Bank Globalization and Monetary Policy Transmission in Small Open Economies

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This paper investigates how the openness of banking sector influences the transmission channels of home and foreign monetary policy shocks in small open economies. For the analysis, I construct a small open economy DSGE model enriched with a banking sector. I consider two forms of bank globalization: international bank capital finance and foreign loan account import. From the analysis, I find that bank globalization leads to a significant attenuation of domestic monetary policy transmission. On the other hand, opening of the banking sector intensifies the impact of foreign interest rate shocks on the local bank activities.

Keywords: Bank globalization, Monetary policy, Dynamic stochastic general equilibrium model, Small open economies

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I . Introduction

This paper examines how the openness of the financial sector, particularly of banks, to international capital flows alters the transmission channels of local and international monetary shocks in SOEs. As banking industries become increasingly integrated, local banks in small open economies (hereafter “SOEs”) broaden their operations in international markets, diversifying funding sources and mediating foreign financial products to domestic consumers.¹⁾ To the extent that financial intermediaries are the important bridges between monetary policy (hereafter “MP”) and its macroeconomic policy targets, this changing environment in the banking industry gives rise to active debates about the consequent change of domestic MP transmission in open economies as well as their economic vulnerability to external macroeconomic and financial shocks (e.g., Bernanke, 2007; Cetorelli and Goldberg, 2012; Bruno and Shin, 2015).

The relationship between financial integration and MP transmission is not a new research topic. However, the relevant literature has critical limitations in explaining the consequences of financial integration for MP transmission due to the lack of consideration of the role of the banks in SOEs. Figure 1 shows that financial markets have a higher dependency on banking (Panel A) and that banks play a more vital role in mediating global liquidity to the domestic sector in the financial globalization process in SOEs (Panel B) compared to a large economy, such as the U.S.²⁾ Furthermore, the banking industry has some distinctive features that differ from direct finance markets. For instance, in most countries, financial supervisory authorities impose regulatory requirements on banks to guarantee financial stability (e.g., capital-asset ratio, macro-prudential measures). Banks also enjoy some degree of market power similar to profit

1) Bank globalization in small open economies can be referred to as (i) international banking of local banks through the international financial market and/or (ii) local banking of global banks branches through internal cross-country capital market (e.g. lending and borrowing between a head office and local branches). Throughout the paper, I refer to the former type of international banking activities as bank globalization in order to reflect the characteristics and roles of the banking sector in the process of financial integration in SOEs.

2) This paper focuses on analyzing the economies with autonomous monetary policies and flexible floating exchange rates rather than the ones dollarized. Thus, the countries illustrated in Figure 1 and analyzed in Chapter 2 are chosen because they accord with such features.

Figure 1: Bank Credit to Private Sector and Bank External Debt

Notes: 1. Domestic depository corporations (except central banks)

2. Non-financial corporations, households, and non-profit institutions serving households

Sources: BIS, World Bank (as of the end of 2016Q3)

maximizing firms (Freixas and Rochet, 1997). However, existing studies on financial integration exclusively focus on the broad issues of capital market openness rather than on the stylized facts regarding the financial markets and

the banking sector in SOEs.³⁾ Therefore, the channels through which international banking affects MP transmission are still far from fully understood despite the importance of the topic in the context of the SOE's MP transmission.

To bridge the gap and examine the systemic relationship between bank globalization and MP transmission, I set up and estimate a dynamic general equilibrium model incorporating a stylized banking sector into a SOE version of Iacoviello (2005). The most notable feature of the banking sector in my model is that banks operate international banking through the international interbank market in two common forms: financing *foreign operating funds* and importing *foreign loan contracts*. Each type of international activity is closely related to banks' decisions on setting interest rates and credit supply. Thus, each activity affects the loan rate and the capital position of the local banks. I then study the effect of openness in the banking sector by comparing the results from alternative models that shut down each globalization channel sequentially.

The findings of the estimated DSGE model support Rey (2015)'s dilemma view as follows.⁴⁾ First, bank globalization attenuates local MP transmission. In case of a monetary tightening shock⁵⁾, on one hand, loan rates increase less in response to a negative monetary shock compared to the responses in financial autarky (referred to as *foreign interest rate channel*). It is because banks set the loan rates by taking into account not only increased domestic policy rates but also unaffected international interest rates as well as appreciation of real exchange rate. A lower rise in loan rates first mitigates interest rate channel and alleviates the financial accelerator effect by not reducing the real value of borrowers' outstanding debt obligations as much. On the other hand, banks'

3) For instance, Woodford (2007) and Tille (2008) analyze the effects of financial globalization on the transmission of monetary shocks without attention to the role of financial intermediaries under the assumption of a frictionless MP transmission through domestic financial markets acting as conventional New Keynesian frameworks.

4) Rey (2015) points out that US dollar is world-wide used as a funding and investment currency and argues that this creates a global financial cycle. Thus, US financial conditions, including US MP shocks, can influence the rest of the world through global financial intermediaries and their leverage. Under the circumstances, autonomous monetary policy can be achieved only when capital flow is controlled and the exchange rate is freely floating, unlike the traditional view of Mundellian trilemma.

5) Note that a monetary easing shock has symmetric effects on the model economy.

international operation deters themselves from reducing their issuance of loans after a monetary contraction, thereby attenuating the transmission of MP shock (*foreign liquidity channel*). In financial autarky, the decline of deposits following policy rate rises pressures banks to reduce their supplies on bank loans to meet the capital-asset ratio. This reduction leads to a decline in household and firm activities. However, the availability of foreign liquidity due to a globalized banking can buffer the shrinkage of bank assets to some extent against negative policy effects.

Second, bank globalization induces bank rates to respond more strongly to foreign MP shocks. In the alternative model without international banking, foreign monetary shocks affect domestic retail loan rates only indirectly through the adjustment of the local policy rate according to a no-arbitrage condition in the foreign exchange market or exchange rate pass-through. However, if banks can import foreign loan accounts and thus set loan rates taking into account the domestic policy rate, international interbank rates and real exchange rate, a new channel is opened, in addition to the aforementioned indirect channels, through which foreign monetary surprise can directly influence local loan rates. This new channel is empirically supported by recent findings in Passari and Rey (2015), showing that mortgage spread in SOEs responds positively to U.S monetary shocks with the same degree of magnitude as the domestic U.S mortgage spread.

This paper contributes to the literature in the following ways. First, to the best of my knowledge, this paper is the first to demonstrate a direct link between bank globalization and MP transmission under the general equilibrium framework enriched with a stylized banking sector. In addition to international banking activities, the model adopts regulatory interventions when obtaining bank liabilities and market power in the banking sector. Over the last decade, a growing number of studies have investigated the role of these features in the banking sector in MP transmission.⁶⁾ Scholars researching the role of the

6) A burgeoning literature sheds light on the conditions from the supply side (i.e. financial intermediaries) of credit markets (Van den Heuvel 2008, Gerali et al. 2010). These studies demonstrate the channels in which typical MP transmission can be distorted by credit frictions embedded in the process of financial intermediaries money mediation, such as the regulatory capital-to-asset ratio (*bank capital channel*) and/or the degree of banking market competition (*bank attenuator channel*).

banking sector in open capital markets are increasingly investigating the role of financial integration in cross-border propagation of liquidity shock.⁷⁾ However, relatively less studies have paid attention to how bank globalization alters the channels of MP transmission under the structures, particularly in the theoretical literature. Most closely related to my study are the studies of Cetorelli and Goldberg (2012) and Goldberg (2013), who empirically demonstrate that global banks isolate themselves from the impact of monetary surprises through their abilities to raise funds abroad as well as influence MP autonomy heterogeneously, depending on the frictions in the international capital market and the stickiness of claims. Although successful in providing some empirical evidence of the relationship between bank globalization and MP transmission, these researchers do not explain why such a link is formulated and how it affects other sectors, in part because of their partial equilibrium approaches. Conversely, this paper investigates the overall change in the supply side of the credit market to uncover the role of bank globalization in MP transmission in a general equilibrium framework.

Second, this paper provides an analysis by subdividing and quantitatively assessing the effects of international banking on MP transmission. The link between bank globalization and MP transmission is ambiguous a priori in the sense that bank globalization involves an adjustment of banks' overall conditions for money mediation. For instance, in the open banking market, banks do not necessarily rely on the domestic credit in their operation. This may change their strategies on interest rate setting and capital position. Two common forms of international banking operation, loan contract import and foreign liquidity borrowing, allow us to understand the detailed effects of banking sector openness.⁸⁾ By determining the effect of each form, this study shows how bank globalization affects MP transmission and which channel is dominant. Each form directly affects loan rates and banks' capital position. By contrast, existing studies

7) See recent work on the international transmission of crises by Schnabl 2012, Kalemli-Ozcan, Papaioannou and Perri 2013, Devereux and Yu 2014, Kang and Dao 2012 and others.

