WP/11/224

IMF Working Paper

Incorporating Financial Stability in Inflation Targeting Frameworks

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INTERNATIONAL MONETARY FUND

 WP/11/224

IMF Working Paper

Asia and Pacific Department

Incorporating Financial Stability in Inflation Targeting Frameworks

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Authorized for distribution by Subir Lall

September 2011

Abstract

The global financial crisis has exposed the limitations of a conventional inflation targeting (IT) framework in insulating an economy from shocks, and demonstrated that its rigid application may aggravate the effect of shocks on output and inflation. Accordingly, we investigate possible refinements to the IT framework by incorporating financial stability considerations. We propose a small open economy DSGE model, calibrated for Korea during the period of 2003–07, with real and financial frictions. The findings indicate that incorporating financial stability considerations can help smooth business cycle fluctuations more effectively than a conventional IT framework.

JEL Classification Numbers:E30, E44,E50

Keywords: DSGE, financial accelerator, monetary policy, financial stability

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[1] We are highly indebted to Subir Lall for his invaluable suggestions; this project would not have materialized without his support. In addition, we have greatly benefited from the inputs of Seung-Cheol Jeon and Minsu Kim. We also thank the participants of the seminars held at the International Monetary Fund and the Bank of Korea.

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I. INTRODUCTION

The recent global financial crisis has demonstrated that strong underlying economic fundamentals cannot insulate an economy from all possible shocks. The crisis, while originating in the subprime segment of the U.S. mortgage market, quickly spread through financial and real channels, and severely affected many economies, even those that did not have any major exposures to the assets at the heart of the crisis. Further, some have argued that the monetary policy settings of the time may have contributed to the buildup of vulnerabilities that led to the subsequent financial instability. For instance, accommodative monetary policies in some countries provided incentives for households and firms to over-leverage. These questions have motivated a review of the scope of monetary policy under inflation-targeting (IT), which had been dominated by the conventional wisdom that monetary policy should remain solely limited to achieving the inflation target, to the exclusion of all other considerations such as financial stability.[2]

A key factor in determining the impact of the global crisis on individual economies was the extent to which underlying vulnerabilities had interacted with the shock and amplified its effect on the financial system and the overall economy. For example, and as it has been well documented by now, the buildup of leverage, rapid house price appreciation or excessive credit growth have all been found to lead to larger economic downturns when an economy is hit by a financial shock.[3] This highlights the role of balance sheet vulnerabilities in the dynamics of an economy when it is subject to shocks. Moreover, it raises the question of the role of inflation targeting frameworks in the run up to the crisis, and whether they can contribute to creating the pre-conditions that better insulate an economy from shocks through improved balance sheets, thereby supporting the mandate of the monetary authority of maintaining price stability as well as minimizing output volatility.

A conventional IT framework generally ignores financial (in)stability considerations despite the effects that monetary policy itself has on the financial system.[4] For instance, when a central bank lowers its policy rate, it reduces the cost of external (i.e., not from own cash reserves) financing for the nonfinancial sector and increases the demand for such financing. A greater volume of external funds does not just increase aggregate investment and consumption, but also raises the leverage of firm and household balance sheets. This may lead to the buildup of systemic vulnerabilities in the economy if, for example, monetary loosening is in the context of an already highly indebted nonfinancial sector. Since the impact

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[2]See Curdia and Woodford, 2009 and 2010, Gertler and Karadi, 2011, Angelini and others, 2010, and Brunnermeier and Sannikov, 2011.

[3]See Cardarelli and others, 2011, and Shin, 2010.

[4]DeFiore and Farr, 2011, argue that monetary policy has real effects in a flexible-price equilibrium because it affects the cost of external finance, causing adverse effects on domestic demand as well as higher bankruptcy rates and a larger waste of monitoring resources for the economy.

of many types of shocks on real activity depends on the degree of leverage in balance sheets, monetary policy could potentially play a useful role in limiting the system-wide buildup of leverage, and the subsequent evolution of prices and output when shocks hit an economy.

A conventional IT framework typically does not respond to financial shocks until the effects are apparent in the standard indicators of output and prices. These frameworks focus only on the usual channels of monetary policy transmission, excluding the underlying balance sheet conditions. Hence, a central bank adopting a conventional IT framework would not react to a financial shock until it has a visible impact on the indicators that are closely linked to output and prices. Given that financial shocks are usually transmitted to the real economy with a lag, a conventional IT framework can respond to some shocks, including financial ones, only partially and with a lag, rather than preemptively.[5] This was also seen during the run up to the global financial crisis when monetary policy remained largely agnostic to the buildup of balance sheet vulnerabilities.

This paper has been motivated by the recognition that financial sector developments play a role in the economy. In particular, we review the appropriateness of an IT framework under the conventional wisdom that monetary policy should remain solely limited to achieving the inflation target, to the exclusion of all other considerations such as financial stability that may affect the dynamics of output and prices over the cycle.

We propose alternative inflation targeting rules that incorporate financial stability indicators. In our alternative policy rules for *inflation targeting incorporating financial stability* (ITFS), a central bank monitors systemically relevant financial stability indicators in addition to the usual developments in inflation and output. Under the ITFS policy rules, a central bank reacts to the deviations of financial indicators from their desirable/equilibrium levels by changing its policy rate, weighted by the importance that it assigns to financial stability indicators in its policy function. We then examine the performance of these alternative policy rules in achieving the central bank's objectives in minimizing the deviations of prices and output from their desired/potential level.

We consider four systemically important financial stability indicators that have direct implications on private sector balance sheets:[6]

- *Nonfinancial sector borrowing spread:* This indicator would be expected to increase along with the rise in the leverage of the nonfinancial sector.[7] This is a systemically important indicator since excessive leverage in households and firms can easily

[5]Of course, most central banks have room for discretion and do not adhere mechanically to the rule implied by the prevailing framework. This was evident in the crisis response of most central banks, but largely only once the economic impact of the financial crisis started becoming evident, rather than in the run up.

[6]Some of these indicators are also used in the earlier research done on monetary policy and financial stability, such as Taylor, 2008, and Curdia and Woodford, 2010

[7]The limitation of this indicator is that spreads can also be affected by factors such as the availability of liquidity or a general decline in risk aversion.

transform into undesirable balance sheet problems, and result in severe economic distress. For instance in Korea, high nonfinancial sector leverage played a role during the 1997 Asian crisis and 2003 credit card crisis.

- *Banks' foreign exchange leverage:* This indicator captures foreign exchange leverage of the banking sector, a source of vulnerability for many banking systems when faced with an external liquidity squeeze. During the 2008 crisis, Korean banks faced a "sudden stop" of short-term capital inflows which required large scale liquidity injections to prevent rapid deleveraging in the financial sector.

- *Credit Volume:* Past experience has shown that developments in the credit market have important implications for the real economy. While credit supports economic activity, excessive credit growth, particularly when the recipients have already weak balance sheets, may exacerbate financial vulnerabilities.

- *Asset Prices:* In particular, we examine the role of house prices as relevant financial indicators. For instance in Korea, housing constitutes more than 70 percent of the households' wealth, and rapid increases in house prices may incentivize these agents to engage in a risky building up of leverage, while sharp declines in house prices may leave them exposed to financial difficulties.

In line with this reappraisal, we propose a small open economy dynamic stochastic general equilibrium (DSGE) model. This model is based on Bernanke and others, 1998 (BGG), and the frictions in this model are price stickiness, investment delays, and financial frictions. Financial frictions are captured by explicitly incorporating a housing sector and entrepreneurs. Frictions in these sectors are modeled using the financial accelerator framework, which captures the amplifying effect of financial shocks on the macroeconomy. The model is calibrated to capture the economic characteristics of Korea during the period of 2003–07.[8]

Our results show that by incorporating financial stability, a central bank can improve on its objectives compared with implementing a conventional IT framework. The effect is particularly important if the source of the shock is from the supply side limiting the investment/consumption activities of the agents, such as a rise in the borrowing spreads of the nonfinancial sector, as opposed to a demand-side shock.[9] For the latter, the performance of the ITFS is similar to that of a conventional IT framework.

One could argue that introducing financial stability into a conventional monetary policy framework would create tradeoffs between the objectives of a central bank. In some

[8]This period corresponds to the times that Bank of Korea has adopted an inflation targeting framework and various financial products, such as mortgage loans, were available in the market. The period ends in 2007 to exclude the effects of the global financial crisis.

[9]We should note that in practice, it may be difficult for a central bank to detect the sources of a shock. Nevertheless, the finding that an ITFS performs either better than or similar to (and no worse than) the *benchmark inflation targeting* (ITB) rule, would be of reassurance for central bankers implementing this new IT framework.

circumstances, such tradeoffs may exist; however, such conflicts between the objectives of a central bank do not differ from those of a central bank that targets only price and output stability: for instance, as experienced in some circumstances, by showing more tolerance to the deviations of inflation than otherwise in order to stabilize output. However, we are not proposing an expansion of the mandate of the central bank; instead, we propose incorporating financial stability considerations in the conduct of an inflation targeting framework where price stability remains the mandate.

The performance of alternative ITFS rules varies in terms of attaining the objectives of price stability and output volatility.[10] Some financial stability indicators perform better than a conventional IT rule in smoothing the volatility of both output and prices. However, others may lead to higher inflation in the short run, while outperforming the conventional IT rule in smoothing business cycle volatility, reflecting a tradeoff that the monetary authority will need to weigh. For instance, monitoring house prices as a financial stability indicator can perform better than a conventional IT framework, in terms of both price and output stability, when the economy is exposed to a shock that raises the nonfinancial sector's borrowing spreads. However, the ITFS incorporating nonfinancial sector leverage may lead to higher short-term inflation even though it does a better job in smoothing the deviations of output from its potential. The appropriateness of the indicator depends on the characteristics of the economy and financial system, and the types of shocks it commonly faces.

Our results show that within the ITFS framework, a central bank could stabilize output and price volatility better by discouraging the excess use of credit. We look at this issue since there is a lack of consensus in the literature regarding the role of credit. Within the ITFS framework, we use credit volume under two financial stability considerations: a central bank ensures financial stability by (i) encouraging credit to the nonfinancial private sector, and (ii) by discouraging credit. The ITFS rule incorporating the level of credit shows that a central bank can do better by curbing excess credit than by promoting rapid credit to the private sector. This finding is significant given that there is yet no consensus in the literature whether a central bank should limit financial risk-taking or encourage credit growth.[11]

The contribution of this analysis to the literature is twofold. First, as a part of the methodology, there is no paper to our knowledge which studies monetary policies under a financial accelerator framework. We incorporate this framework in both the entrepreneurial and housing sectors to capture the accelerating effects of a financial crisis on the real economy. Second, as part of our results, we find that both credit and asset prices are important factors in leading to balance sheet problems. The literature so far has not arrived at a consensus on the role of credit in financial market and the real economy; however, we show

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[10] Akram and others, 2007, argue that gains or losses from responding directly to financial stability indicators are highly shock-dependent. There are gains in terms of inflation and output stability in the case of a house price shock, while there are costs in terms of relatively large variation in inflation and output in the case of a credit shock.

[11] For instance, Curdia and Woodford, 2010, argue that a monetary policy response to credit would not help to stabilize the economy, since it is not clear whether encouraging or discouraging credit to the private sector helps to smooth the nature and persistence of disturbances in the economy.

that a central bank can smooth the effect of shocks on the business cycle should it contain extensive growth of credit. Regarding asset prices, we demonstrate that asset prices can help contain not only the deviations of output but also inflation from its target. The latter is mainly due to the fact that asset price inflation indirectly feeds into the headline inflation.

The roadmap for the paper is as following. The next section is on the impact of the global crisis on the Korean economy, and it aims to provide a context to our analysis. Then, we introduce the benchmark model (Section III), and explain our parameter choices and calibration methodology (Section IV). In Section V, we present a structural vector-autoregression analysis to present the empirical highlights from the Korean data (Section A) and a numerical experiment of the benchmark model in the form of an unanticipated monetary shock (Section B). Then, we introduce the ITFS rules and our numerical experiments for a nonfinancial sector risk premium shock, external demand shock, and technology shock (Section VI). The final section concludes the paper.

