (LEs) of PFIs are considerable, accounting for 126.2 percent of commercial banks' lending to LEs. However, the loans provided by PFIs to small and medium-sized enterprises (SMEs) amount to 42.4 percent of commercial banks' SME loans, which is relatively low compared to the level of corporate loans to LEs. As a result, it is suggested that PFIs must focus more on supporting SMEs rather than LEs. In addition, as corporate loans of PFIs account for 40.1 percent of all corporate loans, the role of PFIs is critical in the Korean financial market.[2]

III. Theoretical Model

Most macroeconomic models in which there is financial friction are divided into two categories. First, there are macroeconomic models that mainly examine

[2]We only could confirm that the French PFI, Bpifrance's corporate loans, accounted for an average of 9.8% of total corporate loans for two years (2018, 2019) (Source: Bloomberg, BankFocus). Although it is difficult to generalize from only French data, it shows that at least the share of PFS in Korea is considerably higher than that in France.

problems associated with consumer financial instruments, such as mortgage loans. On the other side, there are macroeconomic models based on dynamic decision-making models of firm dealing with corporate investments, dividends, and financing. In addition, these corporate financing models are divided into models dealing with equity financing and models dealing with debt financing.

The model in this paper not only focuses on debt financing during dynamic decision making by firms but also assumes that the financial industry in the model has an incomplete information system, i.e., information asymmetry. This means that individual firms should have heterogeneous characteristics, not homogeneous. Inefficiency due to information asymmetry in corporate loan markets has long been discussed. As an example, Stiglitz and Weiss (1981) explain that credit rationing may exist due to information asymmetry in corporate lending. In particular, they show that in a lending market where there is only a single collateral ratio, adverse selection occurs because the lender does not properly observe the risks of the projects, meaning that only risky projects remain in the market as loan interest rates increase. However, the model they develop is a partial equilibrium model, and they do not explain how consumers and governments move in their model. In addition, the loan contract in Stiglitz and Weiss (1981) is a one-shot game and not a repeat game.

In contrast, the firms in our model have repeatedly made corporate decisions under information asymmetry. In fact, since Stiglitz and Weiss (1981), there has been much debate as to whether credit rationing exists in the corporate lending and loan market, but model development based on their information asymmetry has been rare as a general equilibrium model in which consumers, banks and government exist at the same time. Corbae and D'Erasmo (2017) started to analyze social welfare in relation to corporate bankruptcy and restructuring in the general equilibrium model. However, their financial market does not contain asymmetric information because their banks fully observe the firm heterogeneity and offer individual interest rates on loans. Also, they do not consider the disutility of labor in the household problem. On the other hand, there are other general equilibrium models that analyze the relationship between consumers and banks due to information asymmetry in the consumer finance market. In particular, this paper refers to work by Chatterjee, Corbae, Nakajima, and Rios-Rull (2007) as well as Athreya, Tam, and Young (2012) to analyze information asymmetry in the corporate lending and loan market methodologically.

In the economy, corporate decision making is much more complex than consumer decision making. First, firms should optimize certain factors of production, such as capital and labor, considering the investment opportunity cost. Then, the output is determined by the equilibrium price in the market, and the wage for labor is also determined. From a financial point of view, a firm should choose the optimal allocation according to the operating situation when investing and allocating net profits and should choose to procure scarce capital using direct financing or indirect financing. Because firms' decisions about investments, dividends and corporate financing are related to future investment opportunities and cash flows, they are mainly based on a dynamic decision model using the Bellman equation. In general, the literature on dynamic decision making by firms is diverse, but this study is based on work by Zhang (2005); Clementi and Hopenhayn (2006); Cooper (2006); Li, Livdan, and Zhang (2009); Livdan, Sapriza, and Zhang (2009); and Nikolov and

Whited (2014). These studies basically design the firm's decision making as a dynamic model and analyze how this model is influenced by the uncertainty of each firm. They also analyze the impact of these corporate decisions on dividends, investments and stock prices. In particular, Clementi and Hopenhayn (2006) explain firm dynamics using dynamic contract theory under information asymmetry. However, they do not consider invariant firm distributions in the equilibrium model, although firms seek optimal contract terms that entice them into long-term lending contracts.

Our paper makes the following academic contributions. First, by explicitly applying information asymmetry in the dynamic corporate loan market, it creates an economy in which credit rationing is likely to exist. Second, as there is a possibility that a firm may default on a loan, the default value of a firm is determined endogenously in our paper. Third, as a key contribution of our paper, the government's tax policy induces PFS into the economy to provide low-interest financing to firms. Finally, the social welfare effect of PFS is ultimately analyzed by applying labor disutility to the model so that an excessive labor supply due to corporate support can have a negative effect on social welfare. In particular, our study essentially utilizes the economic structure of Hopenhayn (1992). In addition, as in Arellano, Bai, and Zhang (2012), firms fund their capital through bank loans and make decisions about defaults that determine their entry or exit in the market. Although they calculate exogenously the insolvent value of a firm when calculating the invariant firm distribution, in our model, the entry rate is internalized according to the corporate default and liquidation rate. In particular, one of the main features of our model is that the insolvent value of a firm is determined endogenously.

A. *Operating Firms and Technology*

We assume a perfectly competitive market for one homogeneous good that can be used by a representative household or used as capital by all firms that produce only this good. The production function of all firms has a decreasing return to scale, as follows:

$$y = e^x k^\alpha n^\gamma, \quad \alpha + \gamma < 1,$$

in which x is an idiosyncratic productivity shock, i.i.d. across firms, that follows a first-order Markov process with transition matrix $p(x' \mid x)$ that is common knowledge in this economy; $k \in \mathbb{R}^+$ is the capital input, and $n \in (0,1)$ is the labor input. In particular,

$$k \equiv 1 + b,$$

in which 1 represents normalized equity because in our model, there is no stock market, and all firms are assumed to be owned by one household with equity of 1. $b \in \mathcal{B} \equiv [0, \bar{b}]$, where b is the capital borrowed from a bank.