8) Rosenberg and Tirpak (2008) point out the main drivers of banks' foreign currency borrowing: the demand for foreign currency payments in international trade, the domestic capital shortage caused by credit expansion, and interest rate differentials between local and foreign currency.

that incorporate a banking sector into the model usually consider only one side, thereby providing a limited perspective for understanding the overall features of change caused by bank globalization (e.g., credit amount: Kollmann, 2013; Kang and Dao, 2012; interest rate: Brzoza-Brzezina and Makarski, 2011).

The rest of this paper is organized as follows. Section 2 presents empirical evidence on bank globalization using a VAR model. Section 3 describes the baseline SOE DSGE model. Section 4 discusses the calibration/estimation procedure. Section 5 provides an overview of the transmission mechanism of MP shocks through the banking sector and the results of domestic and international monetary contraction. Section 6 concludes the paper.

II. Vector Autoregressive (VAR) Analysis

Before describing the theoretical channels of interaction between international banking and MP transmission, this section first documents the key relationship in data, specifically between monetary shocks and bank lending rates, by giving an overview of VAR evidence. The VAR model is composed of the U.S. federal funds rate, logs of seasonally adjusted industrial production, logs of domestic consumer price indexes, domestic policy rates, short-term (3-month) interest rates, bank lending rates, and logs of nominal exchange rates. The three focal countries—the U.K., Korea, and Canada—are representative SOEs that depend heavily on world economies, approximated here by the U.S., from both macroeconomic and financial market aspects. To identify a stable MP regime, the following quarterly data are used for each country: Canada (1996Q1~2013Q4), Korea (1999Q1~2013Q4), New Zealand (1992Q1~2013Q4), Switzerland (1992Q1~2013Q4) and the U.K. (1997Q1~2013Q4). The lag order is determined by two quarters for all focal countries according to various information criteria. These SOEs are more largely dependent upon the banking sector in intermediating credit domestically and internationally than the U.S., as depicted in Figure 1. Furthermore, these countries have adopted inflation targeting regimes and adjusted short-term interest rates as MP operating

instruments. For comparative purpose, I also estimate a similar model with U.S. data as a benchmark. Four external variables—a crisis dummy, the international commodity price index, the dollar index, and VIX index—are added to insulate exogenous components that may affect endogenous variables in the VAR system contemporaneously (e.g., Kim, 2001; Bjørnland, 2009).

I use a standard Cholesky decomposition to identify VAR (ordered listed as above).⁹⁾ For convenience of comparison, I graph all of the impulse responses of the interest rates to one percentage point of domestic MP shock in each panel in Figure 2. The shaded area plotted in the graph is the 90% bootstrap probability band of loan rate response. Overall, the scales of the effect are shown to be smaller in bank loan rates (red line) than those in policy rates (black line) and short-term rates (blue line) at the time of a contractionary MP shock in SOEs except Canada. Notably, this feature is distinct from the responses in the U.S. (Panel A) where loan rates react similarly to the movement of the federal fund rate. The fact that the bank rates react less to policy shock could be because the banking sector in focal countries has some degree of market power (Gerali et al., 2010; Ha and So, 2013). However, as we shall see in Section 5, the attenuation of MP transmission in banking could also appear due to the bank's international activity.

Figure 3 plots the impulse responses of the domestic policy rate (black line) and loan rates (red line) to one percentage point of foreign (U.S.) MP shock. Many open economy studies typically assume that foreign monetary shocks transmit internationally through the adjustment of short-term rates in a SOE according to interest rate parity (Obstfeld and Rogoff, 1995; Kim, 2001). Considering the international transmission channel as well as the frictions in the banking sector found above, the response of loan rates to foreign monetary shock is predicted to be less than that of the home policy rate (foreign MP shock $\rightarrow$ SOE policy rate $\rightarrow$ (frictions) $\rightarrow$ SOE loan rates). However, the result

9) I test the robustness of the identifying short-run restriction by specifying an alternative ordering of variables, specifically the SOE's interest rates, to consider the simultaneity issues raised among financial variables (Gertler and Karadi 2015, Bjørnland 2009). The results stay robust to these variations.

Figure 2: Impulse Responses of Interest Rates to Domestic MP Shock (1%p)

Notes: Shaded area is 90% bootstrap interval (based on 5,000 draws) of domestic loan rate response.

Figure 3: Impulse Responses of Interest Rates to Foreign MP Shock (1%p)

Notes: Shaded area is 90% bootstrap interval (based on 5,000 draws) of domestic loan rate response.

of VAR seems to be inconsistent with the prediction of this framework. Loan rates in SOEs respond to foreign MP shock as much as policy rates except the Switzerland where its response is significantly lower than the policy rate. This result may indicate the presence of additional channels of international monetary transmission to local loan rates (foreign MP shock $\rightarrow$ SOE loan rates) besides indirect transmission through the SOE policy rate. A theoretical model will be described in next section.

III. Model

The world economy is composed of a continuum of SOEs that are represented by the unit interval. Each SOE is populated by patient households, impatient households, entrepreneurs, and banks, with each group having a unit mass. Households consume, work, accumulate housing stock, and make one-period deposits (patient households) or take out one-period loans (impatient households).¹⁰⁾ Entrepreneurs produce homogenous intermediate goods using capital, real estate, and labor supplied by households. Furthermore, entrepreneurs can also borrow from banks to finance capital purchases. In between the households and the entrepreneurs, banks intermediate funds by supplying financial assets while enjoying some degree of monopoly power. They give out collateralized loans to both impatient households and entrepreneurs, and obtain funding via deposits and foreign liquidity borrowing.

Three types of frictions coexist and interact in the financial sector. First, when having a bank loan, borrowers face a collateral constraint which is tied to the present value of their housing stock. Second, banks face credit constraints in how much they can raise from home depositors and foreign economies. Third, due to a bank's market power, bank rates on loans and deposits are set differently from the domestic interbank rate.

10) I consider heterogeneity in households to apply financial frictions to both firms and households (e.g. Iacoviello, 2005; Gerali et al., 2010). Under the assumption of different agents' discount factors, this set-up allows positive flows of fund among agents (patient households $\rightarrow$ banks $\rightarrow$ impatient households and entrepreneurs).

Figure 4: Model Structure

1. Patient Households

A continuum of patient households consume composite good $c_{P,t}$ and housing $h_{P,t}$, deposit d_t , and supply labor $n_{P,t}$. The expected utility of a representative patient household is given as

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \left[\ln c_{P,t} + j_t \ln h_{P,t} - (n_{P,t})^\eta / \eta \right] \quad (1)$$

where E_0 is a conditional expectation at $t=0$, β_P is the utility discount factor and η is the elasticity of marginal utility of labor. j_t is a random variable which reflects the change in housing preference. It follows an AR(1) process with i.i.d. normal innovations such as Eq (2).

$$\ln j_t = (1 - \theta_j) \ln j + \theta_j \ln j_{t-1} + \varepsilon_{j,t}, \varepsilon_{j,t} \sim N(0, \sigma_j^2) \quad (2)$$