II. The Impact of the Global Crisis on the Korean Economy

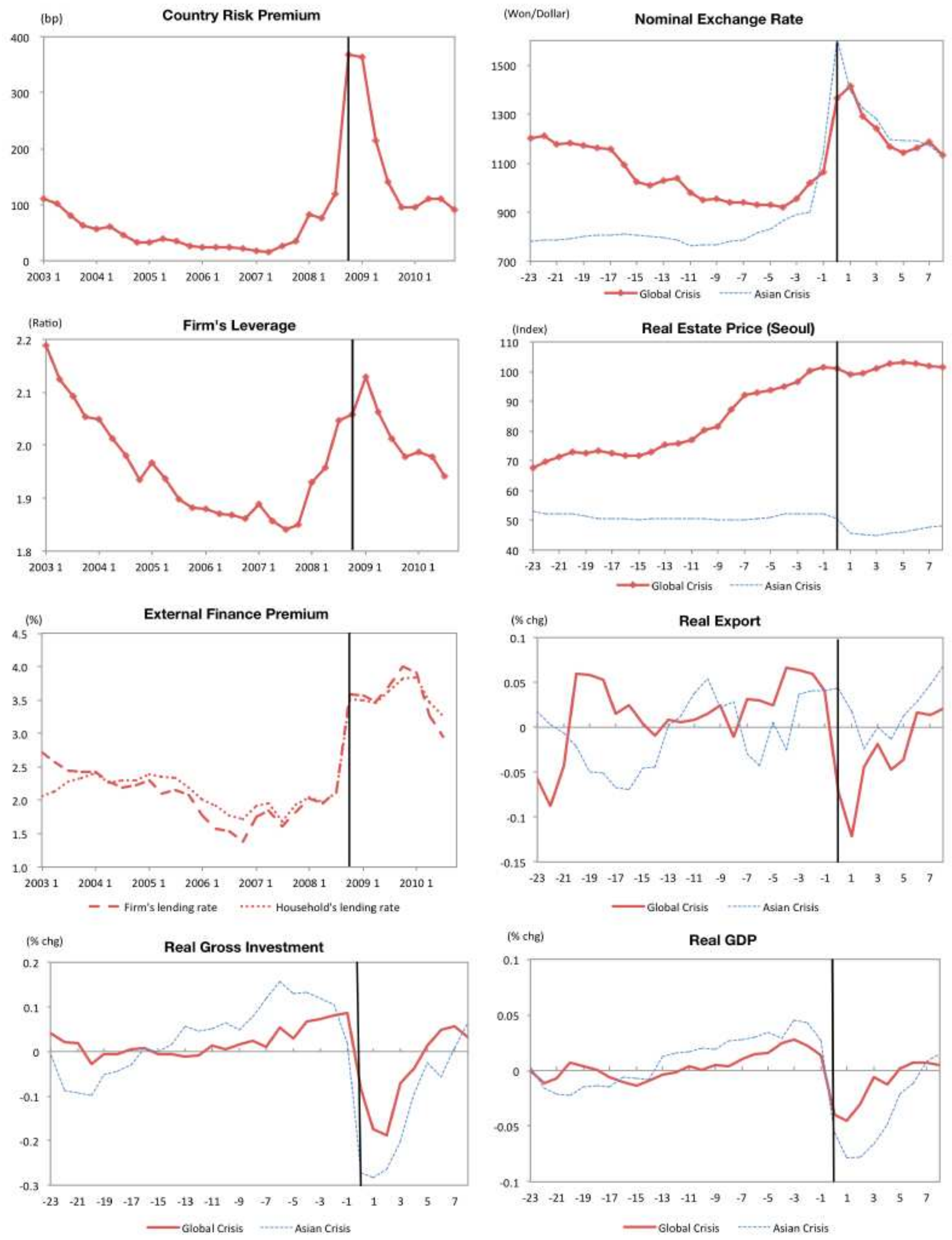
Given the characteristics of its financial system and economy, Korea was vulnerable to the disruptive effects of an unanticipated external shock. Even though macroeconomic performance in the years leading up to the global crisis was strong and the banking system was adequately capitalized, with little exposure to securities at the heart of the crisis, balance sheet vulnerabilities had been building up, making the Korean economy susceptible to shocks. Short-term foreign currency debt of the banking system, and household and small- and medium-enterprise (SME) debt had risen sharply in the years leading to the global crisis.

Despite the strong macroeconomic fundamentals, the interaction of the external shock with underlying financial vulnerabilities had a sizable impact on the Korean economy. The transmission of the financial shock, as well as the sharp contraction in global trade, contributed to an economic downturn in Korea during 2008–09 that was sizable even when compared with the 1997 Asian crisis (Figure 1).

Triggered by a flight-to-safety, the country risk premium of Korea rose sharply,[12] while its currency depreciated abruptly. Korea's country risk premium had been rising gradually during 2008 along with the depreciation of its exchange rate, reflecting the rise in global risk aversion. Following the bankruptcy of Lehman Brothers, Korea's risk premium widened to about 400 basis points and the won lost around half of its value, similar to the magnitude of depreciation during the Asian crisis.

[12] The country risk premium is measured by the exchange equalization fund spread. These funds are securities issued in dollar denomination in order to stabilize the foreign exchange market, and they are traded frequently in the market. The spread on these securities, relative to the U.S. Treasury bond, reflect the country risk premium. Along with the CDS premium, spreads on exchange equalization funds have been used as the main proxies in the aftermath of the global financial crisis.

Figure 1. Korean Economy during Crises



Source: Bank of Korea.

Note: Zero in the x-axis denotes the peak crisis period: 2008Q4 for the global crisis and 1998Q1 for the Asian crisis. Country risk premium is the exchange equalization fund spread; firm's leverage shows average asset-to-equity ratio; real estate price is an index variable; external finance premium is the difference between nonfinancial sector's borrowing and lending rate. All real aggregate variables are the log-deviations from the HP-filtered trend.

The crisis also worsened household and firm balance sheets, and led to an increase in their borrowing costs. The deterioration on the firms' side was much larger, since these companies were exposed both financially and economically through their dependence on exports.[13] The worsening of the nonfinancial sector's balance sheet was reflected in its cost of borrowing, and the external financing premium rose by about 200 basis points during the crisis. Higher funding costs worsened the nonfinancial sector's balance sheet even further by lowering its net worth, and hence led to an even higher borrowing spread for this segment.

Overall, the global financial crisis had a very strong impact on the Korean economy. The developments in the financial indicators affected real aggregate variables with a lag, and the rise in borrowing costs of the nonfinancial sector and the fall in overall exports contributed to the contraction in investment and output during 2008–09.[14] The impact of the global financial crisis on the Korean economy and the accumulated and lagged effects of financial instability on macroeconomic variables suggest that an IT framework incorporating financial stability indicators could be more preemptive and better insulate the Korean economy from such external shocks.

III. The Benchmark Model

The benchmark model is a small open economy DSGE model, where the central bank adopts a conventional IT-framework. The model is a variant of the one developed in Gertler and others, 2007, and makes it feasible to study monetary policy frameworks. Under this setting, the model contains nominal price rigidities, a financial accelerator mechanism and variable capital utilization along with fixed operating costs, to make it resemble the dynamics observed during a business cycle. In addition, we incorporate a real estate and a banking sector. The real estate sector is included in order to capture the empirical evidence that the existence of a highly leveraged housing sector increases the dampening effect of a financial shock on the real economy. Additionally, the banking sector is included to elaborate on the link between the balance sheets of the financial and nonfinancial sectors.

The basic structure of our model is summarized in Figure 2, and as shown in this figure, the agents in our model can be grouped under five categories: (i) consumers, (ii) nonfinancial sector, (iii) financial sector, (iv) government, and (v) the external sector.

Consumers are infinitely-lived risk-averse agents. They work, consume, and save. In every period, they work for the wholesale goods producers for a wage income and decide how much of disposable income (i.e., after taxes) to consume and how much to save. They consume by purchasing tradable goods from domestic and foreign retailers and by renting housing services from homeowners. They save in the form of bank deposits which pay a risk-free interest rate.

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[13] Also, households' balance sheet worsened less, since housing, which constitutes the majority of the household wealth, is highly regulated in Korea.

[14] Trade is a very strong channel for Korea, and its importance during the 2000s was on an increasing trend. The share of imports and exports rose from around 55 percent of its GDP in 2001 to almost 90 percent in 2007.

The nonfinancial sector includes the real estate and the real sector. The real estate sector comprises homeowners and construction companies, while the real sector includes entrepreneurs/wholesale producers, capital producers, and retailers.

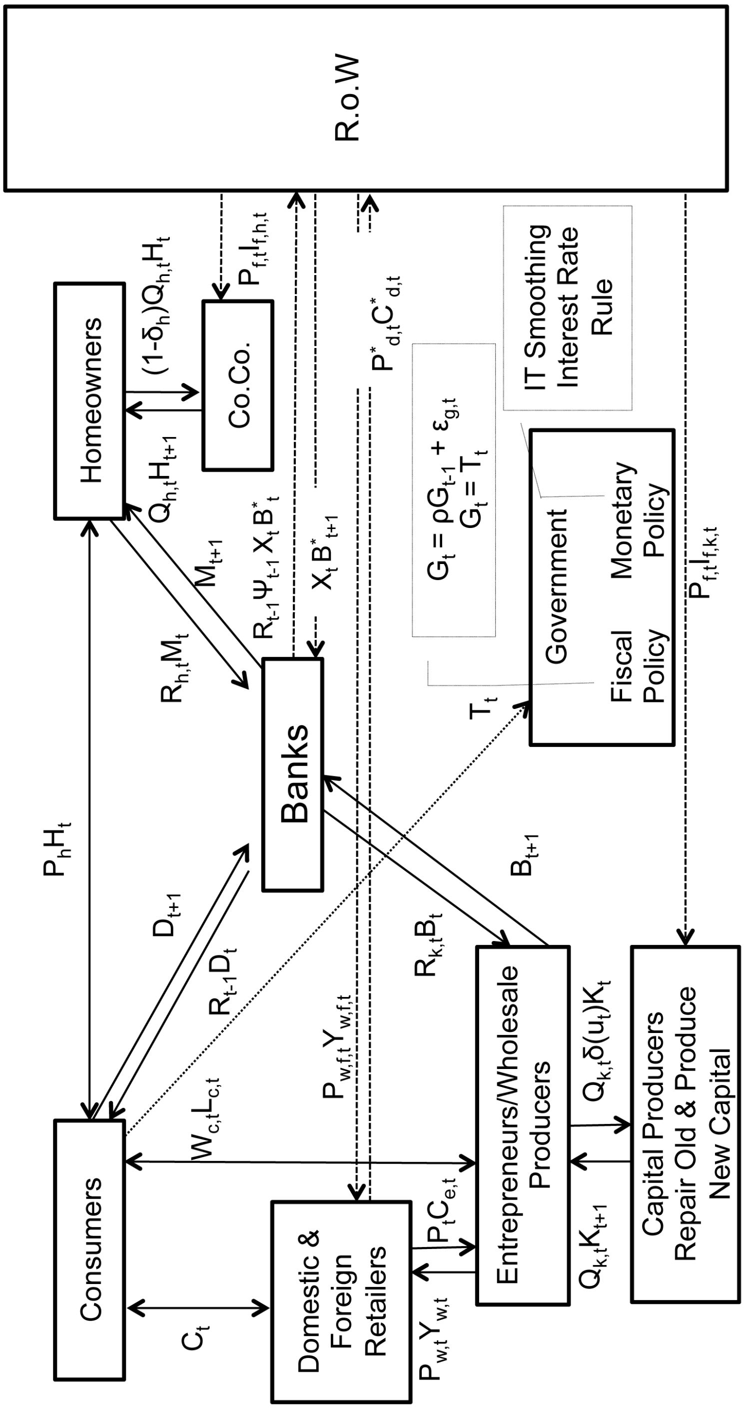

Figure 2. Setup of the Model

- *Homeowners* own the entire housing stock. Their main source of income is the rental payment received from consumers. In each period, as part of their investment decision, they adjust their holdings of housing stock by purchasing new homes from construction companies. Homeowners finance their housing investment through a down payment and a one-period mortgage loan extended by the bank.

- *Construction companies (Co. Co.)* repair old houses and build new housing stock. For production, they use old housing stock purchased from homeowners and domestic and foreign investment goods.

- *Entrepreneurs/wholesale producers* manage the production of wholesale goods. Wholesale goods are produced in every period using capital and labor. Entrepreneurs demand labor contemporaneously, whereas their demand for capital is a decision made one-period ahead, taking into account entrepreneurs' expectations of the returns and the cost of capital. Capital is purchased from capital producers, and the cost is financed partly by the entrepreneurs' net worth and partly by one-period corporate loans extended by banks.

- *Capital producers* use the existing capital stock to produce investment goods. The investment good is composed of domestic and foreign goods. Similar to entrepreneurs, capital producers also make their production plans one period in advance, helping the model to capture the delayed investment response to economic shocks as observed in the data.

- *Retailers* are monopolistically competitive firms owned by consumers. They buy wholesale goods, repackage them, and sell them to consumers as final consumption goods. All retailers have sticky price-setting rule a la Calvo, allowing the introduction of nominal rigidities into the model

The financial sector is comprised of banks. Banks extend corporate and mortgage loans to the nonfinancial sector by relying on their own net worth, consumer deposits, and borrowings from international financial markets. On the liabilities side, banks pay a risk-free interest rate to consumers; for foreign borrowing, they pay an external financing premium, which increases proportionally with banks' external liabilities relative to net worth. On the asset side, banks sign loan contracts with homeowners and entrepreneurs to ensure that they receive an average return free of risk. Accordingly, the loan rate contains an external finance premium to cover for the default risk of a borrower, and it is directly linked to the borrower's leverage ratio.[15]

The government is comprised of the fiscal and monetary authorities. Fiscal authorities follow the fiscal rule of a balanced budget, and the monetary authority, referred to as the central bank, applies an inflation targeting framework. In the baseline model, the central bank follows a conventional IT framework, named as the benchmark rule, which targets price and

[15] This setup is the key aspect of the financial accelerator mechanism which was developed in BGG. The setup links the balance sheets of the nonfinancial sector to that of the financial sector, and is key in capturing the amplifying effect of economic fluctuations.

output stability through an interest rate smoothing rule. Inflation targeting policy is key to our analysis for studying the effectiveness of monetary policy against macrofinancial shocks. The next section introduces the ITFS framework, and compares model outcomes under the ITB and ITFS frameworks.