The operating profit is defined as

$$\pi(b,x) = e^x k^\alpha n^\gamma - wn,$$

in which $w \in \mathbb{R}^+$ denotes the real wage, which is determined competitively. The operating profit by finding the optimal labor input is derived as

$$\pi^*(b,x) = a^* e^x k^\theta,$$

in which $\theta = \alpha / (1-\gamma) < 1$ and $a^* = \left(\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}} \right) w^{\frac{\gamma}{\gamma-1}}$.[3]

B. *Firm's Recursive Problem*

The current value of a firm that was operating normally in the past is as follows:

$$\begin{aligned} V(b,x,0) &= \max_{f \in \{0,1\}} V_f(b,x,0) \\ &= \max \begin{Bmatrix} V_0(b,x,0) \equiv \max_{b' \in B} d + \mathcal{M}\mathbb{E}[V(b',x',0) \mid x] \\ V_1(b,x,0) \equiv \nu b + \mathcal{M}\mathbb{E}[V(0,x',1)] \end{Bmatrix} \end{aligned} \tag{1}$$

in which $V_0(b,x,0)$ denotes the value by which the firm decides to operate normally as of the present, and d is the dividend to the owner. $\mathcal{M}$ is the stochastic discount rate indicating the owner's intertemporal preference. b' is the amount of the new loan contract with a bank, and x' is the idiosyncratic shock in the next period. In the last column, 0 means that there is no history of default.

The dividend is structured as follows:

$$\begin{aligned} d &= \pi^* - i - q_b b + (b' - b) - \Phi(i,k) \\ &= \pi^* - \Phi(i,k) - q_b b - \delta k, \end{aligned}$$

in which i denotes an investment for which the corresponding law of motion is expressed as $i = k' - (1-\delta)k$; k' is the capital installed in the next period, and δ is depreciation rate for the installed capital. q_b is the loan interest rate for b contracted in the last period. $\Phi(i,k)$ is a function of the capital adjustment cost:

$$\Phi(i,k) = \frac{(\phi^+ 1_{\{i \geq 0\}} + \phi^- \phi^+ 1_{\{i<0\}})}{2} \left(\frac{i}{k} - \delta \right)^2 k,$$

[3]See the appendix.

in which ϕ^{+} is the adjustment parameter for a positive investment and ϕ^{-} is the scale parameter for a negative investment, referring to a case in which the firm sells capital. It is assumed that $\phi^{-} > 1$ because in general, an investment in capital is irreversible, implying that firms should pay more when they sell capital compared to when they buy capital (Zhang, 2005). This investment irreversibility increases the likelihood of a firm's default when a firm experiences a very negative shock to production or management.

$V_1(b,x,0)$ is the value when a firm decides to default on the payment of principal and interest to a lender. In particular, if the firm decides to default, the operating profit of the relevant period π^* is paid to the bank (whereas the wages for labor are paid previously), with the bankrupt firm's installed capital bought by the bank at the price of νb. In this case, νb can be interpreted as the liquidation value of the debt, and ν is the liquidation rate for the debt. This process of default and liquidation takes place at the end of the period. In addition, the bank disposes of the installed capital purchased from the bankrupt debtor.

Meanwhile, this capital structure is basically composed such that the size of the loan affects the corporate default and productivity. This is a system for determining the scale of production and the labor supply of the entire economy. In other words, in the capital structure of existing firm decision models, profit induces investments and loans are used as working capital. However, in our model, in the absence of an equity market, loans are used as facility investment funds rather than as working capital. Instead, the profit increases the incentive to be distributed to households as a dividend. This only changes the order in which profit and external funds are distributed to investments and dividends and does not lower the firm value, as the firm value is the present value of the dividends that will be received in the future. In addition, there is no possibility of excessive leverage because the mean and dispersion of investments and the debt ratio are fitted through a simulation.

The value of a firm that liquidates its debt in the last period but has a history of default is as follows:

$$V(0,x,1) = 0 + \mathcal{M}(\xi\mathbb{E}[V(0,x,0)] + (1-\xi)\mathbb{E}[V(0,x',1)\,|\,x]), \tag{2}$$

in which the bankrupt firm's cash flow is naturally zero, and $\mathbb{E}[V(0,x,0)]$ is the entry value of a firm that finally closes down an old project, clearing the history of default and starting a new project. ξ is the closure rate of bankrupt businesses. Finally, the liquidation value for exiting the market is determined endogenously by the entry value into the market again. In addition, firms with new businesses start with zero debt.

C. *Commercial Banking System*

The commercial banking sector is assumed to be a perfectly competitive market with no entry costs. However, taking into account the difference between risk levels in the deposit market and the loan market, the lower limit of the return on the loan market is set as follows:

$$\int_b r_b b\mu(db) - q\int_b b\mu(db) \geq S = \sigma q\int_b b\mu(db),$$

in which r_b is the expected return on b; q is the deposit interest rate and μ is the firm distribution based on beliefs pertaining to the loan market formed by banks through repeated loan contracts with firms. S is the minimum cash flow buffer that the bank must hold, and σ is the minimum buffer ratio. Strictly speaking, this ratio should be applied to risk-weighted assets in terms of the capital ratio, but it is assumed to be a ratio relative to the deposit income for convenience of the calculation.

Given the belief distribution and σ, the return condition for loan products in a perfectly competitive market is as follows:

$$r_b = M^{-1}(q_b)\mu(f=0\,|\,b) + \int_x \left[\frac{\pi}{b} - \nu\right]\mu(f=1,\ dx\,|\,b) = (1+\sigma)q,$$

and we derive the equation for the loan interest rate of b via

$$q_b = M\left[\frac{(1+\sigma)q - \int_x \left[\frac{\pi}{b} - \nu\right]\mu(f=1,\, dx\,|\,b)}{\mu(f=0\,|\,b)}\right] \geq (1+\sigma)q, \tag{3}$$

in which $M[\cdot]$ is a technical function smoothing loan interest rates within similar loan sizes, bs.

The last important assumption in the financial sector is that banks fail to observe firms' idiosyncratic shocks at every time, but when the loan is renewed, only the size of the loan creates a belief about the default probability. Therefore, even if the loan contract is renewed repeatedly, information about defaults held by banks is not updated. In addition, this belief is common knowledge in this economy.