The patient households use labor income $w_{P,t} n_{P,t}$ and dividend income $\Pi_{P,t}^E$ and $\Pi_{P,t}^B$ generated from owning firms and banks, respectively, as well as its

real principal and interest income from deposits $R_{d,t-1}d_{t-1}/\pi_t$ ¹¹⁾ to finance their consumption, housing and deposits. The patient household's budget constraint (in real terms) is

$$c_{P,t} + q_t h_{P,t} + d_t \leq w_{P,t} n_{P,t} + q_t h_{P,t-1} + \frac{R_{d,t-1}}{\pi_t} d_{t-1} + \Pi_{P,t}^E + \Pi_{P,t}^B \quad (3)$$

where q_t and π_t denote, respectively, the price of housing and the inflation rate. Solving this problem yields first-order conditions for the consumption Euler equation, housing demand and labor supply:

$$\frac{1}{c_{P,t}} = E_t \left[\frac{\beta_P}{c_{P,t+1}} \frac{R_{d,t}}{\pi_{t+1}} \right] \quad (4)$$

$$\frac{q_t}{c_{P,t}} = \frac{j_t}{h_{P,t}} + E_t \left[\beta_P \frac{q_{t+1}}{c_{P,t+1}} \right] \quad (5)$$

$$w_{P,t} = (n_{P,t})^{\eta-1} c_{P,t} \quad (6)$$

Notice that the consumers' consumption aggregate is determined as a constant elasticity of substitution (CES) index composed of both home c_t^H and import goods c_t^F :

$$c_t = \left[a^{\frac{1}{\omega}} (c_t^H)^{\frac{\omega-1}{\omega}} + (1-a)^{\frac{1}{\omega}} (c_t^F)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}} \quad (7)$$

where a and $\omega > 0$ are the home bias parameter and intra-temporal elasticity of substitution (EOS) between home and import consumption goods, respectively. Composites for domestic and foreign goods are defined as

$$c_t^H = \left[\int_0^1 (c_t^H(z))^{\frac{\varepsilon^H-1}{\varepsilon^H}} dz \right]^{\frac{\varepsilon^H}{\varepsilon^H-1}} \quad \text{and} \quad c_t^F = \left[\int_0^1 (c_t^F(z))^{\frac{\varepsilon^F-1}{\varepsilon^F}} dz \right]^{\frac{\varepsilon^F}{\varepsilon^F-1}}, \quad \text{and} \quad \varepsilon^H$$

11) Similar to Iacoviello (2005), I assume that deposit and loan contracts are set in nominal terms. Here, $R_{d,t}$ is a gross return and π_t is the price change between $t-1$ and $t (= P_t/P_{t-1})$.

and $\varepsilon^F > 1$ are the EOSs across goods.¹²⁾ Given the CES aggregator, the demand for domestic goods and the demand for imports are represented as follows.

$$c_t^H = a \left(\frac{P_t^H}{P_t} \right)^{-\omega} c_t \quad \text{and} \quad c_t^F = (1-a) \left(\frac{P_t^F}{P_t} \right)^{-\omega} c_t$$

where the corresponding price index is

$$P_t = \left[a (P_t^H)^{1-\omega} + (1-a) (P_t^F)^{1-\omega} \right]^{\frac{1}{1-\omega}}$$

2. Impatient Households

Similar to patient households, impatient households consume goods $c_{I,t}$ and housing $h_{I,t}$ and supply labor $n_{I,t}$. The impatient households maximize the following expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \beta_t^I \left[\ln c_{I,t} + j_t \ln h_{I,t} - (n_{I,t})^\eta / \eta \right] \quad (8)$$

However, they use labor income and new loans $b_{I,t}$ to finance consumption, housing and the reimbursement of loans borrowed in the previous period $R_{b_{I,t-1}} b_{I,t-1} / \pi_t$. In addition, they can borrow only up to a certain portion (m_I) of the expected real value of their housing stock. The budget constraint and the borrowing constraint are

$$c_{I,t} + q_t h_{I,t} + \frac{R_{b_{I,t-1}}}{\pi_t} b_{I,t-1} \leq w_{I,t} n_{I,t} + q_t h_{I,t-1} + b_{I,t} \quad (9)$$

$$R_{b_{I,t}} b_{I,t} \leq m_I E_t \left[q_{t+1} h_{I,t} \pi_{t+1} \right] \quad (10)$$

12) For simplicity, the model does not distinguish between EOS between individual goods and EOS between home and import goods (Obstfeld and Rogoff, 1995).

where m_I is household's loan-to-value (LTV) ratio. The first-order conditions of impatient households are consumption, housing choice and labor supply.

$$\frac{1}{c_{I,t}} = E_t \left[\frac{\beta_I}{c_{I,t+1}} \frac{R_{bl,t}}{\pi_{t+1}} \right] + \lambda'_{I,t} R_{bl,t} \quad (11)$$

$$\frac{q_t}{c_{I,t}} = \frac{j_t}{h_{I,t}} + E_t \left[\beta_I \frac{q_{t+1}}{c_{I,t+1}} + \lambda'_{I,t} m_I q_{t+1} \pi_{t+1} \right] \quad (12)$$

$$\frac{w_{I,t}}{c_{I,t}} = (n_{I,t})^{\eta-1} \quad (13)$$

where $\lambda'_{I,t}$ is the Lagrangian multiplier of borrowing constraint.

3. Entrepreneurs

Entrepreneurs care only about their consumption $c_{E,t}$, and they maximize the following expected utility.

$$E_0 \sum_{t=0}^{\infty} \beta_E^t \ln c_{E,t} \quad (14)$$

Entrepreneurs produce homogeneous intermediate goods $y_{W,t}$ with labor hired from households, capital k_t accumulated through investment, and real estate $h_{E,t}$ by using a Cobb-Douglas type technology as shown in Eq (15). A_t is total factor productivity, which follows an exogenous AR(1) process.¹³⁾

$$y_{W,t} = A_t (k_{t-1})^{\mu} (h_{E,t-1})^{\nu} \left[(n_{P,t})^{\alpha} (n_{I,t})^{1-\alpha} \right]^{1-\mu-\nu} \quad (15)$$

Entrepreneurs finance their consumption, real estate, labor services, capital accumulation and reimbursement of loans by obtaining the revenue from their intermediate goods sales and taking out new loans $b_{E,t}$.

13) The AR(1) coefficient is θ_A , and the standard deviation is σ_A .

$$c_{E,t} + i_t + w_{P,t} n_{P,t} + w_{I,t} n_{I,t} + q_t h_{E,t} + \frac{R_{bE,t-1}}{\pi_t} b_{E,t-1} + \xi_{K,t} \leq \frac{y_{W,t}}{x_t} + q_t h_{E,t-1} + b_{E,t} \quad (16)$$

where it $i_t (= k_t - (1 - \delta)k_{t-1})$ is investment, $x_t (= P_t/P_{W,t})$ is the mark-up of final over wholesale goods, and $\xi_{K,t} = \frac{\kappa_i}{2\delta} \left(\frac{i_t}{k_{t-1}} - \delta \right)^2 k_{t-1}$ is the convex capital stock adjustment cost. Additionally, the amount of loans that entrepreneurs can borrow from banks must be less than a certain portion (m_E) of the expected value of their real estate.¹⁴⁾

$$R_{bE,t} b_{E,t} \leq m_E E_t [q_{t+1} h_{E,t} \pi_{t+1}] \quad (17)$$

Entrepreneurs' first-order conditions are the consumption Euler equation, capital demand, real estate demand and labor demands.

$$\frac{1}{c_{E,t}} = E_t \left[\frac{\beta_E}{c_{E,t+1}} \frac{R_{bE,t}}{\pi_{t+1}} \right] + \lambda'_{E,t} R_{bE,t} \quad (18)$$

$$\frac{1}{c_{E,t}} \left(1 + \frac{\kappa_i}{\delta} \left(\frac{i_t}{k_{t-1}} - \delta \right) \right) \quad (19)$$

$$= E_t \left[\frac{\beta_E}{c_{E,t+1}} \left(1 - \delta + \mu \frac{y_{W,t+1}}{x_{t+1}} \frac{1}{k_t} + \frac{\kappa_i}{\delta} \left(\frac{i_{t+1}}{k_t} - \delta \right) \left(\frac{1}{2} \left(\frac{i_{t+1}}{k_t} + \delta \right) + 1 - \delta \right) \right) \right]$$

$$\frac{q_t}{c_{E,t}} = E_t \left[\frac{\beta_E}{c_{E,t+1}} \left(q_{t+1} + \frac{y_{W,t+1}}{x_{t+1}} \nu \frac{1}{h_{E,t}} \right) \right] + \lambda'_{E,t} m_E E_t [q_{t+1} \pi_{t+1}] \quad (20)$$

$$w_{P,t} = \alpha(1 - \mu) \frac{y_{W,t}}{x_t} \frac{1}{n_{P,t}} \quad (21)$$

$$w_{I,t} = (1 - \alpha)(1 - \mu) \frac{y_{W,t}}{x_t} \frac{1}{n_{I,t}} \quad (22)$$

14) I assume that firms use real estate as collateral as in Iacoviello (2005), noting that firms in SOEs are usually requested to provide real estate, including housing and land, to banks as collateral rather than capital. For example, as of late 2008 in Korea, real estate comprised 88% of the total collateral value pledged by firms and 94% of that pledged by households (Ha and So 2013).