Last, *the external sector* constitutes the economy's trade with the rest of the world. The trade balance consists of the country's exports and imports of consumption and investment goods. Trade is conducted in domestic currency, and the nominal exchange rate is defined as the price of foreign wholesale goods in domestic currency over the price of foreign goods in foreign currency. This definition allows the model to capture temporary deviations from the law of one price. In addition, it also captures the incomplete exchange rate pass-through observed in reality as the retailers of foreign goods also have a sticky price setting rule.

The following two sections elaborate on the model specifications and the fit of the model to the dynamics observed in the Korean economy. Policy oriented readers may skip these sections and directly go to Section VI which studies monetary policy outcomes under the benchmark and ITFS policy rules.

A. Consumers

The economy is populated by infinitely lived consumers. whose preferences are defined by the following life-time utility function

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\epsilon_t \, ln(C_{c,t} - hC_{c,t-1}) + \epsilon_{h,t} \, \varrho_h \, ln(H_t) - \epsilon_{l,t} \, \frac{\varrho_l}{1+\chi} L_{c,t}^{1+\chi} \right] \right\} \tag{1}$$

with discount factor $0 < \beta < 1$ and $0 < h < 1$ habit persistence parameter, $\chi > 0$ inverse of the Frisch labor supply elasticity, ϱ_h scaling parameter for utility of housing, and ϱ_l scaling parameter for disutility of work. Additionally, ϵ_t is the demand shock, $\epsilon_{h,t}$ is the housing demand shock, and $\epsilon_{l,t}$ is the labor supply shock.

At time t, the consumers supply labor services $L_{c,t}$ at the real wage rate $w_{c,t}$, consume a composite consumption good $C_{c,t}$, rent housing services H_t from homeowners at the real rental rate $p_{h,t}$, save D_{t+1} as real deposits in banks in return of a risk-free real gross interest rate R_t, pay lump-sum real taxes T_t to the government, and receive real dividends from retailers and banks, denoted by $\Pi_{r,t}$ and $\Pi_{b,t}$, respectively. Thus, their budget constraint is

$$C_{c,t} + p_{h,t} H_t + D_{t+1} + \frac{\Theta}{2} \left(\bar{D} - D_{t+1} \right)^2 = w_{c,t} \, L_{c,t} + R_{t-1} \, D_t - T_t + \Pi_{r,t} + \Pi_{b,t} \tag{2}$$

In the above expression, the last term on the left handside is the transaction fee the consumers pay to the banks for their deposits.

Composite good and non-housing goods:

$C_{c,t}$ is the composite of the consumption good defined as

$$C_{c,t} = \left[\gamma^{\frac{1}{\rho}} \left(C_{c,d,t}\right)^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} \left(C_{c,f,t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \quad 0 < \rho < 1 \tag{3}$$

where γ is the share of domestic final good in composite consumption good and ρ is the intratemporal elasticity of substitution between domestic and foreign final goods, i.e. $C_{c,d,t}$ and $C_{c,f,t}$, in consumption. Given the composition of the consumption goods, the Consumer Price Index (CPI) becomes[16]

$$P_t = \left[\gamma \left(P_{d,t}\right)^{1-\rho} + (1-\gamma) \left(P_{f,t}\right)^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{4}$$

The domestic final good, $C_{c,d,t}$, is a composite of differentiated products sold by domestic monopolistically competitive retailers which will be discussed in section (C). The demand for domestic relative to foreign final goods by consumers is given as

$$\frac{C_{c,d,t}}{C_{c,f,t}} = \frac{\gamma}{1-\gamma} \left(\frac{p_{f,t}}{p_{d,t}}\right)^{1-\rho} \tag{5}$$

Consumer's decision problem - consumption, labor supply, and savings:

Consumer's objective is to maximize their life-time utility (eqn. 1) subject to the budget constraint (eqn. 2). Accordingly, the optimal consumption/housing allocation, labor supply, and consumption/saving decision are given as

$$\begin{aligned}
\lambda_t &= \left[\epsilon_t \left(C_{c,t} - h\, C_{c,t-1}\right)^{-1} - \beta\, h\, \epsilon_{t+1} \left(C_{c,t+1} - h\, C_{c,t}\right)^{-1}\right] && (6)\\
\Lambda_{t,t+1} &= \lambda_{t+1}/\lambda_t && (7)\\
1 &= \beta\, E_t \left\{\Lambda_{t,t+1}\, R_t\right\} / \left[1 + \Theta(\bar{D} - D_{t+1})\right] && (8)\\
L_{c,t}^{\chi} &= \lambda_t\, w_{c,t} \,/\, \epsilon_{l,t}\, \varrho_l && (9)\\
H_t &= \varrho_h\, \epsilon_{h,t} / \, \lambda_t\, p_{h,t} && (10)
\end{aligned}$$

[16]The price of domestic and foreign consumption goods relative to the price of the composite consumption good are denoted by $p_{d,t}$ and $p_{f,t}$, respectively. Note that the real variables are defined as the nominal variables relative to the price level.

B. Real Estate Sector

Homeowners

Homeowners are risk neutral real estate investors with a finite expected life horizon $1/(1-\phi_h)$ where ϕ_h is the probability that each will survive until next period. The homeowners' population is stationary, with new homeowners entering into the real estate market to replace those who exit. The new homeowners receive funds that are just enough to start up their business.

Homeowners' decision problem, housing stock, mortgage loan decisions:

Homeowners own the entire housing stock and they rent them to consumers as housing services. At each period, as part of their investments, homeowners revise their holding of housing stock first by having their old houses repaired and then investing in new housing. Homeowners finance their new housing purchases by a down payment equal to their net worth and mortgage loans borrowed from the banks.

$$q_{h,t}H_{t+1} \;=\; N_{h,t+1} + M_{t+1} \tag{11}$$

The mortgage loans from the banks come at a cost of

$$E_t\left\{R_{h,t+1}\right\} \;=\; \Psi_{h,t}\, E_t\left\{R_t\right\} \tag{12}$$

where

$$R_t = E_t\left\{\frac{1+i_t}{1+\pi_{t+1}}\right\}. \tag{13}$$

The above equation implies that at the margin, the real return of a house financed by debt would be equal to its real cost in a frictionless financial market compounded by the homeowner's risk premium, $\Psi_{h,t}$. The risk premium of the homeowner is set up following BGG. Accordingly, the homeowner's risk premium is an increasing function of the homeowner's financial condition, i.e. his/her leverage ratio

$$\Psi_{h,t} \;=\; \left[1+\frac{M_{t+1}}{N_{h,t+1}}\right]^{\psi_h} \tag{14}$$

The total net worth of the homeowners left in the next period is defined by

$$N_{h,t+1} \;=\; \phi_h\left[R_{h,t}\, q_{h,t-1}\, H_t - \Psi_{h,t-1}\, R_{t-1}\, M_t\right] + \zeta_h\, q_{h,t-1}\, H_t \tag{15}$$

The first term on the right hand side in the above expression represents the ex post real return on homeowners' investments in houses net of mortgage repayments while the second term represents the transfer the current homeowners receive from the previous ones to start out. The ex post marginal real gross return on house investments is given by

$$R_{h,t} \;=\; \frac{p_{h,t} + \; q_{h,t} - p_{i,h,t}\; \delta_h}{q_{h,t-1}} \tag{16}$$

At time t, $1-\phi$ percent of the homeowners leave the market and consume their remaining equity. The composition of the homeowners' consumption, $C_{h,t}$, into domestic and foreign final good is similar to equation (5)

Construction Companies

At time t, construction companies buy old houses from homeowners at the market price. They first do the capital improvement on the old houses, then build new ones. Hence, part of the construction investment goods, $\delta_h H_t$, is used up for capital improvement and the rest, $I^n_{h,t}$, used for the new housing. The cost on capital improvement, $p_{i,h,t}\delta_h H_t$, is borne by the homeowners. The housing stock flow of motion is characterized by

$$H_{t+1} = H_t + \Phi_h\left(\frac{I^n_{h,t}}{H_t}\right) H_t \tag{17}$$

where

$$I^n_{h,t} = I_{h,t} - \delta_h H_t \tag{18}$$

The construction technology, $\Phi_h(.)$, is constant returns to scale with respect to $I^n_{h,t}$ and H_t. The steady state conditions for the technology is $\Phi_h(0) = 0$, $\Phi'_h(0) = 1$. The investment good $I_{h,t}$ used for the construction is a composite of domestic and foreign final goods,

$$I_{h,t} \;=\; \left[(\gamma_h)^{\frac{1}{\rho_h}}\;\left(I_{h,d,t}\right)^{\frac{\rho_h-1}{\rho_h}} \;+\; (1-\gamma_h)^{\frac{1}{\rho_h}}\;\left(I_{h,f,t}\right)^{\frac{\rho_h-1}{\rho_h}}\right]^{\frac{\rho_h}{\rho_h-1}} \tag{19}$$

with γ_h as the share of domestic final good. Given the CES technology for the composite, the price of investment good becomes

$$p_{i,h,t} \;=\; \left[(\gamma_h)\;\left(p_{d,t}\right)^{1-\rho_h} \;+\; (1-\gamma_h)\;\left(p_{f,t}\right)^{1-\rho_h}\right]^{\frac{1}{1-\rho_h}} \tag{20}$$

The relative demand for domestic and foreign final goods in investments is

$$\frac{I_{h,d,t}}{I_{h,f,t}} \;=\; \frac{\gamma_h}{1-\gamma_h}\;\left(\frac{p_{d,t}}{p_{f,t}}\right)^{\rho_h} \tag{21}$$

Construction Companies' decision problem:

At time $t-1$, the construction companies maximize their expected profit

$$E_{t-1}\left\{q_{h,t}\;\Phi_h\left(\frac{I^n_{h,t}}{H_t}\right) H_t - p_{i,h,t}\; I^n_{h,t} - \tau_{h,t}\right\} \tag{22}$$

with respect to inputs $I_{h,t}$ and H_t. In the above decision problem, $\tau_{h,t}$ is the rest of the cost borne for the production of new houses.[17] New houses are sold at price $q_{h,t}$. The optimality conditions are

$$0 = E_{t-1}\left\{q_{h,t}\,\Phi_h'\left(\frac{I_{h,t}^n}{H_t}\right) - p_{i,h,t}\right\} \tag{23}$$

$$0 = E_{t-1}\left\{q_{h,t}\,\left[\Phi_h\left(\frac{I_{h,t}^n}{H_t}\right) - \Phi_h'\left(\frac{I_{h,t}^n}{H_t}\right)\,\left(\frac{I_{h,t}^n}{H_t}\right)\right]\right\} \tag{24}$$

In order to account for investment delays, the construction companies make their plans to produce new houses one period in advance. Thus, while shocks that affect the real sector affect the house prices immediately, it affects the level of investments with a one-period lag.

C. Real Sector

Entrepreneurs and Wholesale Producers

Entrepreneurs are risk neutral agents who manage wholesale goods production with a finite expected life horizon of $1/(1-\phi_e)$ where ϕ_e is the probability that each will survive until next period. The entrepreneurs' population is stationary, with new entrepreneurs entering the market to replace those who exit. Different then the homeowners, the entrepreneurs are endowed with $L_{e,t}$ units of labor supplied inelastically as managerial input compensated with a real wage rate of $w_{e,t}$. The entrepreneurial labor is normalized to unity.

Entrepreneurs produce domestic wholesale output $Y_{w,t}$ using labor L_t and capital services u_tK_t. u_t is the capital utilization rate endogenously determined in the model.

$$Y_{w,t} = \omega_t\, Z_t\, (u_t K_t)^{\alpha}\ L_t^{1-\alpha} \tag{25}$$

The labor L_t is a composite of household, homeowner, and entrepreneurial labor

$$L_t = L_{c,t}^{\Omega_c}\, L_{e,t}^{\Omega_e} = L_{c,t}^{\Omega_c} \tag{26}$$

The common productivity shock, Z_t, follows an AR(1) process

$$Z_t = Z_{t-1}^{\rho_z}\exp(\epsilon_{z,t}) \qquad \epsilon_{z,t} \sim N(0,\sigma_z^2) \tag{27}$$

The idiosyncratic shock, ω_t, to effective quantity of capital in production of wholesale goods is assumed to be an i.i.d. random variable, distributed continuously with mean equal to one, i.e. $E_t\{\omega_t\} = 1$.

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[17] Whether $\tau_{h,t}$ is a direct or indirect cost is irrelevant for the model.

Entrepreneurs' decision problem, capital and labor demand, and capital utilization decision:

At time t, conditional on Z_t, and ω_t, the entrepreneurs choose labor and the capital utilization rate to maximize their profits

$$\max_{u_t,K_t,L_t} \left[p_{w,t}\, Y_{w,t} \;+\; (q_{k,t} \;-\; p_{i,k,t}\delta_k(u_t))\; \omega_t K_t - w_t\, L_t\right] \tag{28}$$

Note that the entrepreneurs bear the cost of their capital repair. Therefore, the entrepreneurs' profit includes the purchase of depreciated capital required for the repair. In the spirit of Greenwood and others, 1988, the depreciation rate of capital is a function of capital utilization

$$\delta_k(u_t) = \delta \;+\; \frac{b}{1+\xi}\,(u_t)^{1+\xi} \tag{29}$$

where δ, b, and ξ are all positive. The term ξ is the elasticity of marginal depreciation with respect to utilization rate. The functional form for depreciation is based on Baxter and Farr, 2005.