D. *Household Problem without Policy-based Finance*

There is one representative household with a utility function with the unitary Frisch elasticity of labor supply such that

$$U(C,N) = \ln(C) - \frac{\lambda N^2}{2}$$

in which N denotes the aggregate labor such that the labor of a household is perfectly divisible and the household has the following budget constraint,

$$C + B' = D + wN + (1+q)B, \tag{4}$$

in which D, B, and B' are the aggregate dividends and aggregate deposits in the current and subsequent period, respectively.

Therefore, the household problem is as follows:

$$W(C,N) = \max_{B',N} U(C,N) + \beta W(C',N'). \tag{5}$$

From the above equation, we simply derive the first-order conditions as

$$\frac{U_1(C,N)}{U_1(C',N')} = \frac{C'}{C} = \beta(1+q) \ \ and \ \ \frac{U_2(C,N)}{U_1(C,N)} = \lambda CN = w, \tag{6}$$

and $\mathcal{M}\frac{\beta C}{C'}$ and $\beta = 1/(1+q)$ under steady=state equilibrium.

E. *Policy-based Financial System*

Thus far, we have explained the banking industry, which has no government intervention. However, we assume that PFIs enter into the banking industry as facilitated by the government because the government has an incentive to boost the economy through financial support. In particular, in this study, PFIs provide firms with loans with lower interest rates than those in the decentralized market, and commercial banks also offer loans with low interest rates according to the principle of a perfectly competitive market. Commercial banks and PFIs are then supported by the government and are subject to the following budget formula:

$$\int_b r_b b\mu(db) + T - q\int_b b\mu(db) = S \geq \sigma q \int_b b\mu(db),$$

in which T is the tax collected from the household.

There are two ways to support loan interest for corporate loans. Lenders support the loan interest rate in a proportional manner with an identical interest spread for all loans. The method of determining the interest rate is as follows: if $\mu(f=1\,|\,b) > 0$,

$$\begin{aligned} q_b^{\tau} &= \left\{ M \left[\frac{(1+\sigma)q - \int_x \left[\frac{\pi}{b} - v\right] \mu(f=1, dx\,|\,b)}{\mu(f=0\,|\,b)} \right] - \tau_2 \right\} (1-\tau_1) \\ &= (q_b - \tau_2)(1-\tau_1), \end{aligned} \tag{7}$$

and if $\mu(f=1|b)=0$, then

$$q_b^{\tau}=q_b-\tau_2,$$

in which τ_1 is the ratio of proportional interest support and τ_2 is the interest spread. Why do we consider this PFS in the model? Usually, banks determine the interest rates for loans to firms in consideration of the buffer for financial stability and profitability. In the end, the capital productivity of a firm determines the profitability of the loan, which determines the loan interest rate. If it is possible for banks to raise funds at a low interest rate while maintaining financial stability (loan profit > deposit interest) through PFS, even relatively low-productivity firms will survive and participate in production without announcing a default. However, if a firm with overly low productivity survives and causes an excessive labor supply, the disutility of labor increases and social welfare decreases even as production expands. Therefore, the steady-state condition with PFS may have higher social welfare than the steady-state condition without PFS.

F. *Government Budget*

The tax system is based on lump sums such that households do not know how much the tax will be until the end of a period. The tax is determined as follows:

$$T=\int_b (q_b-q_b^{\tau})b\mu(db). \tag{8}$$

G. *Household Problem with Policy-based Finance*

In an economy where the government actively intervenes in the banking industry, the household budget constraint is similar to equation (4):

$$C+B'+T=D+wN+(1+q)B.$$

The household problem is identical to (5), and the household has first-order conditions identical to those in (6). In fact, the assumption of Frisch elasticity of 1 is conservative because the elasticity estimated through microdata is usually lower than 1. If the model assumes that the elasticity is lower than 1, the incentive to expand social welfare through PFS is expected to be lower because the change in the labor supply is relatively small with respect to the change in wages. This means that the optimal level of PFS may be lower than that in the current model.

H. *Invariant Firm Distribution*

We explain how to compute banks' invariant belief system in the firm distribution.

First, the state-mapping function of state variable vector, (b, x, h), is as follows:

$$F(b,x,h'=0)=\begin{cases}1 \ \mathit{if} \ f=0 \ \mathit{and} \ h=0\\ \xi \ \mathit{if} \ h=1\\ 0 \ \mathit{if} \ f=1\end{cases}$$

$$F(b,x,h'=1)=\begin{cases}0 \ \mathit{if} \ f=0 \ \mathit{and} \ h=0\\ 1-\xi \ \mathit{if} \ h=1\\ 1 \ \mathit{if} \ f=1,\end{cases}$$

in which h is the history of default that has a value of 1 if the firm decided to default in the past. The transition function of corporate policy is as follows:

$$\begin{aligned}&P(b,\, x,\, h'=0,\, S)\\ &=\int\left[1_{\{b'\in B/\{0\}\}}F(b,\, x,\, h=0,\, h'=0)+1_{\{b'=0\}}F(b,\, x,\, h=1,\, h'=0)\right]p(dx'\,|\,x),\\ &P(b,\, x,\, h'=1,\, S)\\ &=\int\left[1_{\{b'\in B/\{0\}\}}F(b,\, x,\, h=0,\, h'=1)+1_{\{b=0\}}F(0,\, x,\, h=1,\, h'=1)\right]p(dx'\,|\,x),\end{aligned}$$

in which S is defined as the compact space of state variables. Then, we define the transition function of firm via

$$P^*(b,x,S)=P(b,x,0,S)+P(b,x,1,S).$$

Finally, given (w,Q_b), the distribution of the state vector, (b,x,h), μ is defined as

$$\Upsilon_{(w,Q_b)\mu}(B\times X)=\int P^*(b,x,S)d\mu, \tag{9}$$

in which Q_b is the vector of q_b for all loan products, and Υ is the matrix operator. Therefore, μ is defined as the bank's belief function with respect to b and f. It then becomes possible to compute the default probability and the conditional default probability $\mu(f=1)$ and $\mu(f=1\,|\,b)$ (Athreya, Tam, and Young, 2012). In addition, the unique existence of an invariant distribution refers to Theorem 2 in Chatterjee, Corbae, Nakajima, and Rios-Rull (2007).