4. Firms

There are two sets of firms. Firms in the import goods sector purchase foreign intermediate goods at given world prices P_t^* and transform them into differentiated import goods y_t^F , whereas firms in the home goods sector produce differentiated goods y_t^H using domestic intermediate goods purchased at the wholesale price $P_{W,t}$ from entrepreneurs at no cost. Each firm z then sells their unique variety at a mark-up over world price or wholesale price. Both face a quadratic price adjustment cost, as in Rotemberg (1982).¹⁵⁾

The domestic firm z would set price $P_t^H(z)$ for the domestic goods to maximize the net present value of future profits

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E \left[P_t^H(z) y_t^H(z) - P_{W,t} y_t^H(z) - \frac{\kappa_p^H}{2} \left(\pi_t^H(z) - (\pi_{t-1}^H)^\zeta (\pi^H)^{1-\zeta} \right)^2 P_t^H y_t^H \right] \quad (23)$$

subject to the demand function, $y_t^H(z) = \left(\frac{P_t^H(z)}{P_t^H} \right)^{-w} y_t^H$.¹⁶⁾ $\Lambda_{0,t}^E$ is an inter-temporal discount rate between time 0 and t . Note that the firm is owned by patient households so that inter-temporal discount rate is taken from the problems of patient households. I assume that the price of home goods is indexed to past and steady-state inflation, with relative weights parameterized by ζ and $1 - \zeta$, respectively. Firms in the domestic sector must pay a quadratic cost of price adjustment when they change their prices beyond indexation. κ_p^H is an adjustment cost parameter. After imposing symmetry, the first-order condition yields the following hybrid Phillips curve in the home goods market.

15) Calvo-pricing and Rotemberg-pricing are two widely used assumptions in the New-Keynesian literature for price stickiness. To a first order of approximation, both pricing assumptions yield similar dynamics of the economy. However, it is well known that, at a higher order of approximation, these assumptions entail different welfare costs. See Blanchard and Fischer (1989 Ch. 8.2), and Lombardo and Vestin (2008) for further details.

16) An index for the aggregate output for each country is assumed to be analogous to the one introduced for consumption.

$$1 - \omega + \frac{\omega}{x_t} - \kappa_p^H \left(\pi_t^H - (\pi_{t-1}^H)^\zeta (\pi^H)^{1-\zeta} \right) \pi_t^H \quad (24)$$

$$+ \beta_p \frac{c_{p,t}}{c_{p,t+1}} \kappa_p^H E_t \left[\left(\pi_{t+1}^H - (\pi_t^H)^\zeta (\pi^H)^{1-\zeta} \right) (\pi_{t+1}^H)^2 \frac{y_{t+1}^H}{y_t^H} \right] = 0$$

As shown in Eq (25), log-linearizing Eq (24) (with hat representing the log deviation from the steady state) indicates that domestic inflation is driven by past and future inflation, and mark-up rate.

$$\widehat{\pi}_t^H = -\frac{\omega - 1}{\kappa_p^H (1 + \beta_p \zeta)} \widehat{x}_t + \frac{\beta_p}{1 + \beta_p \zeta} E_t \widehat{\pi}_{t+1}^H + \frac{\zeta}{1 + \beta_p \zeta} \widehat{\pi}_{t-1}^H \quad (25)$$

where $\widehat{\pi}_t^H$ is the inflation of home goods defined as the price change of domestic goods between t and $t-1$, i.e. $\widehat{\pi}_t^H \equiv \widehat{P}_t^H - \widehat{P}_{t-1}^H$.

As with the price of home goods, the price of imported goods is sticky. Importing firms face a quadratic adjustment cost when they determine the prices for import $P_t^F(z)$ to maximize the profit

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E \left[P_t^F(z) y_t^F(z) - e_t P_t^*(z) y_t^F(z) - \frac{\kappa_p^F}{2} \left(\pi_t^F(z) - (\pi_{t-1}^F)^\zeta (\pi^F)^{1-\zeta} \right)^2 p_t^F y_t^F \right] \quad (26)$$

subject to $y_t^F(z) = \left(\frac{P_t^F(z)}{P_t} \right)^{-w} y_t^F$. κ_p^F is the adjustment cost parameter measuring the degree of price rigidity for imported good. The first-order condition for the import goods market is obtained as Eq (27), or log-linearized expression (28).

$$1 - \omega + \omega \psi_t - \kappa_p^F \left(\pi_t^F - (\pi_{t-1}^F)^\zeta (\pi^F)^{1-\zeta} \right) \pi_t^F \quad (27)$$

$$+ \beta_p \frac{c_{p,t}}{c_{p,t+1}} \kappa_p^F E_t \left[\left(\pi_{t+1}^F - (\pi_t^F)^\zeta (\pi^F)^{1-\zeta} \right) (\pi_{t+1}^F)^2 \frac{y_{t+1}^F}{y_t^F} \right] = 0$$

$$\widehat{\pi}_t^F = \frac{\omega - 1}{\kappa_P^F (1 + \beta_P \zeta)} \widehat{\psi}_t + \frac{\beta_P}{1 + \beta_P \zeta} E_t \widehat{\pi}_{t+1}^F + \frac{\zeta}{1 + \beta_P \zeta} \widehat{\pi}_{t-1}^F \quad (28)$$

where $\psi_t = e_t P_t^* / P_{F,t}$ denotes the law of one price (LOP) gap defined as the difference between the world price and domestic price of imports, and π_t^F is the inflation of imported goods denominated in home currency. Price change of imported goods is thus determined by past and future inflation, and deviations from LOP.

5. Inflation, Real Exchange Rate and Terms of Trade

In an open economy, CPI inflation π_t is distinct from home goods inflation π_t^H because the price of imported goods influences the domestic economy. From the definition of CPI, the log-linearized expression of π_t can be expressed as

$$\widehat{\pi}_t = a \widehat{\pi}_t^H + (1 - a) \widehat{\pi}_t^F \quad (29)$$

The terms of trade, which are defined as the relative prices of home goods to imported goods, i.e., $S \equiv P_t^H / P_t^F$, are linked to home goods inflation and CPI inflation according to

$$\widehat{\pi}_t = \widehat{\pi}_t^H - (1 - a) \Delta \widehat{S}_t \quad (30)$$

I assume that LOP does not hold. Deviations from purchasing power parity (PPP) in this model arises from deviation from LOP. The real exchange rate $Q_t (\equiv e_t P_t^* / P_t)$ can be expressed as

$$\widehat{Q}_t = a \widehat{S}_t + \widehat{\psi}_t \quad (31)$$

6. Banks

Banks, as an intermediary, are in charge of all financial transactions among households and entrepreneurs in the model economy. To capture the market power in the banking sector, banks are assumed to be monopolistically competitive. Each bank j is composed of a retail and a wholesale unit, and each unit can access domestic and international interbank markets. The retail branch obtains funding by purchasing differentiated deposits from patient households and provides differentiated loans made from credits taken in the domestic and international interbank markets to impatient households and entrepreneurs. The wholesale branch manages the capital position of the bank using the asset and liability raised in the domestic and international interbank markets while providing financial instruments to its retail unit. They also face regulatory intervention in their operations, such as capital adequacy constraints and foreign debt requirements.

6.1. Loan and Deposit Demand

I model monopoly power in the banking industry with a Dixit-Stiglitz framework after Gerali et al (2010). First, I assume that a unit of deposit contracts purchased by patient households is a composite constant elasticity of substitution (CES) basket of differentiated deposits supplied by a bank j .¹⁷⁾

$$d_t = \left[\int_0^1 d_t(j)^{\frac{\varepsilon_d - 1}{\varepsilon_d}} dj \right]^{\frac{\varepsilon_d}{\varepsilon_d - 1}} \quad (32)$$

where ε_d is an elasticity of substitution of deposits. The demand for deposit as the outcome of the banks' deposit-taking operation can be derived by solving the cost minimization problem. Banks sell deposit contracts at the price $1/R_d$. Thus,

17) For simplicity, I treat the EOSs between deposits and between loans as exogenously determined.

minimizing over $d_t(j)$ the gross interest payment given by the formula (33) subject to (32) yields the demand for deposits of patient households.¹⁸⁾

$$\int_0^1 \frac{1}{R_{d,t}(j)} d_t(j) dj \quad (33)$$

Similarly to deposits, I assume that loan contracts purchased by impatient households and entrepreneurs are a composite CES basket of differentiated loans intermediated by a bank j .

$$b_{s,t} = \left[\int_0^1 b_{s,t}(j)^{\frac{\varepsilon_{bs}-1}{\varepsilon_{bs}}} dj \right]^{\frac{\varepsilon_{bs}}{\varepsilon_{bs}-1}} \quad (34)$$

for $s = I, E$. ε_{bs} denotes an elasticity of substitution of loans. Demand for loans to impatient households and firms can be obtained from maximizing over $b_{s,t}(j)$ the gross loan revenue given by

$$\int_0^1 R_{bs,t}(j) b_{s,t}(j) dj \quad (35)$$

subject to (34).