The optimal choice of labor maximizing the entrepreneur's profit are

$$(1-\alpha)\,\Omega_c\,\frac{Y_{w,t}}{L_{c,t}} \;=\; \frac{w_{c,t}}{p_{w,t}} \tag{30}$$

$$(1-\alpha)\,\Omega_e\,\frac{Y_{w,t}}{L_{e,t}} \;=\; \frac{w_{e,t}}{p_{w,t}} \tag{31}$$

The optimal choice of the capital utilization rate maximizing the entrepreneur's profit is

$$\alpha\,\frac{Y_{w,t}}{u_t} \;=\; \delta_k'(u_t)\,\omega_t\,K_t\,\frac{p_{i,k,t}}{p_{w,t}} \tag{32}$$

At the end of period t, the entrepreneur purchases capital that will be used in the subsequent period. The purchase is partly financed with the entrepreneur's real net worth, $N_{e,t+1}$, and by borrowing from banks, B_{t+1}. Thus,

$$q_{k,t}\,K_{t+1} \;=\; N_{e,t+1} \;+\; B_{t+1} \tag{33}$$

The entrepreneurs' demand for capital depends on the expected marginal real external financing cost and the expected marginal real return. The former is defined as

$$E_t\left\{R_{k,t+1}\right\} \;=\; \frac{E_t\left\{p_{w,t+1}\,\alpha\,\frac{\bar{Y}_{w,t+1}}{K_{t+1}} + q_{k,t+1} - p_{i,k,t+1}\delta_k(u_{t+1})\right\}}{q_{k,t}} \tag{34}$$

where $\bar{Y}_{w,t+1} = Y_{w,t+1}/\omega_t$ is the average income per entrepreneur.

The external financing of the capital acquired for the wholesale production is also defined based on BGG, financial accelerator framework. Hence, the external finance premium is the additional return to the bank and is an increasing function of the entrepreneur's leverage ratio.

$$\Psi_{e,t} \;=\; \left[1 + \frac{B_{t+1}}{N_{e,t+1}}\right]^{\psi_e} \tag{35}$$

The entrepreneur's overall marginal cost of funds is the product of the gross premium for external funds and the gross real opportunity cost of funds in the financial market without frictions.

$$E_t\left\{R_{k,t+1}\right\} \;=\; \Psi_{e,t} E_t\left\{R_t\right\} \tag{36}$$

The above equation implies that at the margin, the real return of a unit of capital financed by debt would be equal to its real cost in a frictionless capital market compounded by risk premium. Equation (36) relates the financial condition of the entrepreneur to the marginal cost of funds, and to the demand of capital.

The net of worth of entrepreneur defined above is the sum of the value of entrepreneurial capital net of borrowing costs carried over from the previous period, and the managerial wage.

$$N_{e,t+1} \;=\; \phi_e\;\left[R_{k,t}\;q_{k,t-1}\;K_t - \Psi_{e,t-1}\;R_{t-1}\;B_t\right]\;+\;w_{e,t} \tag{37}$$

The equations above suggest that the financial condition of the entrepreneur is closely related to unforecastable fluctuations in capital$/$asset prices.

At time t, $1-\phi_e$ percent of the entrepreneurs go out of business and consume their equity in the market, $C_{e,t}$. The relative demand for domestic and foreign final goods is similar to that of the other agents (5) and (3).

Capital Producers

After the wholesale production, capital producers competitively engage in repair of the depreciated capital and construction of new capital goods. In order to repair the depreciated capital, producers require $\delta_k(u_t)K_t$ units of the investment good, the cost $p_{i,k,t}\,\delta_k(u_t)K_t$ is borne by entrepreneurs who own the capital stock.

Constructing new capital:

To construct new capital, producers use both investment goods and existing capital. The construction is constant returns to scale $\Phi_e(.)$ with respect to $I^n_{k,t}$ and K_t. The steady state conditions for the technology is $\Phi_h(0) = 0$, $\Phi'_h(0) = 1$. The economy-wide new capital production function is

$$K_{t+1} \;=\; K_t + \Phi_e\left(\frac{I^n_{k,t}}{K_t}\right)\;K_t \tag{38}$$

where $I^n_{k,t}$ is the amount of investment good used for construction of the new capital goods

$$I^n_{k,t} \;=\; I_{k,t} - \delta_k(u_t)K_t \tag{39}$$

The investment good for capital good is also composed of domestic and foreign final goods

$$I_{k,t} \;=\; \left[(\gamma_k)^{\frac{1}{\rho_k}}\;(I_{k,d,t})^{\frac{\rho_k-1}{\rho_k}} \;+\; (1-\gamma_k)^{\frac{1}{\rho_k}}\;(I_{k,f,t})^{\frac{\rho_k-1}{\rho_k}}\right]^{\frac{\rho_k}{\rho_k-1}} \tag{40}$$

where γ_k is the share of domestic final good. The price of the investment good, on the other hand, is

$$p_{i,k,t} \;=\; \left[(\gamma_k)\;(p_{d,t})^{1-\rho_k} \;+\; (1-\gamma_k)\;(p_{f,t})^{1-\rho_k}\right]^{\frac{1}{1-\rho_k}} \tag{41}$$

The optimal proportion of domestic and foreign final goods in investments is determined through the following condition

$$\frac{I_{k,d,t}}{I_{k,f,t}} \;=\; \frac{\gamma_k}{1-\gamma_k}\;\left(\frac{p_{d,t}}{p_{f,t}}\right)^{\rho_k} \tag{42}$$

Capital producers' decision problem:

At time t-1, the capital producers maximize their expected profit

$$E_{t-1}\left\{q_{k,t}\;\Phi_e\left(\frac{I^n_{k,t}}{K_t}\right)\;K_t - p_{i,k,t}\;I^n_{k,t} - \tau_{k,t}\right\} \tag{43}$$

with respect to inputs $I^n_{k,t}$ and K_t. In the above decision problem, $q_{k,t}$ and $\tau_{k,t}$ is the price of new capital goods and the rest of the cost borne for the production new capital, respectively.

The optimality conditions for net investment and capital are

$$0 \;=\; E_{t-1}\left\{q_{k,t}\;\Phi'_e\left(\frac{I^n_{k,t}}{K_t}\right) - p_{i,k,t}\right\} \tag{44}$$

$$0 \;=\; E_{t-1}\left\{q_{k,t}\;\left[\Phi_e\left(\frac{I^n_{k,t}}{K_t}\right) - \Phi'_e\left(\frac{I^n_{k,t}}{K_t}\right)\frac{I^n_{k,t}}{K_t}\right]\right\} \tag{45}$$

Retailers

There is a continuum of monopolistically competitive retailers that are owned by the consumers. They buy wholesale goods in a competitive market, differentiate the product at a fixed cost κ, and sell those goods to the consumers. The fixed cost is assumed to be proportional to the steady state value of wholesale output such that at steady state the retailers' profit equals zero.

The final domestic good is a CES composite of individual retail goods differentiated by retailer z.

$$Y_{d,t} \;=\; \left[\int_0^1\;(Y_{d,t}(z))^{\frac{\upsilon-1}{\upsilon}}\;dz\right]^{\frac{\upsilon}{\upsilon-1}} - \kappa \tag{46}$$

The price of the composite domestic final good is then

$$p_{d,t} \;=\; \left[\int_0^1 \left(p_{d,t}(z)\right)^{1-\upsilon} dz\right]^{\frac{1}{1-\upsilon}} \tag{47}$$

The isoelastic demand for the differentiated final domestic good is derived as

$$Y_{d,t}(z) = \left(\frac{p_{d,t}(z)}{p_{d,t}}\right)^{-\upsilon} Y_{d,t} \tag{48}$$

Since retailers differentiate the goods slightly the marginal cost of domestic final good is the relative wholesale price, $(p_{w,t}/p_{d,t})$.

Source of price stickiness:

The retailers set the nominal prices on a staggered basis à la Calvo (Calvo, 1983). With probability $(1-\theta)$, the retailers will reset their prices to the optimal price independent of the time elapsed since the last adjustment, else they will keep it fixed at the previous period's price. Let $\bar{p}_{d,t}$ be the optimal price at time t

$$\bar{p}_{d,t} \;=\; \mu \prod_{i=0}^{\infty} \left(p_{w,t+i}\right)^{(1-\beta\theta)(\beta\theta)^i} \tag{49}$$

where $\mu = 1/(1-(1/\upsilon))$ is the retailer's gross mark-up over wholesale prices. Note that the retailers reset their prices based on the expected future path of their marginal cost.

Gross inflation rate:

The gross inflation rate for domestically produced goods is

$$\frac{p_{d,t}}{p_{d,t-1}} \;=\; \left(\mu\, \frac{p_{w,t}}{p_{d,t}}\right)^{\lambda} E_t\left\{\frac{p_{d,t+1}}{p_{d,t}}\right\}^{\beta} \tag{50}$$

where $\lambda = (1-\theta)(1-\beta\theta)/\theta$. The equation implies that the current inflation is related to expected future inflation and the real marginal cost of retailers.

Foreign goods sold in the home country are subject ‘to an analogous mark-up over foreign wholesale price, $p^f_{w,t}$. Thus, the gross inflation rate of foreign final goods is

$$\frac{p_{f,t}}{p_{f,t-1}} \;=\; \left(\mu_f\, \frac{x_t\, p^*_{f,t}}{p_{f,t}}\right)^{\lambda_f} E_t\left\{\frac{p_{f,t+1}}{p_{f,t}}\right\}^{\beta} \tag{51}$$

where similarly $\lambda_f = (1-\theta_f)(1-\beta\theta_f)/\theta_f$. x_t is the real exchange rate defined as

$$x_t = \frac{p^f_{w,t}}{p^*_{f,t}} \tag{52}$$

This specification of the pricing process for domestically sold foreign goods implies temporary deviations from the law of one price because of the delay in the exchange rate pass-through mechanism captured by the parameter θ_f.

Equations (50) and (51), implies that the gross inflation rate CPI is

$$1+\pi_t == \left(\mu\,\frac{p_{w,t}}{p_{d,t}}\right)^{\lambda\,\gamma}\ \left(\mu_f\,\frac{p_{w,f,t}}{p_{f,t}}\right)^{\lambda_f\,(1-\gamma)}\ E_t\left\{1+\pi_{t+1}\right\}^{\beta} \tag{53}$$

D. Financial Sector

The financial sector consists of banks. Banks are risk neutral and owned by the consumers with finite expected life horizon of $1/(1-\phi_b)$ where ϕ_b is the probability that each will survive until next period. The banks' population is stationary, with new banks entering into the financial market to replace those who exit. To ensure the continuity of the financial sector, each of the new intermediaries receives a negligible start up transfer from their counterparts who exit the market.

The banks' balance sheet[18]

$$S_{t+1} = N_{b,t+1}\ +\ D_{t+1}\ +\ x_t\ B^*_{t+1} \tag{54}$$

consists of S_{t+1}, the financial claims on nonfinancial sector's equity held by the banks

$$S_{t+1} = B_{t+1} + M_{t+1} \tag{55}$$

and their liabilities that are the deposits from consumers, D_{t+1}, the debt issued in the international financial markets, $x_t\ B^*_{t+1}$. Finally, $N_{b,t+1}$ is the banks' net equity calculated at the end of period t which will be transferred to period t+1.

The cost the banks bear on their liabilities are R_t, that is the deposit rate, and $\Psi_{b,t}R_t$, the banks' cost of borrowing from the international markets. Here, $\Psi_{b,t}$ is the bank's risk premium given its leverage ratio.

$$\Psi_{b,t}\ =\ \left[1+\frac{x_t B^*_{t+1}}{N_{b,t+1}}\right]^{\psi_b} \tag{56}$$

The domestic and foreign gross real interest rates are related in conjunction with the uncovered real interest parity condition.

$$E_t\left\{R_t\right\} = E_t\left\{R^f_t\ \frac{x_{t+1}}{x_t}\right\} \tag{57}$$

[18]The banks' balance sheet and borrowing/lending decisions is modeled in accordance with the characteristics of the banking sector in Korea. For a broad but definitive picture of Korean banking sector balance sheet structure and borrowing/lending decisions please refer to Appendix II.

where R_t^f is the gross real interest rate of the small open economy in the international markets. It is assumed to follow an AR(1) process

$$R_t^f = \left(R_{t-1}^f\right)^{\rho_f} \exp\left(\epsilon_{f,t}\right) \qquad \epsilon_{f,t} \sim N(0,\sigma_f^2) \tag{58}$$

Banks' decision problem:

As in BGG and Carlstorm and Fuerst, 1997, the banks design their lending contracts, to ensure that the borrowers, i.e. homeowners and entrepreneurs, pay their debt back regardless the idiosyncratic shocks. Thus, the expected return the banks will be receiving from each lending contract (in other words, their financial claims) will be

$$E_t \left\{R_{k,t+1}B_{t+1} + R_{h,t+1}M_{t+1}\right\} \tag{59}$$

Defining the share of financial claims on entrepreneurs' equity held by the banks as $\lambda_{b,t} = B_{t+1}/S_{t+1}$ the expected return on financial claims can be defined as

$$E_t \left\{R_{b,t+1}\right\} = E_t \left\{\gamma_{b,t}\, R_{k,t+1} + (1-\gamma_{b,t})\, R_{h,t+1}\right\} \tag{60}$$

Given the reduced form of returns, the banks' expected profit is defined as

$$E_t \left\{\Pi_{b,t}\right\} = E_t \left\{R_{b,t+1}\, S_{t+1} - R_t\, D_{t+1} - \Psi_{b,t}\, R_t\, x_t\, B^*_{t+1} - \Xi_t + \Delta_t\right\} \tag{61}$$

$$= E_t \left\{\left[R_{b,t+1} - R_t\right] S_{t+1} + R_t\, N_{b,t+1} - R_t\left(\Psi_{b,t} - 1\right) x_t\, B^*_{t+1} - \Xi_t + \Delta_t\right\} \tag{62}$$

where Δ_t is the deposit transaction receipts and Ξ_t the total debt monitoring costs. Note that the latter term is a negligible amount given that the optimal lending contracts are designed to minimize these monitoring costs.