I. *Bayesian General Equilibrium*

Definition. The Bayesian general equilibrium lists (a) the real wage w^*, (b) the vector of loan interest rates $Q_b^{\tau*}\in(\mathbb{R}^+)^l$ and the deposit interest rate $q^*\in\mathbb{R}^+$, (c) if PFIs offer corporate loans, the support system $\tau^* = (\tau_1^*, \tau_2^*) \in (0,1)^2$, and (d) lenders' belief about the firm distribution μ^* satisfying the following:

1. Firms solve the optimization problems of n^*, b'^* and f^* given w^* and $Q_b^{\tau*}$ in (1).

2. Lenders offer $Q_b^{\tau*}$ as a Bayesian Nash equilibrium under perfect price competition given τ^*, b'^*, f^*, μ^* and q^* in (7).

3. The government balances the tax T^* given τ^*, b'^*, $Q_b^{\tau*}$ and μ^* in (8).

4. The household solves the optimization problem of B'^* and N^* given w^*, q^*, μ^* and T^* in (5).

5. Labor, loan and Deposit markets clear at w^*, q^* and $Q_b^{\tau*}$:

$$N^* = \int_{b,x} n^* \left(1 - 1_{\{(f^*, b^*)=(1,0)\}}\right) \mu^*(db,dx) \ \ and \ \ B'^* = \int_{b,x} b'^* \mu^*(db,dx).$$

6. According to Walras's law, the household budget constraint according to the goods market clearing condition is as follows:

$$C^* = Y^* + q^* B^* - \Psi^* - \int_b q_b^* b^* \mu^*(db) - \delta K^*.$$

in which

$$Y^* = \int_{b,x} y^* \left(1 - 1_{\{(f^*, b^*)=(1,0)\}}\right) \mu^*(db,dx),$$

$$\Psi^* = \int_{b,x} \Phi(i^*, k^*) 1_{\{f^*=0\}} \mu^*(db,dx),$$

$$K^* = \int_{b,x} (1+b^*) 1_{\{f^*=0\}} \mu^*(db,dx),$$

and i^* and k^* are solved based on the firm's problem (1).

IV. Policy Simulation Methodology

A. *Computational Methodology*

This study computes the equilibrium interest rates of the loan market and the equilibrium real wage of the labor market considering the heterogeneity of firms. In particular, for a social welfare analysis, λ, which determines the marginal utility of labor, is estimated while assuming that there is no policy-based finance and that the real wage is fixed at 1. It is also important to calculate the upper limit of b, $\bar{b}$. In this study, firms need a reasonable ceiling to grow their businesses through the loan market, not the stock market. Thus, we define $\bar{b}$, which is interpreted as the maximum leverage, as 11 and calculate the base model.[4]

We define firms' idiosyncratic shocks as AR(1):

$$x' = \eta(1-\rho) + \rho x + \varepsilon',$$

with $|\rho|<1$ and $\varepsilon \sim N(0,\omega)$. We discretize this process into a 20-state Markov process $\{x_1, \cdots, x_{20}\}$ using the method of Adda and Cooper (2003). In particular, we do not estimate the parameters of idiosyncratic shocks using exogenously reduced forms with firm data, as in other studies such as Corbae and D'Erasmo (2017), but rather estimate the parameters in a way that minimizes the distance between moments from the simulated model and the moment of the financial data. Specific techniques for these computations are described in the appendix.

B. *Parameters*

This study requires 15 parameters for the model simulation. The parameters are divided into two groups. The first group is calculated independently of the model using corporate and financial data. Table 2 shows their values, α as the capital income share is 0.33, which is commonly used in the macroeconomic literature. In addition, γ uses a rate of 51.6%, the average of the labor income share obtained from the Bank of Korea (BOK: https://ecos.bok.or.kr/) from 1961 to 2020. θ is 0.682 from $\alpha/(1-\gamma)$ in the firm's problem. q is 1.79%, the average yield of the ten-year treasury bonds adjusted by consumer price index (CPI) from 2001 to 2020. σ is 0.09,

TABLE 2—PARAMETER VALUES

Parameter	Value	Targets
α	0.330	Capital income share: standard parameter
γ	0.516	Labor income share
θ	0.682	α / (1 − γ)
q	0.018	Ten-year treasury bonds yields
σ	0.090	(three-year corporate bonds (AA-) yields minus q) / q
β	0.982	1 / (1 + q) from (6)
δ	0.051	Accumulated depreciation of property, plants and equipment
ξ	0.380	Closure rate of firms under court receivership
ϕ^+	4.381	Adjustment cost of positive net investment
ϕ^-	1.366e + 3	Adjustment cost of negative net investment
ν	0.270	Liquidation rate for debt
η	-1.262	Mean of the AR(1) process
ρ	0.911	Auto-correlated parameter of the AR(1) process
ω	0.417	Standard deviation of the AR(1) process
λ	4.960	Parameter for the disutility of labor: weight on leisure

Note: 1) The first group shows base parameters calculated using independent corporate and financial data, 2) The second group shows parameters estimated from the minimization of the simulation moments and the target moments.

[4]In order to check the robustness, we conducted a social welfare analysis using different values of $\bar{b}$, finding, however, no qualitative difference in the results.

which is the average yield of the three-year corporate bond (AA-) adjusted by CPI from 2001 to 2020 minus q and then divided by q. β is 0.982 from $1/(1+q)$ from (6). To use δ, first we calculate the annual sum of the decrements of tangible asset depreciation for unlisted non-financial firms audited externally from 2001 to 2020, taking the average after dividing the value by tangible assets.[5] With this process, δ is 5.1%. The liquidation rate of bankrupt firms is calculated as 38.0%, as 388 out of the 1021 enterprises that filed for court receivership from 2008 to 2015 were closed.[6]

The second group of parameters is estimated from the simulated model. In particular, we estimate the parameters using a method that minimizes the distance between simulated moments and data moments weighted by a selected weighting matrix, as follows:

$$\Theta = \arg\min \left[m^d - m^s(\Theta) \right]' \mathcal{W} \left[m^d - m^s(\Theta) \right],$$

in which θ is a set of parameters; m^d are data moments; m^s are the simulated moments at parameters θ, here as $\int_{b,x} z^s(\Theta) d\mu^*$, where z^s is a value for an individual state vector, which means that our moments computed from the simulated firm distribution differ from those generated by the simulated method of moments (SMM) with random numbers, and $\mathcal{W}$ is a positive definite weighting matrix selected to equalize the positions of the first decimal digit in all moments.