The demand for deposits and the demand for loans are

$$d_t(j) = \left(\frac{R_{d,t}(j)}{R_{d,t}} \right)^{\varepsilon_d} d_t \quad (36)$$

$$b_{s,t}(j) = \left(\frac{R_{bs,t}(j)}{R_{bs,t}} \right)^{-\varepsilon_{bs}} b_{s,t} \quad (37)$$

6.2 Wholesale Branch

The perfectly competitive wholesale branch controls the balance sheet position of the bank. On the liability side, the wholesale branch takes wholesale deposits

¹⁸⁾ Note that this formulation is equivalent to a formulation where banks maximize profit from taking deposits defined

as $\frac{1}{R_{d,t}} d_t - \int_0^1 \frac{1}{R_{d,t}(j)} d_t(j) dj$

d_t through retail units and raises foreign funds l_t^F on the international interbank market. On the asset side, the branch gives out wholesale loans $b_{I,t}^H$ and $b_{E,t}^H$ to retail branch.

A wholesale unit maximizes the expected utility (38) over $c_{B,t}, d_t, b_{I,t}, b_{E,t}$, and l_t^F

$$E_0 \sum_{t=0}^{\infty} \beta_B^t \ln c_{B,t} \quad (38)$$

subject to budget constraint:

$$\begin{aligned} c_{B,t} + \frac{R_{t-1}^{IB}}{\pi_t} d_{t-1} + b_{I,t}^H + b_{E,t}^H + Q_t \frac{R_{t-1}^{IB*}}{\pi_t} l_{t-1}^F \\ \leq d_t + \frac{R_{t-1}^{IB}}{\pi_t} (b_{I,t-1}^H + b_{E,t-1}^H) + Q_t l_t^F - \xi_{d,t} - \xi_{bI,t} - \xi_{bE,t} - \xi_{l,t} \end{aligned} \quad (39)$$

where $c_{B,t}$ is the wholesale unit's consumption, R_t^{IB} and R_t^{IB*} are domestic and international interbank rates,¹⁹⁾ and $\xi_{d,t} \equiv \frac{\phi_d}{2} (\Delta d_t)^2$, $\xi_{bI,t} \equiv \frac{\phi_{bI}}{2} (\Delta b_{I,t}^H)^2$, $\xi_{bE,t} \equiv \frac{\phi_{bE}}{2} (\Delta b_{E,t}^H)^2$, and $\xi_{l,t} \equiv \frac{\phi_l}{2} (\Delta l_t^F)^2$ are quadratic portfolio adjustment costs.²⁰⁾ To reflect the standard capital requirements that are imposed on banks, I assume that the amount of capital (total asset $b_{I,t} + b_{E,t}$ minus liabilities $d_t + Q_t l_t^F$) must be greater than a certain portion $(1 - \gamma)$ of its asset, as in (40). Additionally, the bank's borrowing in the international interbank market cannot exceed a certain portion (m_F) of the net value of domestic capital (total asset $b_{I,t} + b_{E,t}$ minus domestic liability d_t), as in (41).²¹⁾

19) I assume that banks can access unlimited finance at interbank rate R_t^{IB} supplied by the central bank. Thus, by arbitrage, the wholesale bank rates are equal to the domestic interbank rate.

20) Note that I assume that a wholesale unit maximizes its utility rather than profit. This assumption is to consider this unit's role in managing the capital position in a more general form. FOCs derived from this setup are identical to the ones from profit maximization. See Iacoviello (2015) and Kang and Dao (2012) for instance. Additionally, the introduction of portfolio adjustment costs in the model helps to characterize real world financial frictions and derives the supply and demand of financial contracts. It also resolves the non-stationarity problem of the SOE model with incomplete financial markets. See Schmitt-Grohe and Uribe (2003) for details.

21) Similar assumptions on bank constraints are adopted by Iacoviello (2015) and Kang and Dao (2012). In practice, this type of capital control is regarded as the FX-related prudential measure (Ostry et al. 2011).

$$d_t + Q_t l_t^F \leq \gamma (b_{I,t} + b_{E,t}) \quad (40)$$

$$Q_t l_t^F \leq m_F (b_{I,t} + b_{E,t} - d_t) \quad (41)$$

The first-order conditions are banks' credit supply to households and entrepreneurs and demand for foreign bank liquidity.

$$\frac{1 - \phi_d (d_t - d_{t-1})}{c_{B,t}} = E_t \left[\frac{\beta_B}{c_{B,t+1}} \left(\frac{R_t^{IB}}{\pi_{t+1}} - \phi_d (d_{t+1} - d_t) \right) \right] - \lambda'_{B,t} - \lambda''_{B,t} m_F \quad (42)$$

$$\frac{1 + \phi_{bI} (b_{I,t} - b_{I,t-1})}{c_{B,t}} = E_t \left[\frac{\beta_B}{c_{B,t+1}} \left(\frac{R_t^{IB}}{\pi_{t+1}} + \phi_{bI} (b_{I,t+1} - b_{I,t}) \right) \right] - \lambda'_{B,t} \gamma - \lambda''_{B,t} m_F \quad (43)$$

$$\frac{1 + \phi_{bE} (b_{E,t} - b_{E,t-1})}{c_{B,t}} = E_t \left[\frac{\beta_B}{c_{B,t+1}} \left(\frac{R_t^{IB}}{\pi_{t+1}} + \phi_{bE} (b_{E,t+1} - b_{E,t}) \right) \right] - \lambda'_{B,t} \gamma - \lambda''_{B,t} m_F \quad (44)$$

$$\frac{1 - \phi_l (l_t^F - l_{t-1}^F)}{c_{B,t}} = E_t \left[\frac{\beta_B}{c_{B,t+1}} \left(Q_{t+1} \frac{R_t^{IB*}}{\pi_{t+1}^*} - \phi_l (l_{t+1}^F - l_t^F) \right) \right] - \lambda'_{B,t} Q_t - \lambda''_{B,t} Q_t \quad (45)$$

where $\lambda'_{B,t}$ and $\lambda''_{B,t}$ are Lagrangian multipliers on the capital requirement and the foreign debt constraints.

6.3 Retail Branch

Retail branches operate in a monopolistically competitive manner with the demand function given by (36) and (37). Each retail branch faces quadratic costs for adjusting its retail rates on loans and deposits.

As for deposits, the retail unit of bank j takes deposit $d_t(j)$ from patient households at the interest rate $R_{d,t}(j)$ and transfers them to the wholesale branch at rate R_t^{IB} . The retail branch sets deposit rates to maximize the profit from taking deposit over $R_{d,t}(j)$

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^B \left[R_t^{IB} d_t(j) - R_{d,t}(j) d_t(j) - \frac{\kappa_d}{2} \left(\frac{R_{d,t}(j)}{R_{d,t-1}(j)} - 1 \right)^2 R_{d,t} d_t \right] \quad (46)$$

subject to demand (36). κ_d is an adjustment cost parameter measuring the degree of stickiness for deposit rate and $\Lambda_{0,t}^B$ is the discount factor between time 0 and t .²²⁾ The first-order condition for deposit rate determination is

$$\begin{aligned} -1 - \varepsilon_d + \varepsilon_d \frac{R_t^{IB}}{R_{d,t}} - \kappa_d \left(\frac{R_{d,t}}{R_{d,t-1}} - 1 \right) \frac{R_{d,t}}{R_{d,t-1}} \\ + \beta_p E_t \left[\frac{c_{p,t}}{c_{p,t+1}} \kappa_d \frac{d_{t+1}}{d_t} \left(\frac{R_{d,t+1}}{R_{d,t}} - 1 \right) \left(\frac{R_{d,t+1}}{R_{d,t}} \right)^2 \right] = 0 \end{aligned} \quad (47)$$

The log-linearized version of deposit rate dynamics is drawn as

$$\begin{aligned} \widehat{R}_{d,t} = \frac{1 + \varepsilon_d}{1 + \varepsilon_d + (1 + \beta_p) \kappa_d} \widehat{R}_t^{IB} \\ + \frac{\kappa_d}{1 + \varepsilon_d + (1 + \beta_p) \kappa_d} \widehat{R}_{d,t-1} + \frac{\beta_p \kappa_d}{1 + \varepsilon_d + (1 + \beta_p) \kappa_d} E_t \widehat{R}_{d,t+1} \end{aligned} \quad (48)$$

This equation highlights how the retail unit sets deposit rate based on its past and future rate as well as the domestic interbank rate given the degree of adjustment costs and the intensity of competition in the deposit market.