Accordingly, the banks' objective is to maximize their expected discounted terminal profit given as

$$\max_{S_{t+1+\tau}} E_t \left\{\sum_{\tau=0}^{T} (1-\phi_b)\, \phi_b^\tau\, \beta^\tau \Lambda_{t,t+1+\tau}\, \Pi_{b,t+\tau}\right\} \tag{63}$$

Now, to the extent that $\beta^\tau \Lambda_{t,t+1+\tau}\ \left(R_{t+1+\tau} - R_{t+\tau}\right)$, i.e. the discounted risk adjusted premium in any period, is positive the intermediary will expand its assets to the point the consumers supply deposits and borrowing in the international markets is not costly. However, note that banks borrow from the international markets at a cost which increases directly with their leverage ratio.

As was mentioned before, the number of banks at each period is stationary and normalized to unity. Therefore, at each period, there are ϕ_b existing banks and $1-\phi_b$ banks exiting the market. The banks exiting the market are replaced by new banks. The new banks receive funds that are just enough to start up their banking services.

Thus, at the end of time t, the net equity in the banking sector can be written as

$$N_{b,t+1} \;=\; \phi_b \; [R_{b,t} \; S_t - R_{t-1} \, D_t - R_{t-1} \, \Psi_{b,t-1} \, x_{t-1} \, B_t^*] \; + \; \zeta \, S_t \tag{64}$$

E. Government

Fiscal Policy:

The government pursues a balanced budget policy

$$G_t = T_t \tag{65}$$

where the government spending evolves exogenously as an AR(1) process.

$$G_t = G_{t-1}^{\rho_g} \; \exp(\epsilon_{g,t}) \quad \epsilon_{g,t} \sim N(0, \sigma_g^2) \tag{66}$$

Monetary Policy:

The central bank implements an inflation-targeting policy using the following benchmark interest rate rule with a smoothing factor of ρ_m.

$$R_t = \; [R_{t-1}]^{\rho_m} \; \left[(1+\pi_t)^{\rho_\pi} \left(\frac{Y_{d,t}}{\bar{Y}_d} \right)^{\rho_y} \right]^{(1-\rho_m)} \exp\left(\epsilon_{m,t}\right) \tag{67}$$

where $\epsilon_{m,t} \sim N(0, \sigma_m^2)$ is a pure monetary shock.

F. External Balances

Exports of Domestic Final Good:

There is a demand for the domestic final goods, $C_{d,t}^*$, from the rest of the world.

$$C_{d,t}^* = \left[\left(\frac{P_{d,t}^*}{P_t^*} \right)^{-\epsilon} \; Y_t^* \right]^{\eta} \left(C_{d,t-1}^* \right)^{1-\eta} \; \exp\left(\epsilon_{c^*,t}\right), \quad 0 \le \eta \le 1 \quad \epsilon_{c^*,t} \sim N(0, \sigma_{c^*}^2) \tag{68}$$

In the above equation, P_t^*, $P_{d,t}^*$, Y_t^* represents the price level in foreign currency, price of domestic good in foreign currency, and the real output produced in the rest of the world, respectively.

G. Resource Constraint

Finally, the domestic resource constraint of the economy is

$$Y_{d,t} = C_{c,d,t} + C_{h,d,t} + C_{e,d,t} + C^{*}_{d,t} + I_{k,d,t} + I_{h,d,t} + G_t + \Xi_t \tag{69}$$

IV. Parameter Choices and Calibration

The choice of parameter values which we will use for our quantitative analysis consists of two sets. The first set contains those that are often used in the relevant literature and are considered to be the conventional values. The second set, on the other hand, are those that are meant to capture the economic features of the Korean economy during the period of 2003-07.

Preferences:

The discount factor, β, is set to 0.9971 in order to obtain an annual real interest rate of 1.1%. The habit persistence parameter, h, is fixed at 0.5. The intertemporal elasticity of substitution is taken as 0.5. The Frisch elasticity of substitution, $1/\chi$, is set to 1. On the other hand, the relative utility weight on labor $\varrho_l = 0.1617$ is calibrated to fix households' hours worked L_c at $1/3$ of available time. Additionally, $\varrho_h = 0.0136$ is calculated to fix housing service demand to the steady state housing supply determined from the data.The intratemporal elasticity of substitution between the domestic and foreign consumption goods, ρ, is set to 1. The share of domestic goods in the composite consumption good, γ, is taken as 0.7403, as the data suggests. Finally, the deposit transaction fee coefficient Θ is taken as 0.00074.

Real Estate Sector:

Homeowners: The homeowners are assumed to have the same time discounting factor as consumers. Each period, they stay in the market with probability 0.9728. According to the data, the house value to net worth ratio of the homeowners in the real estate sector is 1.5, whereas the mortgage spreads are 1.9% above the annual domestic interest rate. Finally, the start-up transfer rate of homeowners is 0.0132.

Construction Companies: In the house construction sector, while the intratemporal elasticity of substitution between the domestic and foreign investment goods, ρ_h, is 0.5, the data suggest that 11% of the output is investment in the construction sector and the share of domestic intermediate goods in this investment, γ_h, is 0.6423. The quarterly depreciation rate of real estate is taken as the conventional 0.016. Given the depreciation rate, the price elasticity of houses with respect to I_h^n/H ratio is calibrated as 2. In our calibration exercise, the average gross fixed capital formation-to-output ratio in the real estate sector, i.e. 5%, is used to calculate the steady state value of the domestic investment goods.

Real Sector:

Technology: The capital share within the wholesale technology, α, is calculated from the data as 0.4. The steady state utilization rate of capital is normalized at 1 while the steady state depreciation rate for physical capital, $\delta_k(u)$, is taken as the conventional value 0.025. The parameter ξ that is the elasticity of marginal depreciation with respect to the utilization rate, $u\delta^{''}(u)/\delta^{'}(u)$, is also set to 1. $\Omega_e = 0.01$, that is the share of entrepreneurial labor in the total wage bill is set to 1%. Finally, for our linearization exercises, according to the data, the domestic capital investment-to-output ratio in the wholesale sector, i.e. 10%.

Entrepreneurs: The parameter ϕ_e is 0.9728. According to the data, the capital value to net worth ratio and the external finance premium charged to entrepreneurial debt are 1.1 and 2.1%, respectively.

Capital Producers: The intratemporal elasticity of substitution between the domestic and foreign investment goods, ρ_k, is set to 0.25. According to the data, 12% of the output goes to the capital investments and the share of domestic intermediate goods in this investment good, γ_k, is 0.6423. Finally, the price elasticity of capital with respect to investment-to-capital ratio is taken as 2.

Retailers: The steady state markup value on the domestic and foreign final goods, μ and μ_f are set to 1.2. Hence, the fixed resource cost is 20% of the output. For the Calvo pricing convention, the probability of fixing prices both in domestic and foreign final goods market, $\theta = \theta_f$ is 0.75.

Banks:

The banks' survival rate is set to 0.975. Moreover, the share of assets transferred to the new banks, ζ, is 0.0593. Over the period of 2003–07, the average asset-to-equity and asset-to-deposit ratios are given as 18.42 and 17.92, respectively. Given these values, the share of the entrepreneurial loans in the banks' financial claims are calculated as 0.6920. The rest of the financial claims are in the form of mortgage loans. Both for entrepreneurs and homeowners, the idiosyncratic shocks are taken as log-normal with a variance of 0.28. Additionally, the realized payoffs lost in bankruptcy, μ, is 0.12.

Exports:

Over the period of 2003–07, the average exports-to-output ratio is 24%. The steady state value of exports is calibrated using this information. In addition to this, the price elasticity of exports is taken as 2 and the income elasticity of exports is taken as 1.

Government Policy:

The steady state value of government spending-to-output ratio is taken from the data as 20%. Regarding the interest rate rule, the smoothing coefficient is taken as 0.7, the weight of CPI inflation is taken as 1.5, and the weight on the output gap is taken as 0.5.

Table 1: Parameters and Calibration

Variables	Value	Definition
β	0.9971	consumer's discount factor
h	0.5	habit persistence parameter
ρ	1.0	elasticity of substitution btw domestic and foreign consumption goods
γ	0.7403	share of domestic consumption good in composite consumption good
χ	1/2	inverse of the Frisch labor supply elasticity
L	1/3	labor supply at steady state
ϱ_l	0.1617	scale parameter for disutility of work
ϱ_h	0.0136	scale parameter for utility of housing services
$Q^h H/N_h$	1.5	homeowners' house value to net worth ratio
Ψ_h	1.9%	external finance premium on homeowners' leverage ratio
ϕ_h	0.9728	homeowners' survival rate
ρ_h	0.5	elasticity of substitution btw domestic and foreign housing investments
ζ_h	0.0132	share of exiting homeowners' assets transferred to new homeowners
γ_h	0.6423	share of domestic final good in composite investments
$I_{h,d}/Y_d$	0.11	capital investment to output
δ_h	0.016	depreciation rate of real estate
Ω_e	0.01	share of entrepreneurs' managerial labor
α	0.4	share of capital use in production of wholesale goods
$I_{k,d}/Y_d$	0.12	capital investment to output
u	1.0	steady state utilization rate
$\delta_k(u)$	0.025	steady state depreciation rate of capital
ξ	1.0	elasticity of marginal depreciation with respect to utilization rate
ϕ_e	0.9728	entrepreneurs' average survival rate
$Q^k K/N_e$	1.1	entrepreneurs' capital value to net worth ratio
Ψ_e	2.1%	external finance premium on entrepreneurs' leverage ratio
ρ_k	0.25	elasticity of substitution btw domestic and foreign capital investments
γ_k	0.6423	share of domestic final good in composite investments for capital
μ	1.2	domestic retailers' mark-up over domestic wholesale prices
μ_f	1.2	foreign retailers' mark-up over foreign wholesale prices
κ	0.2	fixed costs born by retailers
θ	0.75	probability of price fixing in domestic final goods market
θ_f	0.75	probability of price fixing in foreign final goods market
ϕ_b	0.975	banks' survival rate
S/N_b	18.42	banks' asset-to-equity ratio
D/N_b	17.92	banks' deposit-to-equity ratio
ζ_b	0.0593	share of exiting banks' assets transferred to new banks
σ	0.28	banktruptcy loss
μ^2	0.12	variance of idiosyncratic shock
X/Y_d	0.4	exports to output
ε	2	price elasticity of export demand
η	1	income elasticity of export demand
G/Y_d	0.20	government spending to output
ρ_m	0.7	interest rate smoothing factor

ρ_π	1.5	weight on inflation within interest rate rule
ρ_y	0.5	weight on output gap within interest rate rule

V. An Unanticipated Monetary Shock

In this section, the results of an unanticipated monetary shock are laid out. The first subsection presents the impulse responses from a structural vector autoregression analysis and the second one presents the responses from our benchmark model.

A. Structural Vector-Autoregression Analysis

In this section, we study how the Korean economy reacts to a rise in the short-term interest rates using the data for the period of 2001–10. Results of this empirical analysis will provide us a reference in evaluating the findings of our model. In particular, it would be helpful to assess whether the direction of responses of our model economy to an unanticipated monetary shock is similar to what the data produces.

For this purpose, we construct a quarterly structural vector-autoregression (SVAR) based on four endogenous variables and two exogenous variables. Endogenous variables are consumer prices, real GDP, policy rate, and a financial variable of interest. Exogenous variables are average petrol prices per liter denominated Korean won and a global financial crisis dummy, starting from the second half of 2008 through the first half of 2009, to capture the effects of external dynamics on the domestic economy.[19] Given the limited estimation sample, we construct the SVAR with one financial variable at a time in order to gain from degrees of freedom, and the financial variables of interest are mortgage lending spread, corporate borrowing spread and bank leverage.[20]

In the SVAR, endogenous variables are listed as prices, output, policy rate and a financial variable, in the order which the literature has produced a consensus.[21] For instance in this

[19] Even though a majority of the empirical analyses applied to the US economy place oil prices within the system of endogenous variables, Granger causality test results indicate that price, output and the policy rate do not Granger cause oil prices in Korea. Hence we treat oil prices as an exogenous variable.