Table 3 shows the data moments selected to provide the identification of the parameters, also showing benchmark moments under the economy without a policy-based financial system.[7] In fact, the selected data moments do not have an exact one-to-one relationship with the parameters. However, we can only explain that the selected moment has more information about the parameters we want to estimate than the other moments. In the table, the defaulted debt/total corporate debt levels and real interest rates must be related to ϕ^+, ϕ^- and ν directly, and the net investment must influence the parameters η, ρ and ω of the idiosyncratic shock. The debt/equity ratio and corresponding standard deviation are related to all parameters.

TABLE 3—COMPARISON OF DATA AND MODEL MOMENTS

Moments	Target	Benchmark Model
Defaulted Debts / Corporate Debt on Credit (%)	6.32	6.15
Net Investment Ratio (%)	18.82	12.56
Debt/Equity (%)	201.5	224.6
Standard Deviation of Debt/Equity (%)	233.8	238.4
Real Interest Rate on Corporate Loans (%)	3.33	3.33
Labor	0.3	0.34

Note: This table lists the moments of the data and the simulated model (benchmark model) under an economy without policy-based finance.

[5] Accounting data for firms audited externally are obtained from KISVALUE.

[6] Data related to court receivership and the liquidation of businesses are obtained from KISLINE and the National Tax Service, respectively.

[7] See the appendix for the generation of data moments.

In addition, according to studies such as that by Gourio and Miao (2011), the benchmark labor at equilibrium is set to 0.3 in order to estimate λ. Finally, returning to the table, it can be seen that the moments simulated by our model approximate the target moments well.

ϕ^{+} and ϕ^{-} in Table 2 are estimated as 4.381 and $1.366e+3$, which are relatively large compared to those in Zhang (2005) but at the reasonable level where firms decide to default. In addition, ν is estimated to be 0.270, which means that the lender buys the installed capital of a bankrupt firm for 27% of the debt minus its cash holdings. η, ρ and ω, defining the movement of idiosyncratic shocks, are estimated to be -1.262, 0.911 and 0.417, respectively. These values appear to be desirable enough compared to those in Zhang (2005); Li, Livdan, and Zhang (2009); Livdan, Sapriza, and Zhang (2009); and Nikolov and Whited (2014). Finally, λ is estimated to be 4.960 by applying C^{*} and N^{*} from the simulated model to (6).

V. Social Welfare Analysis

A. *Benchmark Model Properties*

As described above, the benchmark model assumes an economy in which there is no policy-based finance in order to estimate basic parameters such as λ or analyzing the social welfare of policy-based finance. First, we explain how firms' decision rules on bankruptcy are made in the benchmark model. Panel (A) in Figure 1 shows the bankruptcy decision rule with respect to the state variables (k,x). As expected, firms with high capital levels and negative production shocks are likely to go bankrupt. In particular, a large amount of installed capital means not only that there is a considerable amount of debt but also that the firm is more vulnerable to production shocks due to the irreversibility of the investments. As a result, it can be seen that according to this decision rule, firms are concentrated in the category with relatively high productivity and a low debt structure in the invariant firm distribution $\mu(k,x)$ (Panel (B) in Figure 1).

Panels (C) and (D) in Figure 1 show the relationship between the loan interest rate Q_b, debt distribution $\mu(b)$ and default probability for each loan size $\mu(f=1|b)$. It can be seen that the higher the debt, the higher the default probability, with the loan interest rate increasing accordingly. Also, in Panel (D), the default probability is rather high for firms with very small loans. This occurs because if a firm starts a new business, the initial productivity shock is given equally, after which the start-up's default probability is higher than those of surviving firms due to the persistence of the shock. Although this appears to be in conflict with Panel (A), it only shows the bankruptcy decision rule and does not take into account the firm distribution. Nevertheless, in Panel (D), the loan interest rate is relatively low for startups because their cash level, that is, operating profit paid by bankrupt start-ups to the bank, is relatively high when the debt is liquidated, which ensures the bank's profitability even with a high default probability.