22) Note that the bank is owned by patient households so that discount factor is taken from the problem of patient households.

Similar to the deposit taking, the retail unit of bank j receives wholesale loans $b_{s,t}^H(j)$ from the wholesale unit at the cost of R_t^{IB} or $b_{s,t}^F(j)$ in the international interbank market at R_t^{IB*} for $s = I, E$, and sales them to impatient households and entrepreneurs. As in Brzoza-Brzezina and Makarski (2011), I assume that the bank is equipped with a technology of transforming each unit of credit taken in the domestic and international interbank (denominated in home currency) into a unit of retail loan contract.

$$b_{s,t}(j) = b_{s,t}^H(j) + Q_t b_{s,t}^F(j) \quad (49)$$

Formally, the profit maximization problem from loan issuance over $R_{bs,t}(j)$ can be stated as

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^B \left[R_{bs,t}(j) b_{s,t}(j) - R_t^{IB} b_{s,t}^H(j) - R_t^{IB*} Q_t b_{s,t}^F(j) - \frac{\kappa_{bs}}{2} \left(\frac{R_{bs,t}(j)}{R_{bs,t-1}(j)} - 1 \right)^2 R_{bs,t} b_{s,t} \right] \quad (50)$$

subject to demand (37), and with a technology (49) for $s = I, E$. Solving the problem yields the first-order conditions for loan rates as (51) or their log-linearized expression as (52):

$$1 - \varepsilon_{bs} + \varepsilon_{bs} \frac{m R_t^{IB} + (1-m) Q_t R_t^{IB*}}{R_{bs,t}} - \kappa_{bs} \left(\frac{R_{bs,t}}{R_{bs,t-1}} - 1 \right) \frac{R_{bs,t}}{R_{bs,t-1}} \quad (51)$$

$$+ \beta_P E_t \left[\frac{c_{P,t}}{c_{P,t+1}} \kappa_{bs} \frac{b_{s,t+1}}{b_{s,t}} \left(\frac{R_{bs,t+1}}{R_{bs,t}} - 1 \right) \left(\frac{R_{bs,t+1}}{R_{bs,t}} \right)^2 \right] = 0$$

$$\begin{aligned}
\widehat{R}_{bs,t} = & \underbrace{\frac{\varepsilon_{bs} m R^{IB}}{R_{bs} (\varepsilon_{bs} - 1 + \kappa_{bs} (1 + \beta_p))}}_{\text{domestic interbank rate}} \widehat{R}_t^{IB} \\
& + \underbrace{\frac{\varepsilon_{bs} (1-m) R^{IB*}}{R_{bs} (\varepsilon_{bs} - 1 + \kappa_{bs} (1 + \beta_p))}}_{\text{foreign interbank rate}} \widehat{R}_t^{IB*} + \underbrace{\frac{\varepsilon_{bs} (1-m) R^{IB*}}{R_{bs} (\varepsilon_{bs} - 1 + \kappa_{bs} (1 + \beta_p))}}_{\text{real exchange rate}} \widehat{Q}_t \\
& + \underbrace{\frac{\kappa_{bs}}{\varepsilon_{bs} - 1 + \kappa_{bs} (1 + \beta_p)}}_{\text{past loan rate}} \widehat{R}_{bs,t-1} + \underbrace{\frac{\beta_p \kappa_{bs}}{\varepsilon_{bs} - 1 + \kappa_{bs} (1 + \beta_p)}}_{\text{future loan rate}} E_t \widehat{R}_{bs,t+1}
\end{aligned} \tag{52}$$

These equations indicate that banks set the loan rates based on the domestic and foreign interbank rates, their past and future rates and the real exchange rate, taking into account loan rate adjustment costs and the degree of market competition. The components associated with the foreign interbank rate plus the real exchange rate can be interpreted as the currency risk premiums created by capital flow (Hofmann, Shim and Shin 2017).²³⁾

Additionally, solving banks' problem results in the uncovered interest parity (UIP) condition because banks have access to the international interbank market. The UIP shock ($\varepsilon_{e,t}$ and its standard deviation σ_e) is assumed, as in Kollmann (2002), given the empirical findings on foreign exchange rates which have deviated strongly and persistently from the UIP condition after the end of Bretton Woods era.

$$R_t^{IB} = R_t^{IB*} E_t \left(\frac{e_{t+1} \varepsilon_{e,t}}{e_t} \right) \tag{53}$$

where e_t denotes the nominal exchange rate.

23) Note that in financial autarky, the dynamics of the loan rate are formulated based only on domestic interbank rate, and past and future rates.

6.4 The Foreign Sector and Monetary Policy

Because I assume a SOE, the foreign economy is exogenous to the domestic economy and there is some flexibility in specifying the behavior of foreign variables, $\hat{\pi}_t^*$, $\hat{y}_t^*$ and $\widehat{R_{t+1}^{IB*}}$. To explore the dynamic relationships among the variables of the rest-of-the-world, approximated by the U.S. economy, I consider a structural VAR of three U.S. variables (ordered as listed above) as in Ghironi (2000).²⁴ The data used for estimation is between 1980Q1 and 2008Q2 from Federal Reserve Economic Data (FRED), and the lag order is chosen as two quarters according to the various information criteria. The details of the set-up and estimation results are summarized in Appendix A-1.

As in common New Keynesian literature, a central bank determines the nominal policy rate according to a Taylor rule given by

$$R_t^{IB} = \left(R_{t-1}^{IB}\right)^\rho \left[\left(R^{IB}\right) \left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \right]^{1-\rho} \varepsilon_{R^{IB},t} \quad (54)$$

where ρ , ϕ_π , and ϕ_y are weight parameters of the policy rate inertia, inflation, and output growth, respectively. R^{IB} and π stand for steady state value of policy rate and inflation. $\varepsilon_{R^{IB},t}$ (with standard deviation $\sigma_{R^{IB}}$) represents monetary policy shocks which is white noise.

6.5 Market Clearing

The model is closed by specifying the market clearing conditions for the goods markets, the housing market, and the balance of payments. The market clearing condition in the final goods market is:

$$y_t = c_{P,t} + c_{I,t} + c_{E,t} + c_{B,t} + i_t \quad (55)$$

24) Another popular way to model the exogenous rest-of-the-world is to assume that foreign variables are AR processes. See Matheson (2010) for example.

Next, the market clearing condition in the housing market is expressed as

$$\bar{h} = h_{P,t} + h_{I,t} + h_{E,t} \quad (56)$$

where $\bar{h}$ is fixed housing stock. The market clearing condition for balance of payment expressed in home currency is

$$\frac{P_t^H}{P_t} y_{W,t} - y_t = Q_t \frac{R_{t-1}^{IB*}}{\pi_t^*} (b_{I,t-1}^F + b_{E,t-1}^F + l_{t-1}^F) - Q_t (b_{I,t}^F + b_{E,t}^F + l_t^F) \quad (57)$$

IV. Calibration and Estimation

Data from Korea are used for the estimation because Korea is a typical small open economy where the financial system largely depends on the banking sector.²⁵⁾ I first calibrate some parameters that can be relatively easily obtained in the data and/or that have been well established in the previous literature. The rests are estimated with the Bayesian methods described in An and Schorfheide (2007).

1. Calibrated Parameters

The discount factors for each agent are within the range of the band interval (0.91, 0.99) according to Carroll and Samwick (1997). The discount factor of patient households (β_P) is set to 0.99 to match the long-term average of the quarterly household deposit rate of 3.8% in the sample. I set the discount factors of impatient households, entrepreneurs and banks (β_I , β_E and β_B) as 0.95, 0.95, and 0.96, respectively, close to Kang and Dao (2012) to ensure positive financial

25) The Korean financial market shows high dependency on banking, but low portion of direct financing such as bonds and stocks. In particular, financing through banking sector occupied 90% and 54% for households and firms, respectively, whereas the portion of firms depending on the direct financing market was only 20% (as of 2008). For more details on the Korean financial institutions, see Ha and So (2013).