[20] We calculated mortgage spread as the difference between mortgage lending rate and the policy rate; corporate borrowing spread as the wedge between bank lending rate to corporations and the policy rate; and bank leverage as the total assets to equity ratio of the total banking system. Calculating the mortgage and corporate borrowing spreads relative to the policy rate or the deposit rate does not change the impulse response dynamics, since the deposit rate closely follows the dynamics of the policy rate.

[21] See BGG.

setup, we assume that prices in the current period are sticky and do not respond to contemporaneous shocks coming from output, interest rate and financial indicators. On the other hand, interest rates are allowed to respond to changes in prices and output, but can only affect them with a lag. Similarly, we allow financial variables to react contemporaneously to any shocks hitting the system. We listed financial variables as the last item of the system, given that the markets may react to any changes in the macrofinancial environment instantaneously, while it takes more time for monetary policy to react.

For the empirical analysis, the data sample starts from the first quarter of 2001 and ends in the last quarter of 2010. The period is chosen in order to use an overlapping sample as the one used in calibrating the model.[22] Monetary and exchange rate policies applied prior to this period were characterized by a different structure. Data are obtained from the Bank of Korea (BOK) and CEIC database. For the regression analysis, we have used consumer prices, output and petrol prices in a logarithmic base and all other variables as ratios.

Impulse response functions are obtained from estimating the SVAR of the aforementioned system by including the first two lags of the endogeneous variables.[23] The structural restrictions are imposed as following on the lower triangular A matrix and the diagonal B matrix:

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{pmatrix} \qquad B = \begin{pmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ 0 & 0 & b_{33} & 0 \\ 0 & 0 & 0 & b_{44} \end{pmatrix}$$

Figure 3 shows the impulse response of the three standard macroeconomic variables to a one standard error policy rate shock,[24] say the monetary policy committee surprises the markets by unexpectedly taking a more hawkish stance. After this shock, interest rates rise immediately around 15-20 basis points, and it takes around a year for the rates to normalize. Prices and output on the other hand respond with a lag, and the response of prices is rather small. These responses are in line with the findings of empirical monetary policy analyses in the literature.[25]

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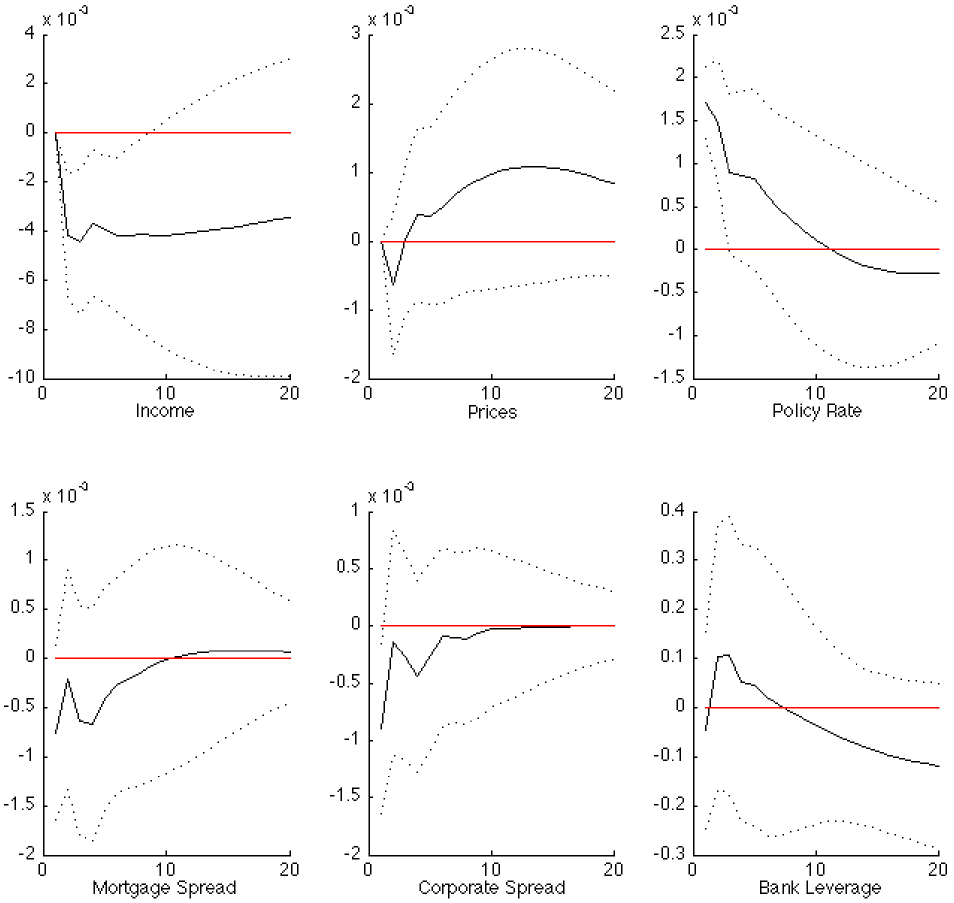
[22]We have a slightly larger sample than the one used for calibrations in order to gain from degrees of freedom. However, for some financial sector indicators, data, such as mortgage lending, are available only by 2003. We control for the post-2007 period through a global financial crisis dummy.

[23]Both Akaike and Schwarz information criterion indicate that the SVAR with two lags is the most efficient one. All the inverse roots of the autoregressive polynomial lie within the unit circle, indicating that the estimated VAR is stationary.

[24]Impulse responses plotted on this figure are obtained from the following VAR: [Price, output, policy rate, mortgage spread], and the response of the macroeconomic variables to a monetary policy shock is invariant of the financial variable used in the system of equations.

[25]Christiano and others, 2008

Figure 3. SVAR Impulse Responses: Monetary Shock



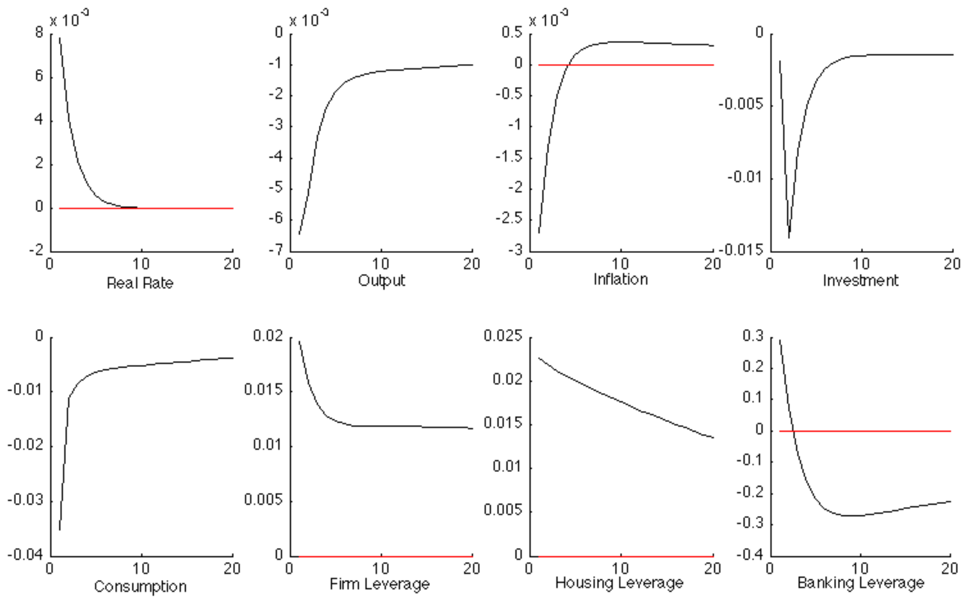
Next, we analyze the transmission of a monetary shock to financial variables by respectively estimating the SVAR with the mortgage spread, corporate borrowing spread, and bank leverage. The data show that a rise in interest rates initially reduce nonfinancial firms' borrowing spreads. Since the spread is calculated as the difference between the borrowing rate and the policy rate, a rise in the latter would lead to an immediate decline in spreads. However, once higher interest rates get reflected to homeowners' and firms' net worth, banks start charging higher interest rates to their borrowing. A slower convergence of the nonfinancial sector's borrowing spread to its equilibrium compared to how fast the policy rate returns back to its equilibrium supports this observation. On the bank balance sheet side, the effect of a policy rate hike is less clear, since the dynamics affect bank's assets and liabilities differently depending on whether a dominant factor is the decline in the demand for bank loans or an increase the bank's supply of credit.

B. The Benchmark Model Experiment

The quantitative analysis begins with an experiment of an unanticipated monetary shock, i.e. a 1% exogenous increase in the policy rate, under the benchmark interest rate rule.The impact of a monetary shock on the standard macroeconomic remarks is in line with the empirical analysis provided earlier (Figure 4). The shock raises the policy rate, and leads to an immediate decline in output. The effect on inflation is quite minimal.

The hump-shaped response of bank leverage to a monetary policy shock matches quite well the impulse response observed through the SVAR analysis. However, the initial response of the nonfinancial sector's (homeowners and entrepreneurs) borrowing spread differs, given that agents can only sign 1-period contracts in our model. Therefore, the impact of a policy shock feeds immediately into risk spreads by increasing their cost of borrowing.[26] The rise in the risk spread of the nonfinancial sector, is small given that new borrowing is scaled by their net worth. However, higher spreads revert back to steady-state rather slowly due to the financial accelerator setting we used in this model. These credit market dynamics also explain the slower inertia behind real variables as reflected in output returning back to its equilibrium much later than the normalization of the interest rates.[27]

Figure 4. Impulse Response to a Monetary Shock



[26]In the data, a monetary policy shock affects spreads with a lag. Nevertheless, such a discrepancy would not be of a concern looking at the rather insignificant magnitude of the impulse responses generated both from the data and our model. Further, more than 70 percent of mortgage contracts are floating rate, linked to the 90-day CD-rate in Korea.

[27]Please refer to the external finance premium shock for further details on how credit market dynamics interact with real variables leading to a lingering effect in the normalization of real and financial variables.

Overall, the response of our model economy to a monetary policy shock is similar to the dynamics extracted from the data. Our model can mimic the slower return of the real and financial variables to their steady state values as shown in the data, and the relative magnitude of these responses are also comparable to that observed in the SVARs.

VI. FINANCIAL STABILITY UNDER INFLATION-TARGETING

In this section, we compare the "benchmark" interest rate rule to alternative ITFS rules.[28] In the alternative interest rate rule, price stability is the main objective of the central bank, and along with output stability, the central bank also reacts to financial stability considerations.

We consider four alterntive ITFS rules:

Alternative ITFS Rule I:

After the global financial crisis there has been a lengthy debate on how one should define the natural rate of interest which appears in the simple Taylor Rule as a policy tool. It is evident that in periods of financial distress the natural interest rate introduced by Wicksell, 1898 is no longer unique. There are multiple interest rates such as the savings and the borrowing interest rates, and the wedge between these two types increases as the financial conditions deteriorate. In light of this, it is intuitive for the central bank to monitor this wedge along with the deviations from the inflation target and the changes in the output gap. Therefore, our first augmented interest rate rule incorporates "nonfinancial sector risk premium" into its monetary rule. This is a risk indicator which increases along with the rise in the leverage of the nonfinancial sector. This indicator is particularly important since excess leverage in households and firms can easily be amplified by an unexpected shock and result as a severe economic downturn.[29]

$$\tilde{r}_t = \rho_m \, \tilde{r}_{t-1} + (1-\rho_m) \, \left[\rho_\pi \, \tilde{\pi}_t + \rho_y \, \tilde{Y}_{d,t} + \rho_\psi \, \left[\tilde{\Psi}_{e,t} + \tilde{\Psi}_{h,t}\right]\right] + \epsilon_{m,t}$$

In our experiments the weight of the nonfinancial sector risk premium, ρ_ψ, is taken as -0.5 and -1.[30] The coefficients suggest that at times of financial distress during which the model predicts higher default rates in the nonfinancial sector, the central bank should reduce the base interest rate to ease the pressure on the repayment costs on loans.

[28]The interest rate rules are in linearized form.

[29]Adjusting the policy rate in response to changes in credit spreads, for any given level of output and inflation, was studied by DeFiore and Tristani, 2011, and Curdia and Woodford, 2010.

[30]The weight of the coefficients in this policy rule and the following are chosen randomly, within the range used earlier in the literature for some other financial indicators.