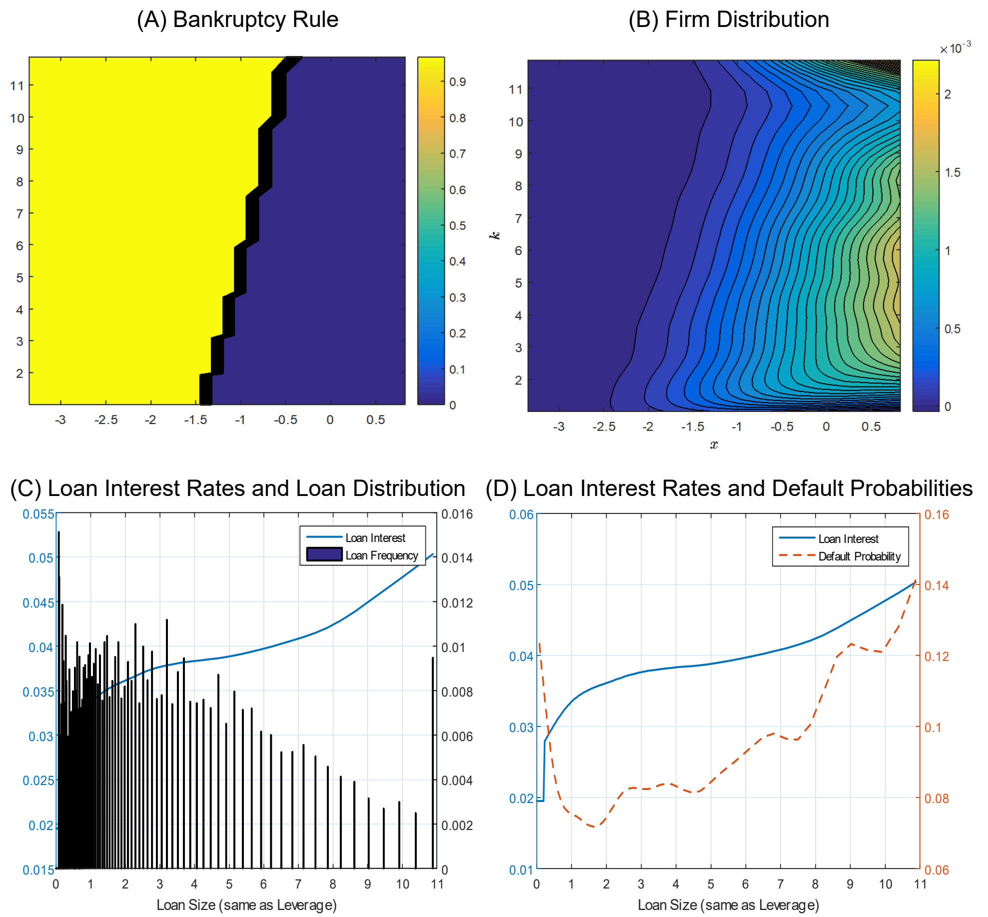

FIGURE 1. PROPERTIES OF BENCHMARK MODEL

Note: 1) This figure displays the properties of the benchmark model: the economy does not have policy-based finance, 2) Panel (A) shows bankruptcy decision rule γ w. r. t. capital k and idiosyncratic shock x, 3) Panel (B) shows invariant firm distribution $\mu(k,x)$, 4) Panel (C) shows loan interest rates Q_b and invariant loan distribution $\mu(b)$: left axis is Q_b and the right axis is $\mu(b)$, 5) Panel (D) shows loan interest rates Q_b and conditional default probabilities $\mu(f=1\mid b)$: the left axis is Q_b and the right axis is $\mu(f=1\mid b)$.

B. *Results of the Social Welfare Analysis*

The range of τ for the social welfare analysis is set as follows:

$$\tau_1 \in [0, 0.75] \ \textit{and} \ \tau_2 \in [0, 0.01],$$

that is, we compute the social welfare when all interest rates are lowered by the same rate of up to 100bp for the market prices in the benchmark model or by up to 75% in proportion. Figure 2 shows the values of social welfare and other macro-variables with respect to τ_1 and τ_2 using contour plots. The contours of Panel (A) show that social welfare $W^*(\tau)$ is high when τ_1 is in the range of 0.05 to 0.45 and when τ_2 is less than 0.001, which means that it is more effective to adjust loan interest rates

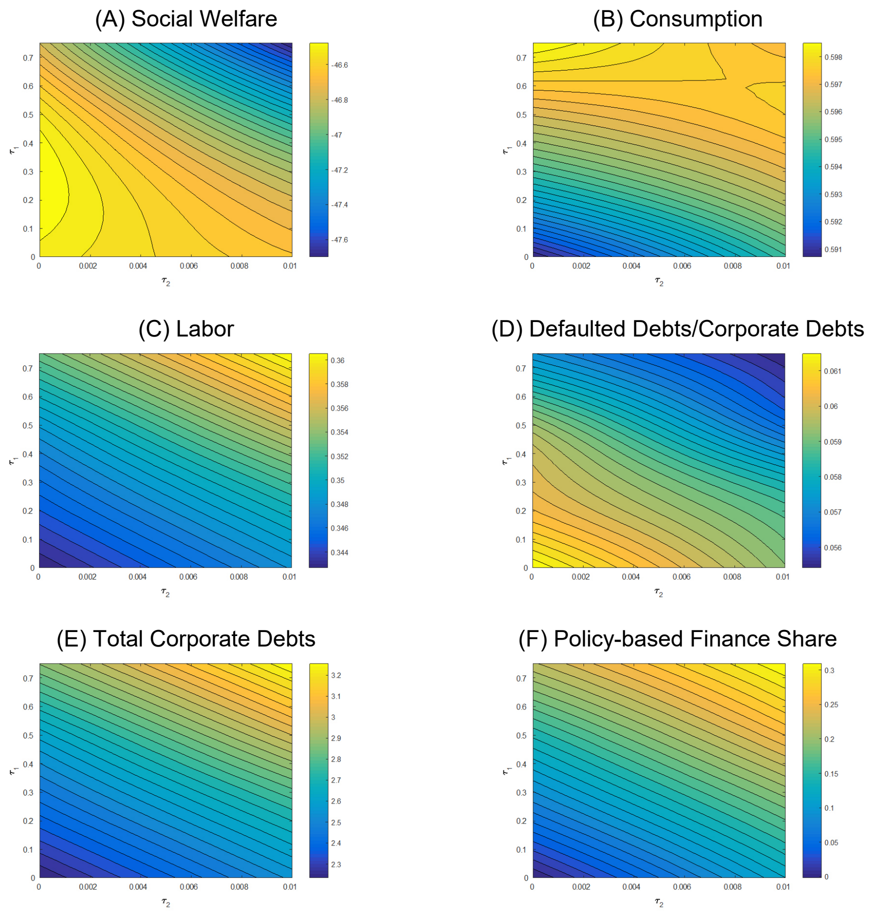

FIGURE 2. COMPARISON OF SOCIAL WELFARE ACCORDING TO τ

Note: 1) This figure displays social welfare and macro variables w. r. t. (τ_1, τ_2), 2) Each panel shows social welfare (W^*), consumption (C^*), labor (N^*), defaulted debt/corporate debt, total corporate debt, and shares of policy-based finance in the financial market using contour plots.

with τ_1 than with τ_2. As explained above, given that social welfare in our model takes into account the disutility of labor, the optimal τ would be lower if we assume that labor elasticity is not one but that it low as labor demand increases.

Panel (B) shows us the important characteristic of this policy, specifically that interest policies pertaining to corporate loans are consistently effective in reviving the economy. More specifically, lowering the interest rate on corporate loans results in lower capital costs, which in turn increases future cash flows. Therefore, if there is no disutility of labor in the social welfare function, the optimal social welfare continues to expand due to this financial support. This means that there is no Laffer curve phenomenon that occurs when taxes are applied to the supply side. However, this model does not consider the inefficiency and restructuring costs of marginal firms surviving in the market due to the support of policy-based finance. Returning to the panel again, we see that as τ increases, taxes increase, whereas consumption $C^*(\tau)$ does not decrease but instead steadily increases. In particular, it can be seen here that τ_1 is more effective than τ_2.