Table 1: Calibrated Parameters

Parameter	Description	Value
β_P	Patient Households' discount factor	0.99
β_I	Impatient Households' discount factor	0.94
β_E	Entrepreneurs' discount factor	0.94
β_B	Banks' discount factor	0.96
μ	Capital share in the production function	0.36
α	Patient/Impatient household ratio in the production function	0.70
v	Real estate share in the production function	0.04
ω	Elasticity of substitution between home and foreign goods	6.0
a	Share of home consumption component in the consumption index	0.7
ε_d	Elasticity of substitution between deposit	1442.29
ε_{bI}	Elasticity of substitution between loans for impatient households	139.40
ε_{bE}	Elasticity of substitution between loans for entrepreneurs	211.48
m	Share of home loan component in the loan index	0.85
m_I	LTV on loans to households	0.5
m_E	LTV on loans to entrepreneurs	0.8
m_F	Foreign capital regulation ratio	0.5
γ	Capital adequacy ratio	0.85
δ	Capital depreciation rate	0.025
η	Weight on leisure	1.01
ρ	Policy rate inertia in Taylor rule	0.75
ϕ_y	Weight on output in Taylor rule	1.9
ϕ_π	Weight on inflation in Taylor rule	0.4

flow in the steady state.²⁶⁾ The technology parameters (μ , v and α) are chosen as 0.36, 0.04 and 0.70 on the basis of the data sample mean. The EOSs between deposits and loans (ε_d , ε_{bI} and ε_{bE}) are determined to match the steady-state markups of each rate on the policy rate. Notice that the EOS for deposit is set high because commercial banks in Korea typically determine deposit rates following the movement of policy rate. The LTV ratios on loans to households and entrepreneurs (m_I and m_E) and capital adequacy ratios (γ and m_F) are calibrated to the long-term average of data obtained from bank business

26) Home banks borrow the funds from abroad only if the borrowing cost is cheaper than the domestic financing cost ($R^{IB*} < R_d$). For impatient households and entrepreneurs to borrow from banks, the interest rates that the banks charge should be low enough for borrowers, i.e. $\frac{1}{\beta_I} > R_{bI}$ and $\frac{1}{\beta_E} > R_{bE}$.

analysis data and the financial information statistics system (FISIS). The parameters in Taylor rule ρ , ϕ_y and ϕ_π are set to 0.75, 1.9 and 0.4 according to the Bank of Korea's empirical estimates. The rest of the calibrated parameters are taken from Iacoviello (2005) and Gerali et al. (2010).

2. Data and Estimation

To estimate the remaining parameters, i.e., adjustment cost parameters and the standard error and autoregressive coefficients of all of the shocks, seven quarterly macroeconomic and financial time-series data are imported from the Economic Statistics System (ECOS) of the Bank of Korea. These data include the (seasonally adjusted) real GDP, CPI inflation, overnight call rate, bank loans to households and firms, and bank loan rates to households and firms.²⁷⁾ The sample period is chosen as 1999Q3~2014Q4 to correspond to a period of a homogeneous monetary policy regime.²⁸⁾ The data are detrended using an HP-filter with a smoothing parameter of 1,600. The detrended data are plotted in Figure 5.

I use the Metropolis-Hastings (MH) algorithm to obtain the posterior distribution of the parameters by running 10 chains, with 100,000 draws each. Tables 2 and 3 report the summary statistics of prior and posterior distributions. Similar to Gerali et al. (2010) prior means of parameters controlling price stickiness (κ_P^H and κ_P^F) are set at 50, and those for interest rate adjustment costs (κ_d , κ_{bI} and κ_{bE}) are set at 10. The prior mean for the capital adjustment cost (κ_K) is set at 2.5. Following Iacoviello (2015) and Kang and Dao (2012), I also set the prior means of banks' portfolio adjustment cost parameters (ϕ_d , ϕ_{bI} and ϕ_{bE}) at 0.25.²⁹⁾ I impose priors for the standard deviations of the above

27) There are seven exogenous shocks in the model. As in the usual practice for the estimation, I use as many observable variables as shocks.

28) The Bank of Korea has been adopting inflation targeting since 1999 and manipulates short-term interest rates (overnight call rate before February 2008, base rate after February 2008) as a policy instrument.

29) These parameters are linked to the elasticity of loan and deposit supplies. The derivatives of loan adjustment cost

functions, for instance, can be written as $\frac{d_{\kappa_{bs}}}{db_s} = \phi_{bs} (b_{s,t} - b_{s,t-1})$. This situation indicates that when quarterly

Figure 5: Data Used in Estimation

Notes: 1. The model parameters are estimated using data from 1999Q3 to 2014Q4. All of the variables are expressed as log deviations from the HP-filter trend.
 2. IHs: Impatient households, Es: Entrepreneurs

parameters reasonably loosely or set as common values that are found in the literature. As for the shock processes, the prior means of standard deviations for shocks are set at 0.01.

For the parameters governing the degree of stickiness in bank rates, deposit rates change more rapidly than loan rates to the adjustment of the policy rate. Regarding portfolio adjustment costs, deposits change faster than loans in line with Gerali et al. (2010). Concerning the nominal rigidities, I find that the stickiness of the foreign price is slightly stronger than that of the domestic price. The median of the capital adjustment costs is 1.6, which is somewhat lower than Smets and Wouters' (2007) estimate. The shocks following AR(1) processes are persistent.

loan rates rise by 25bp (100bp in annual), the loan supply increases by $0.25/\phi_{ls}$ in percentage terms. Thus, the value of the parameter 0.25 implies an increase of the loan supply by 1% responding to a 1% rise in loan rates. See Iacoviello (2015) for the details.

Table 2: Prior and Posterior Distribution of Parameters:
Structural Parameters

Parameter	Prior Distribution			Posterior Distribution		
	Distribution	Mean	St.dev.	Median	Mean	St.dev.
κ_d	Gamma	10,0	2,5	4,29	4,30	0,130
κ_{bI}	Gamma	10,0	2,5	22,65	23,34	0,506
κ_{bE}	Gamma	10,0	2,5	7,51	7,66	0,585
ϕ_d	Beta	0,25	0,1	0,24	0,24	0,001
ϕ_{bI}	Beta	0,25	0,1	0,26	0,26	0,001
ϕ_{bE}	Beta	0,25	0,1	0,25	0,25	0,001
ϕ_l	Beta	0,25	0,1	0,24	0,24	0,001
κ_p^H	Gamma	50,0	10,0	41,74	41,91	2,765
κ_p^F	Gamma	50,0	10,0	44,70	45,23	0,875
κ_K	Gamma	2,5	1,0	1,60	1,60	0,044

Table 3: Prior and Posterior Distribution of Parameters:
Exogenous Processes

Parameter	Prior Distribution			Posterior Distribution		
	Distribution	Mean	St.dev.	Median	Mean	St.dev.
<i>AR coefficients</i>						
θ_A	Gamma	0,8	0,01	0,80	0,80	0,010
θ_j	Gamma	0,8	0,01	0,81	0,81	0,010
<i>Standard deviations</i>						
σ_A	Inv. Gamma	0,01	0,05	0,01	0,01	0,005
σ_j	Inv. Gamma	0,01	0,05	0,24	0,25	0,034
σ_{R^B}	Inv. Gamma	0,01	0,05	0,04	0,04	0,003
σ_e	Inv. Gamma	0,01	0,05	0,06	0,06	0,006
$\sigma_{R^{EP}}$	Inv. Gamma	0,01	0,05	0,04	0,04	0,004
σ_y^*	Inv. Gamma	0,01	0,05	0,02	0,02	0,002
σ_π^*	Inv. Gamma	0,01	0,05	0,05	0,05	0,005

3. Empirical Fit of the Model

The empirical fit of the model is first assessed by the comparison between the steady state values and the long-term average of variables (1998Q1~2014Q4). Table 4 summarizes the steady state values of the key macroeconomic variables calculated from the model, including consumption, investment and the interest rate, and compares them with observed data. Overall, the steady state ratios of main variables (e.g., the ratio of macroeconomic variables to GDP) are largely similar to the actual data, which implies that the parameters in the model represent the reality of the Korean economy.³⁰⁾

As an additional test of the reliability of model, I assess the model in fitting actual data that are not used in the model estimation. This exercise is performed to address the critique that the DSGE model performs well in fitting the data in the sample but is poor at fitting the rest of the data (e.g., Iacoviello, 2015). Figure 6 contrasts the actual data for consumption, deposit, deposit rate (from ECOS), and housing price (from the Kookmin bank housing price index) with the model simulated series. Overall, the model's smoothed estimates trace well their data counterparts. In furtherance of a similar idea, the unconditional standard deviations of the observable variables at the posterior mean are compared with the standard deviations of actual data series. The difference between the two standard deviations (std. of observable variable in the model std. of actual data) by main variable is less than 0.03 (consumption: 0.00, investment: 0.01, deposit: -0.03, housing price: 0.00).