Alternative ITFS Rule II:

As explained in section D banks have two access lines to capital. First is the deposits and the second is foreign capital. At times of economic distress deposits are no longer resourceful for banks. However, foreign capital is available to channel liquidity to the nonfinancial sector, but only if its cost is sufficiently low. Our second augmented interest rate rule incorporates "financial sector risk premium" into its monetary rule. This is an indicator to capture the foreign exchange leverage in the banking sector, which is the Achilles' heel of many emerging market economies when faced by an external liquidity squeeze, such as experienced by many during the global financial crisis. Similar to the alternative policy rule above, the weight of the financial sector risk premium , ρ_{ψ}, is taken as -0.5 and -1.

$$\tilde{r}_t = \rho_m \, \tilde{r}_{t-1} + (1 - \rho_m) \, \left\{ \rho_\pi \, \tilde{\pi}_t + \rho_y \tilde{Y}_{d,t} + \rho_{\psi b} \, \tilde{\Psi}_{b,t} \right\} + \epsilon_{m,t}$$

Alternative ITFS Rule III:

Past experience has shown that developments in the credit markets have an important affect on the real economy. Under this rule we use credit volume under two financial stability considerations: a central bank ensures financial stability by (i) encouraging credit to nonfinancial private sector and (ii) by discouraging credit, given that there is no consensus reached regarding the role of credit within the financial stability and monetary policy literature yet. Therefore, we choose the weight of credit volume, ρ_s, as -0.1 and 0.1.

$$\tilde{r}_t = \rho_m \, \tilde{r}_{t-1} + (1 - \rho_m) \, \left\{ \rho_\pi \, \tilde{\pi}_t + \rho_y \tilde{Y}_{d,t} + \rho_s \, \left[\tilde{B}_{t+1} + \tilde{M}_{t+1} \right] \right\} + \epsilon_{m,t}$$

Alternative ITFS Rule IV:

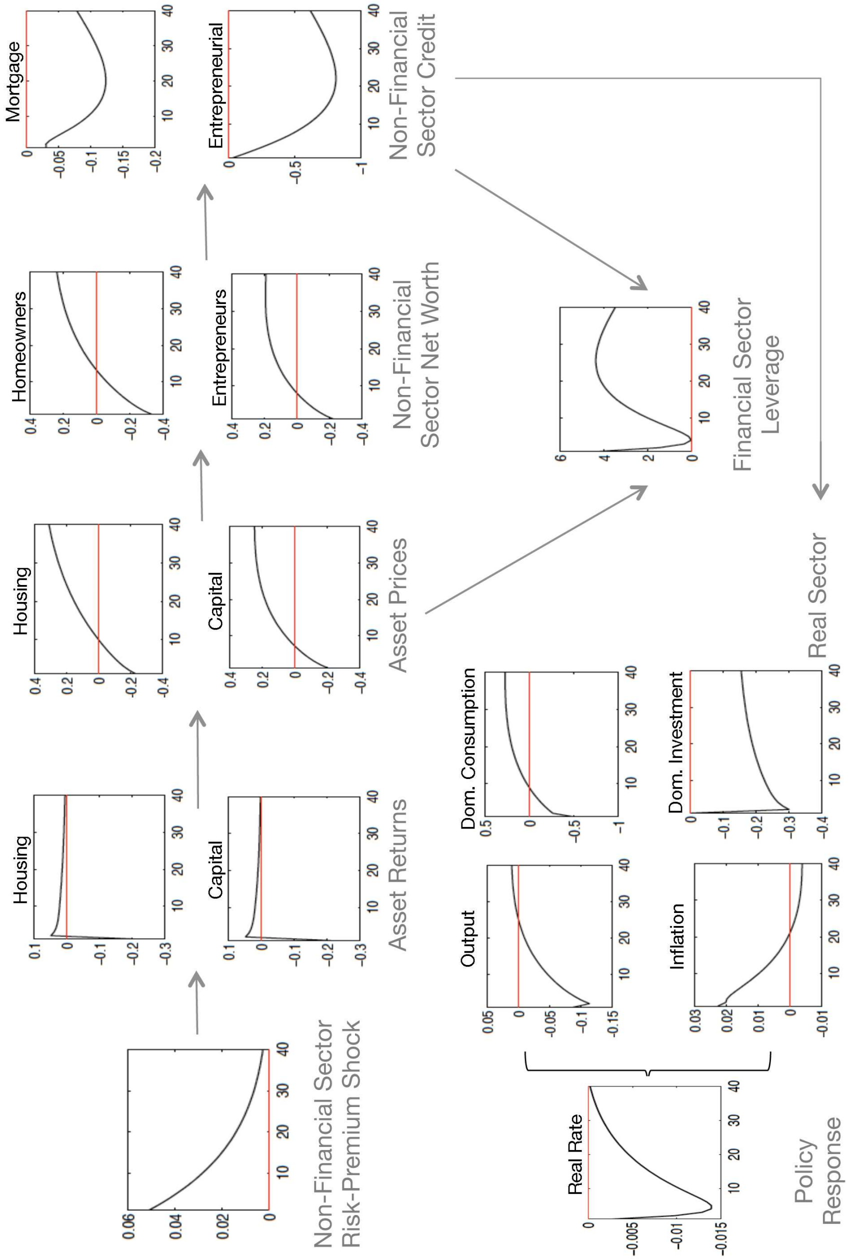
There is no doubt that addressing whether asset prices are overvalued or not is a challenging situation. However, incorporating asset prices into the monetary framework is not to judge the equilibrium level of these prices, but rather to assess whether the positions taken by leveraged households pose a financial risk to the system. And house prices are particularly important in Korea, since around 70 percent of total household wealth is preserved under housing. Therefore, as our last alternative, we incorporate the volatility in the house prices to the the benchmark ITFS rule choosing the weight on the volatility, ρ_{qh}, as 0.5 and 1.5.

$$\tilde{r}_t = \rho_m \, \tilde{r}_{t-1} + (1 - \rho_m) \, \left\{ \rho_\pi \, \tilde{\pi}_t + \rho_y \tilde{Y}_{d,t} + \rho_{qh} \, [\tilde{q}_{h,t} - \tilde{q}_{h,t-1}] \right\} + \epsilon_{m,t}$$

A. An Unanticipated Adverse Shock to Nonfinancial Sector Risk Premium

In this section, we analyze the economy under the benchmark and ITFS frameworks when a financial shock hits the economy. The financial shock is a 5 percent rise in the risk premium of the nonfinancial sector loans.[31] Even though the magnitude of the shock is much smaller in the model, the nature of the shock was quite similar to what the Korean economy has experienced during the global financial crisis and is thus appropriate for demonstration.

Figure 5. Transmission Mechanism



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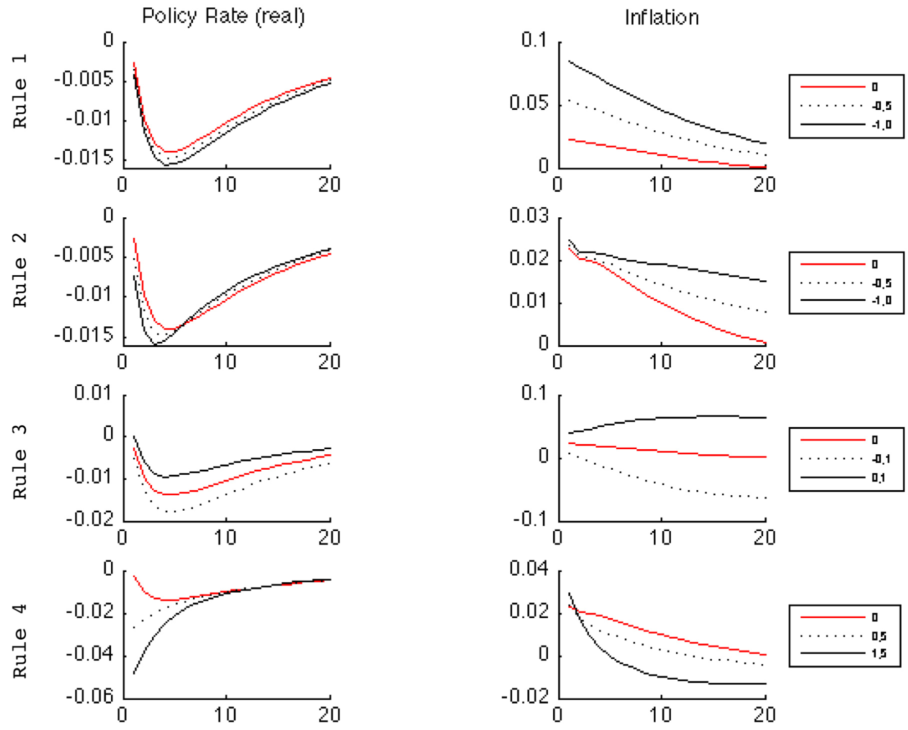
[31]The shock follows an autoregressive process with a persistence parameter of 0.95.

Figure 5 presents the transmission of a 5 percent financial shock under the benchmark model. The shock affects the borrowing spreads of the nonfinancial sector immediately. However, its adverse impact on the borrowing spreads dies out slowly, as experienced in Korea in the aftermath of the global financial crisis. The shock's transmission to real aggregate variables operates with a lag. Because of this lag between the time of the shock and the time that it passes on to the real aggregate variables, the central bank's reaction under the benchmark rule comes later than how it would under the ITFS framework.

For this, we compare the benchmark interest rate rule to the alternative ITFS when the economy is exposed to an adverse risk premium shock. The purpose of this exercise is to demonstrate how the central bank's reaction function, and output and price dynamics can vary across different ITFS rules and different weights on the financial stability indicators. Comparison of alternative ITFS frameworks to a conventional IT rule are provided in Figures 6-7.

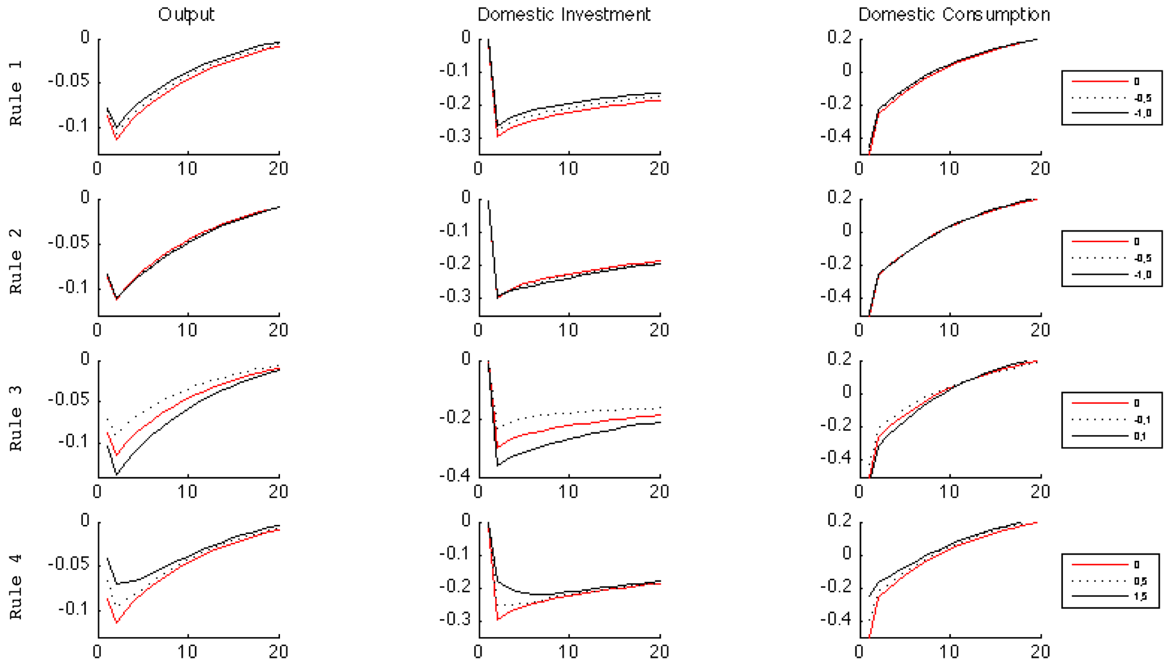
Figure 6. Impulse Response to a Nonfinancial Sector Risk Premium Shock I



Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

Results indicate that ITFS rules do a better job in smoothing business cycle volatility. When the economy is exposed to a rise in the risk premium of the nonfinancial sector's borrowing spread, the central bank responds by more under the ITFS rule than under the ITB framework (Figure 6). As a result, the deviations of real economic indicators, such as output, investment and consumption are smaller in this framework compared to the ITB (Figure 7).[32]

Figure 7. Impulse Response to a Nonfinancial Sector Risk Premium Shock II



Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

However, the performance of financial stability indicators varies (Table 2). While financial stability indicators targeting nonfinancial sector risk premium and credit volume perform better in smoothing the business cycle, they produce higher inflation in the short run. However, the ITFS rule with house prices improves both on output and price stability, since house prices also affect overall consumer inflation.

[32]In all ITFS rules, except the one under scenario two, output volatility is smaller than how it would be under the benchmark case. Scenario two produces similar results as that of ITB.

Table 2. Comparing the Alternative ITFS Rules to the Benchmark Rule

Alternative ITFS Policy Rule	Output Volatility	Inflation Volatility
Financial Premium Shock		
$\rho_\psi = -0.5$	✓	
$\rho_\psi = -1.0$	✓	
$\rho_{\psi b} = -0.5$	✓	✓
$\rho_{\psi b} = -1.0$	✓	✓
$\rho_s = -0.1$		
$\rho_s = 0.1$		
$\rho_{qh} = 0.5$	✓	✓
$\rho_{qh} = 1.5$	✓	✓

Check marks show that the ITFS policy improves volatility relative to ITB.