Panel (C) and Panel (D) show total the labor used in production and the ratio of defaulted debt out of corporate debt. With respect to τ, labor tends to increase monotonically, and the ratio of defaulted debt decreases monotonically with consumption, as described above. Panel (E) and Panel (F) also show the size of the corporate loan market in the banking sector as a whole and the share of corporate loans provided by policy-based finance. In particular, the size of policy-based finance is calculated according to how much the corporate loan market expands from the benchmark model due to financial support. Furthermore, it is important to understand that the range of the optimal level of policy-based finance is 1.6% to 13.7% of the total corporate loan market considering social welfare as displayed in Panel (A). In particular, the optimal social welfare level is achieved when the policy-based finance accounts for 8.6% of the total corporate loan market.

To explain the gap between the model and reality, the reason for the existence of PFS is a function of effectively lending funds to firms before the economy develops, that is, a function of correcting the failure of the financial market. This explains the situation in which PFS basically raises funds at a low interest rate and lends money to firms at a lower interest rate than those offered by the market. In addition, it acts as a buffer in the financial market in response to economic fluctuations. However, as the financial market developed along with the economy, the financial market became decentralized. Nonetheless, policy-based financial institutions continued to expand the size of PFS without considering social welfare while continuing the growth-driven policies of the past. This appears to be the cause of the widening of the difference between the model's results and reality. Also, to explain this in terms of the simulation model, as low-interest loan support is extended to low-productivity firms that need to enter the market after being expelled, an excessive labor demand arises and the social welfare of households decreases. In other words, the current situation is that corporate loans procured at low interest rates encourage production, but the social welfare generated through additional production is rather low due to the excess supply of labor.

On the other hand, our model as described thus far can be criticized in many ways. First, as mentioned above, our economy is structured to impose taxes on the demand side and to support the supply side, which is contrary to the usual fiscal policy of imposing taxes on the supply side and supporting the demand side. Moreover, if corporate taxes are levied on firms and tax revenue from corporations supports households, it can be considered that the effect of financial support on the corporation can be circulated back to households. However, there could be a trade-off effect because corporate taxes have a negative impact on the bankruptcy decisions of firms such that they may reduce the effect of financial support to firms. Second, our model does not explicitly assume social costs such as the inefficiencies or moral hazards of policy-based finance. It is obvious that in assuming so, the optimal level of policy-based finance will be lower than it is currently. Although the efficiency of policy-based finance is assumed to be identical to that of commercial banks, our model shows that the current level of policy-based finance in the Korean financial market needs to be moderated. Third, there is no financial intermediation through equity financing in our model. However, even if there is no stock market, the pecking order theory suggests that equity is the last resort of financing, and if a firm becomes close to insolvent, the cost of equity financing will increase rapidly such that our results would not be fundamentally different from those with equity financing. The last issue is that in our model, there is no inefficiency in production due to the survival of marginal firms in the market. If firms that will exit exist in the market due to financial support, the effects of policy-based finance may deteriorate due to externalities such as a decrease in the productivity of the same industry.

VI. Conclusions

We investigate the social welfare effect of a policy-based financial system in the financial market. In particular, this paper develops a general equilibrium model: first, firms are heterogeneous; second, commercial banks and policy-based banks have an incomplete information system in corporate lending. In addition, firms make decisions about bankruptcy under this information asymmetry. The last characteristic is that unconditional economic growth may be not best because the disutility of labor is reflected in the social welfare function.

As a result, the optimal level of policy-based finance in the simulation is estimated to be 8.6%. This figure is well below the average of 40.1% in the Korean financial market over the past three years. In addition, it is argued that the policy-based finance scheme implemented by the government in the Korean financial market needs to be moderate given that policy-based finance is more likely to be morally hazardous and less efficient than schemes operated by commercial banks. Finally, our model may be refuted as imperfect to reflect reality in terms of policymaking, but the main result of this paper will be continuously effective to those developing financial policies.

APPENDIX

A. *Solving the Operating Profit for Labor*

We solve the first-order condition of the operating profit with respect to n,

$$n^* = \gamma^{\frac{1}{1-\gamma}} w^{\frac{1}{\gamma-1}} e^{\frac{x}{1-\gamma}} k^{\frac{\alpha}{1-\gamma}},$$

then,

$$\pi^* = e^x k^\alpha \left(\gamma^{\frac{1}{1-\gamma}} x^{\frac{1}{1-\gamma}} k^{\frac{\alpha}{1-\gamma}} w^{\frac{1}{\gamma-1}} \right)^\gamma - w\gamma^{\frac{1}{1-\gamma}} e^{\frac{x}{1-\gamma}} k^{\frac{\alpha}{1-\gamma}} w^{\frac{1}{\gamma-1}}$$

$$= \frac{1}{k^{\frac{\alpha}{\gamma-1}}} \frac{w^{\frac{\gamma}{\gamma-1}}}{e^{\frac{x}{-1+\gamma}} \gamma^{\frac{\gamma}{\gamma-1}}} - \frac{1}{k^{\frac{\alpha}{\gamma-1}}} \frac{w^{\frac{\gamma}{\gamma-1}}}{e^{\frac{x}{-1+\gamma}} \gamma^{\frac{1}{\gamma-1}}}$$

$$= \left(\gamma^{\frac{\gamma}{1-\gamma}} - \gamma^{\frac{1}{1-\gamma}} \right) w^{\frac{\gamma}{\gamma-1}} e^{\frac{x}{1-\gamma}} k^{\frac{\alpha}{1-\gamma}}$$

$$= a^* e^{\frac{x}{1-\gamma}} k^{\frac{\alpha}{1-\gamma}}.$$

B. *Computational Algorithm*

1. Benchmark Model

We set grids for k, b and x; real wage $w=1$, with the initial loan price vector Q_b^0:

1. **Solve Firm's Recursive Problem:** Given w, Q_b^0, solve the firm problem recursively to obtain k, b, n, and bankruptcy decision rule f as well as the value functions in (1) and (2).

2. **Solve the Firm Distribution:** Given the firm's decision rules and $p(\cdot|\cdot)$, compute the invariant frim distribution μ in (9).

3. **Compute the Loan Price:** Using the firm's decision rules and μ, compute Q_b^1 in (3).

4. If $\| Q_b^1 - Q_b^0 \| < \varepsilon_Q$ for a small ε_Q, we set Q_b^1 as the equilibrium loan price Q_b^* and continue to the next step. Otherwise, we update the loan price $Q_b^0 = Q_b^1$

and return to step 1.