B. Adverse Shock to Technology and External Demand

As a final exercise, we analyze the transmission of shocks when an adverse supply or external demand shock hits the economy. ITFS rules produce similar results when there is an adverse technology shock (Table 3).[33]

Table 3. Comparing the Alternative ITFS Rules to the Benchmark Rule

Alternative ITFS Policy Rule	Output Volatility	Inflation Volatility
Technology Shock		
$\rho_\psi = -0.5$		
$\rho_\psi = -1.0$		
$\rho_{\psi b} = -0.5$	✓	✓
$\rho_{\psi b} = -1.0$	✓	✓
$\rho_s = -0.1$		
$\rho_s = 0.1$	✓	✓
$\rho_{qh} = 0.5$	✓	✓
$\rho_{qh} = 1.5$	✓	✓
External Demand Shock		
$\rho_\psi = -0.5$		
$\rho_\psi = -1.0$		
$\rho_{\psi b} = -0.5$		
$\rho_{\psi b} = -1.0$		
$\rho_s = -0.1$	✓	✓
$\rho_s = 0.1$		
$\rho_{qh} = 0.5$		
$\rho_{qh} = 1.5$		

Check marks show that the ITFS policy improves volatility relative to ITB.

[33] See Appendix for the impulse response figures of these shocks.

Indeed, a financial shock can be classified as a supply side shock, since it limits the agents' ability to invest and/or consume. However, under a demand shock, this shock is transmitted at the same speed as to the real and financial stability indicators. Therefore, a central bank applying a conventional IT framework does not respond differently from a central bank applying an ITFS framework. Hence, the deviation of output and inflation under ITB and ITFS are similar when a demand shock hits the economy.

VII. Conclusion

The global financial crisis has once again demonstrated that despite strong fundamentals, economies cannot be fully insulated from exogenous shocks. Moreover, financial vulnerabilities that have accumulated in balance sheets during the cycle can amplify the effect of these exogenous shocks on the real economy.

This paper examines the role that refinements in the IT framework can play in strengthening policy frameworks, and proposes alternative IT rules for a central bank that incorporates financial stability indicators. These monetary policy rules focus on systemic vulnerabilities in the financial and nonfinancial sector, which may interact with unanticipated shocks in destabilizing the economy. Under our proposed alternative policy rules, a central bank monitors the level of risk in the nonfinancial sector's borrowing spread, bank leverage, credit volume, or house prices, and reacts by changing its policy rate whenever these indicators deviate away from their desired level.

Incorporating financial stability into a central bank's policy rule should not be seen as a substitute for a more comprehensive macrofinancial framework. An ITFS is a complementary part of this framework. Since the scope of interest rate policy is limited by its objectives, a more comprehensive macrofinancial framework is essential to limit the undesirable effects of sectoral risks affecting the overall economy, such as by monitoring sectoral and systemic risk indicators and using macroprudential tools, consistently within the macrofinancial framework, to avoid any buildup of systemic risks.

Our simulations show that a central bank can do much better by incorporating financial stability to its IT framework, in particular should the distortions come from the supply side. For other distortions affecting the demand side of the economy, an inflation targeting rule with or without financial stability is comparable.

Even though interest rate rules incorporating financial stability smooth output volatility much better than a conventional interest rate rule, for some alternative rules, there are tradeoffs between output gains and inflation convergence to the target. Some ITFS rules, such as the one targeting house prices, can outperform a conventional IT rule both in price and output stability; however, others may lead to tradeoffs between output gains and inflation in the short term.

The ITFS rules in this paper should be interpreted as indicative of the slant of monetary policy rather than for precise estimates of the gains. In this paper, we do not estimate the optimal weights on the ITFS rule or the optimal financial stability indicator. Instead, we analyzed the performance of various financial stability indicators relative to that of a conventional interest rate rule. The purpose of the analysis was to demonstrate the directional impact of interest rate rules when an economy is exposed to unanticipated shocks as in the case of Korea, and to demonstrate that an ITFS rule can improve on an ITB. Future work is aimed at deriving the optimal monetary policy rule incorporating financial stability which is best suited for minimizing both output and price volatility. Of course, arriving at an operational IT rule would require further work along these lines and in other dimensions.

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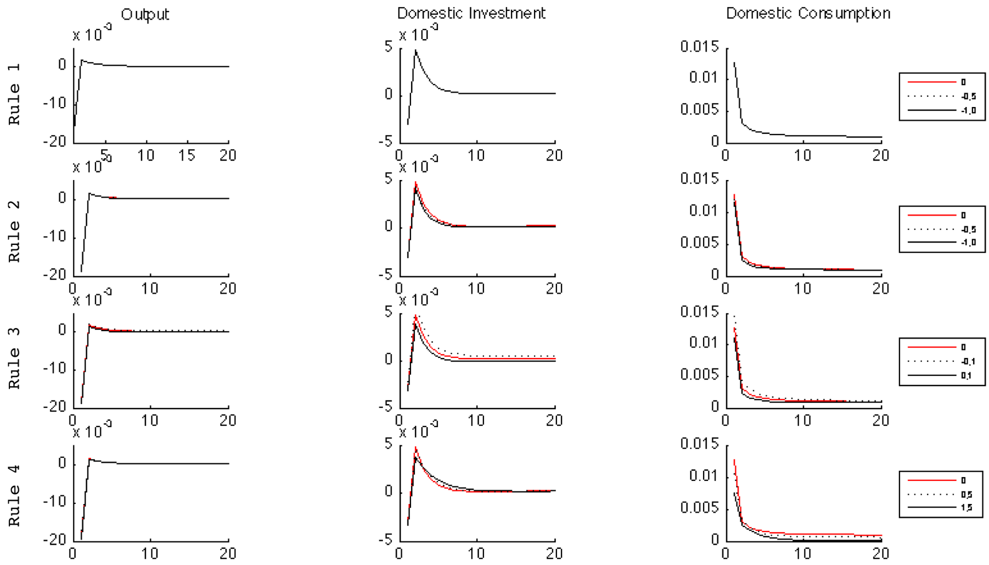
APPENDIX I. FIGURES

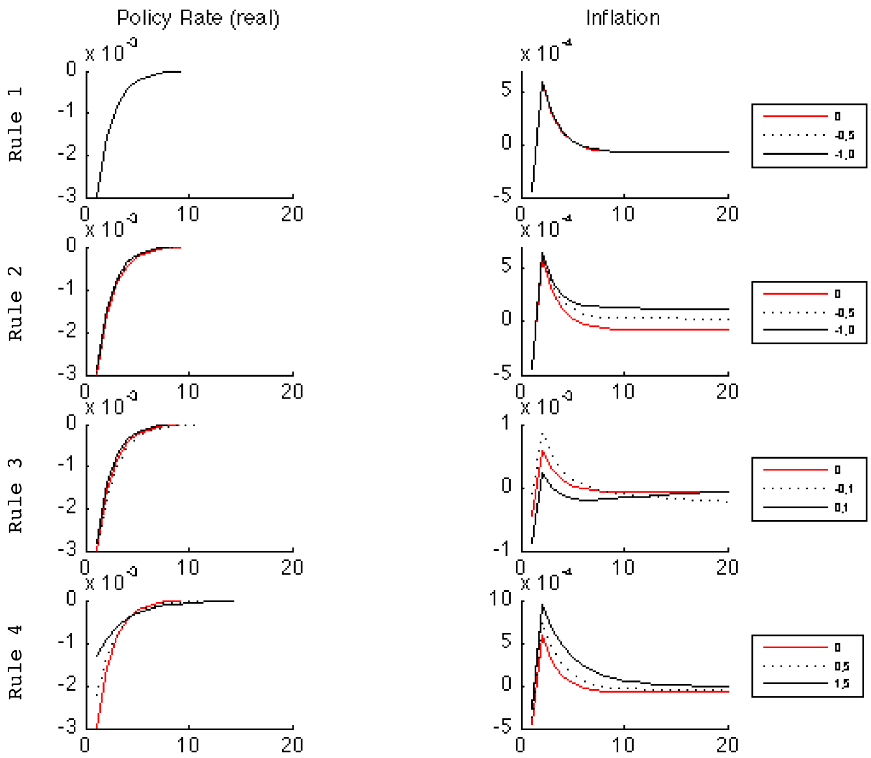
A. Impulse Response Functions

Figure 8. Impulse Response to an Adverse External Demand Shock I



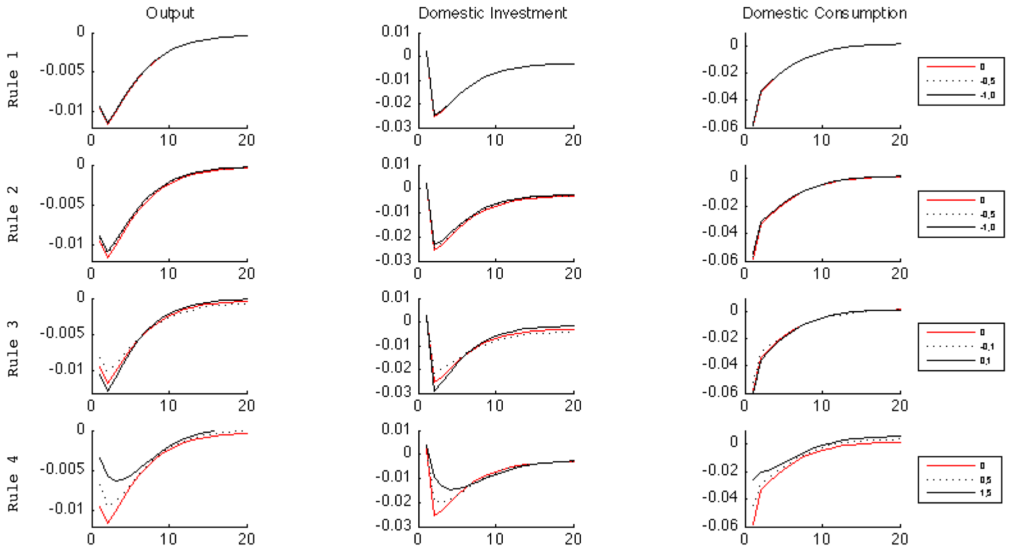
Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

Figure 9. Impulse Response to an Adverse External Demand Shock II



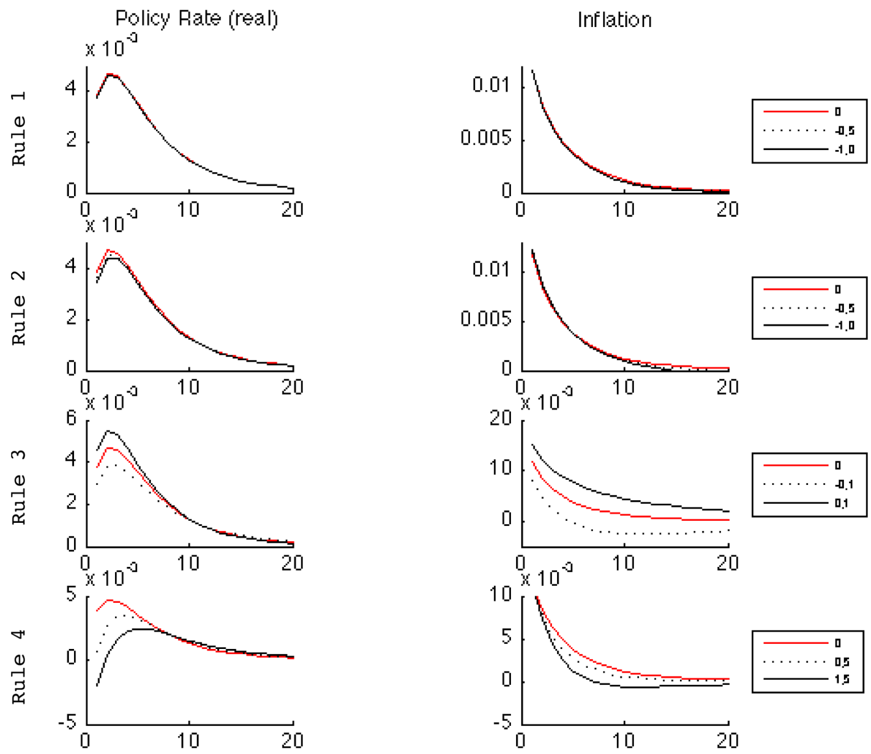
Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

Figure 10. Impulse Response to Adverse Technology Shock I



Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

Figure 11. Impulse Response to Adverse Technology Shock II



Note: Red solid line shows the impulse response under the ITB rule, where the financial stability consideration has a zero weight. The black lines are the impulse responses under the ITFS policy rules with different weight on coefficients as presented in the accompanying legend.

APPENDIX II. KOREAN BANKING SECTOR

As shown in Figure 12, Korean banks obtain more than 85 percent of interest bearing financing in domestic currency, and 70 percent of that borrowing is through deposits. There are several reasons why deposits take the majority of Korean banks financing portfolio. First, domestic savers have limited options to invest overseas. Second, savers have a home country bias since their savings at home are insured through the deposit insurance fund. Third, from banks point of view, borrowing other than deposits is costlier, as shown in Figure 12, since banks need to pay a default premium on the risk that they pose to their investors.

Figure 12. Data on Interest Rates