5. **Compute Simulated Moments:** Using the firm's decision rules μ, Q_b^*, q and w, compute the simulated moments.

6. **Find λ:** Computing C^* and N^*, find the value of λ in (6).

2. Social Welfare Analysis

We set grids for τ_1 and τ_2 and the initial real wage $w^0 = 1$ and initial loan price vector $Q_b^0 = Q_b^*$, and repeat the following algorithm according to $\tau = (\tau_1, \tau_2)$:

1. **Compute Loan Price w.r.t. τ:** Given Q_b^0, compute the new loan price vector $Q_b^{\tau 0}$ in (7).

2. **Solve the Firm's Recursive Problem:** Given w^0, $Q_b^{\tau 0}$, solve the firm problem recursively to obtain k, b, n and the bankruptcy decision rule f as well as the value functions in (1) and (2).

3. **Solve the Firm Distribution:** Given the firm's decision rules and $p(\cdot|\cdot)$, compute the invariant firm distribution μ in (9).

4. **Compute the Loan Price:** Using the firm's decision rules, μ and τ, compute $Q_b^{\tau 1}$ in (7).

5. If $\| Q_b^{\tau 1} - Q_b^{\tau 0} \| < \varepsilon_Q$ for a small ε_Q, we set $Q_b^{\tau 1}$ as the equilibrium loan price $Q_b^{\tau *}$ and continue to the next step. Otherwise, we update the loan price $Q_b^{\tau 0} = Q_b^{\tau 1}$ and return to step 1.

6. **Compute Real Wage:** Using the firm's decision rules, μ, $Q_b^{\tau *}$, q and w^0, compute C^* and N^*, then compute w^1 in (6).

7. If $\| w^1 - w^0 \| < \varepsilon_w$ for a small ε_w, we set w^1 the equilibrium real wage $w^{\tau *}$ and continue to the next step. Otherwise, we update the real wage $w^0 = w^1$ and return to step 1.

8. **Compute Tax:** Using μ, b, $Q_b^{\tau *}$ and Q_b^* from the benchmark model, compute the tax T^* in (8).

9. **Compute Social Welfare and Simulated Moments:** Using the firm's decision rules, μ, $Q_b^{\tau *}$, q, $w^{\tau *}$ and T^*, compute the social welfare $W^*(\tau)$ in (5) and the simulated moments.

C. *Generation of Data Moments*

The data used here are provided by FISIS (http://fisis.fss.or.kr), KISVALUE or BOK (https://ecos.bok.or.kr/).

1. Defaulted Debt/Corporate Debt on Credit

   a. **Defaulted Debt:** [Allowance for bad debts] for all domestic banks from FISIS (http://fisis.fss.or.kr)

   b. **Corporate Debt on Credit:** [Corporate loan balance - (Collateralized loan balance - Household collateralized loan balance)] for all domestic banks from FISIS (http://fisis.fss.or.kr)

   c. **Defaulted Debt/Corporate Debt on Credit:** Average from 2008 to 2020

2. Net Investment Ratio

   a. **Net Investment:** [Increment of accumulated depreciation for tangible assets + Net increment of tangible assets] from KISVALUE

   b. **Net Investment Ratio for each Firm:** Average of [Net investment/Tangible assets] from 2001 to 2020 for each unlisted non-financial firm audited externally

   c. **Net Investment Ratio:** Average of all net investment ratios

3. Debt/Equity and Standard Deviation

   a. **Debt/Equity for each Firm:** Average of [Total liabilities/Equity] from 2001 to 2020 for each unlisted non-financial firm audited externally from KISVALUE

   b. **Debt/Equity:** Average of Debt/Equity ratios between 0% and 1,000%

   c. **Standard Deviation of Debt/Equity:** Standard deviation of Debt/Equity ratios between 0% and 1,000%

4. Real Interest Rate on Corporate Loans

   a. **Annual Real Interest Rate on Corporate Loans:** [Annual average interest rate on corporate loans - Annual CPI inflation] from the BOK

   b. **Real Interest Rate on Corporate Loans:** Average from 2001 to 2020

REFERENCES

Adda, J. and R. Cooper. 2003. *Dynamic Economics: Quantitative Methods and Applications,* The MIT Press.

Arellano, C., Y. Bai, and J. Zhang. 2012. "Firm Dynamics and Financial Development,*" Journal of Monetary Economics*, 59: 533-549.

Athreya, K., X. A. Tam, and E. R. Young. 2012. "A Quantitative Theory of Information and Unsecured Credit," *American Economic Journal: Macroeconomics*, 4: 153-183.

Chatterjee, S., D. Corbae, M. Nakajima, and J. Rios-Rull. 2007. "A Quantitative Theory of Unsecured Consumer Credit with Risk of Default," *Econometrica*, 75: 1525-1589.

Clementi, G. L. and H. Hopenhayn. 2006. "A Theory of Financing Constraints and Firm Dynamics," *Quarterly Journal of Economics*, 121: 229-265.

Cooper, I. 2006. "Asset Pricing Implications of Nonconvex Adjustment Costs and Irreversibility of Investment," *Journal of Finance*, 61: 139-170.

Corbae, D. and P. D'Erasmo. 2017. "Reorganization or Liquidation: Bankruptcy Choice and Firm Dynamics," NBER Working Paper Series.

Gourio, F. and J. Miao. 2011. "Transitional Dynamics of Dividend and Capital Gains Tax Cuts," *Review of Economic Dynamics*, 14: 368-383.

Hopenhayn, H. 1992. "Entry, Exit, and Firm Dynamics in Long Run Equilibrium," *Econometrica*, 60: 1127-1150.

Li, E. X. N., D. Livdan, and L. Zhang. 2009. "Anomalies," *Review of Financial Studies*, 22.

Livdan, D., H. Sapriza, and L. Zhang. 2009. "Financially Constrained Stock Returns," *Journal of Financial Economics*, 74: 401-421.

Nikolov, B. and T. M. Whited. 2014. "Agency Conflicts and Cash: Estimates from a Dynamic Model," *Journal of Finance*, 69: 1883-1921.

Stiglitz, J. and A. Weiss. 1981. "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71: 393-410.

Zhang, L. 2005. "The Value Premium," *Journal of Finance*, 60: 67-104.