V. The Transmission Mechanism of MP Shocks

As in existing studies, the model suggests several channels that explain the transmission of local MP shocks: the real rate, nominal debt, financial

30) Steady state ratios of banks' deposits and loans to GDP are smaller than the ratios of their data counterparts. This discrepancy may be attributed to strong assumptions on the banks' balance sheets. For instance, banks' reserves, and security and cash holdings are not considered in the model.

Table 4: Steady State Ratio of the Model

Variable	Description	Model	Data
$\frac{c_P + c_I}{y}$	Households' consumption to GDP	0.68	0.68
$\frac{i}{y}$	Facility investment to GDP	0.08	0.09
$\frac{b_E}{y}$	Loans to entrepreneur to GDP	1.02	1.12
$\frac{b_I}{y}$	Loans to household to GDP	1.55	0.88
$\frac{d}{y}$	Deposit to GDP	1.80	2.59
$\frac{h}{y}$	Housing stock to GDP	1.98	1.77
$\frac{k}{y}$	Capital stock to GDP	3.35	3.78

Figure 6: Historical Decomposition of Model Series and Actual Data

Notes: All of the variables are expressed as log deviations from the HP-filter trend.

accelerator, bank attenuator and bank lending channel (studied mainly in closed economy models; see Iacoviello, 2005; Gerali et al., 2010; Van den Heuvel, 2008 for instance).³¹⁾ Additionally, foreign interest rate shocks can be migrated to the SOE's financial market by adjusting the domestic interbank rate according to the interest-parity condition or by adjusting the bank's interest rate setting with consideration for the domestic and international interbank rate (Obstfeld, 2014; Passari and Rey, 2015).

In this section, I study how banking sector openness alters the transmission mechanism of home and foreign MP shocks, particularly focusing on the channels related to the banking sector.

1. Transmission of Home MP Shock

The introduction of banking sector openness attenuates the impulse responses to an unanticipated contractionary MP shock via the following two channels:³²⁾

First, the effects of domestic policy rate adjustment are transmitted less to loan rates (i.e., *foreign interest rate channel*). In financial autarky, the banks can take loans only domestically at the cost of R_t^{IB} , and thus the retail rates for loans are set based on the mark-up over the domestic interbank rate (Gerali et al., 2010; Ha and So, 2013). By contrast, if banks can access the international

31) In response to a policy rate rise, real rates increase due to the presence of price stickiness, thus leading to a fall in the aggregate spending of households and firms (*real rate channel*). A fall in the price caused by a policy rate increase raises the real cost of borrowers' current debt obligation and the real remuneration on saver's deposits (*nominal debt channel*). On a contractionary MP shock, banks cut their loans to constrained borrowers due to the decline of the net present value of tomorrow's collateral, thereby creating an additional downward pressure on aggregate demand (*financial accelerator channel*). Bank presence influences the impact of MP shocks on the economy. However, the overall effect is not clear. In response to a negative shock to the bank capital/asset ratio caused by contractions of bank deposit, banks tighten their lending standards, which worsen credit conditions (*bank lending channel*). Due to the presence of a bank's market power, banks raise the remuneration of deposits and the cost of loans by a lower amount following the policy rate increase, and thus financial intermediation moderates the overall effects listed above (*bank attenuator channel*).

32) As proposed by Gerali et al. (2010), domestic MP transmission may also be attenuated due to the presence of monopoly power in the deposit and loan markets. I provide the analysis of the effect of market power in the banking industries in Appendix A-2. Overall, the attenuating effect of bank globalization is comparable to the bank attenuator effect.

Table 5: Decomposition of MP Transmission Channels

	Baseline Model (BM)	Alternative Models	
		(AM1)	(AM2)
Foreign liquidity channel (A)	○	○	×
Foreign interest rate channel (B)	○	×	×
Identify		(A)	(B)

Notes: ○—Existing in the model, ×—Not existing in the model.

interbank market to import wholesale loan accounts at rate R_t^{IB*} , they can set loan rates, taking into account not only domestic interbank rates but foreign interbank rates as well as real exchange rate. Loan rates under banking sector openness are therefore affected by domestic MP shocks only up to the portion for which banks rely on the domestic borrowers. In addition, the real exchange rate appreciates (i.e. declines) in response to a contractionary domestic monetary shock. This situation reduces the strength of the real rate effect (depression of consumption and investment triggered by real rates increases) and the financial accelerator effect (downward pressure on aggregate demand created by the contraction in bank loans to constrained borrowers' net present value of collaterals).

Second, the global liquidity management of SOE banks can insulate credit supply from domestic monetary shock as in Cetorelli and Goldberg (i.e., *foreign liquidity channel*). An increase in policy rate has negative impact on output and, subsequently, on household labor income. A fall in income leads to contractions in deposits, thereby tightening banks' balance sheet conditions. Under financial autarky, the shock is transmitted to the banks' asset side. Banks that cannot substitute liabilities with other external funding sources must reduce their assets (or loans) against the change of the balance sheet position. Banks' adjustment of lending activity puts additional strain on aggregate demand because households and firms depend on bank credit to run their activities. Meanwhile, in a model

Figure 7: Impulse Response to Contractionary Domestic MP Shock (25bp)

Notes: 1. BM: Baseline model,
 AM1: Alternative model 1(no foreign interest rate channel),
 AM2: Alternative model 2(AM1 + no foreign liquidity channel)
 2. IHs: Impatient households, Es: Entrepreneurs
 3. Horizontal axis: Quarters from the shock;
 Vertical axis: Percentage deviation from steady state.

with bank globalization, globalized local banks can accommodate the shock. Foreign liquidity that banks raise in the international interbank market plays a role as a buffer for absorbing or mitigating the negative MP impact on the balance sheet.

To understand which of the two effects prevails when international banking is introduced and to quantitatively assess the relevance of the different channels in shaping the dynamic properties of the economy, I compare the responses of the

baseline model examined in the previous section with those of the alternative models where I shut down the transmission channels of MP one by one against the same contractionary monetary shocks (25 basis points increase): (i) only the foreign interest rate channel is blocked in AM1 and (ii) both the foreign interest rate channel and foreign liquidity channel are blocked in AM2. However, all channels work with significance in BM as previously assumed. To be specific, the foreign liquidity channel is blocked if bank borrowing from abroad is set to zero ($l_t^F = 0$). Similarly, to shut down the foreign interest rate channel, we may assume that bank can collect and sell loan accounts only in their home countries ($b_{s,t} = b_{s,t}^H$ for $s = I, E$). Table 5 briefly describes the strategy of verifying the direction and strength of each channel by comparing the results between each model in response to the same MP shocks.

Figure 7 exhibits the impacts of policy tightening on key macroeconomic and financial variables through each transmission channel, and Table 6 summarizes the average impulse response of key variables in the first year. Parameter values are set at the estimated posterior mean. The responses of BM (black line) are standard. Deposit and loan rates rise following policy rate increases. This change in bank rates leads to housing price declines (-0.11% in the first year), which reduces the net present value of tomorrow's collateral. Consequently, the amount of loans decreases, and the output (-0.20%) and inflation (-0.04%) fall because the productive sector of the economy relies on bank credit.³³⁾

The role of bank globalization begins to appear when we consider the responses of the AM1 (red line) and the AM2 (green line), which block the foreign interest rate channel and the foreign liquidity channel, respectively. The main result that emerges from comparing AM1 and AM2 with the baseline model is that the introduction of international banking attenuates the effects of contractionary MP shocks.

First, when comparing BM and AM1 with regard to the responses of each

33) For your reference, on the same policy shock, output and inflation decrease by 0.18% and 0.05%, respectively, according to the Bank of Korea's BOKDSGE model.

Table 6: Comparison of the Impacts of MP Tightening (25bp)
through Each Channel

								(%, %p)
	y	R_{bI}	R_{bE}	R_d	b_I	b_E	d	MP shocks
BM	-0.20	0.02	0.02	0.12	-0.26	-0.11	-0.29	—
AM1	-0.27	0.13	0.09	0.13	-0.42	-0.18	-0.46	—
AM2	-0.30	0.13	0.09	0.14	-0.45	-0.20	-0.41	—
Foreign interest rate channel (BM–AM1)	0.07	-0.11	-0.07	-0.01	0.16	0.07	0.18	Weakened
Foreign liquidity channel (AM1–AM2)	0.03	-0.01	-0.01	-0.01	0.03	0.01	-0.05	Weakened

Notes: Average impulse responses in the first year.

macroeconomic and financial variable to the MP tightening shocks by 25bp, the responses of loan rates are smaller in the former model than the latter with a gap of 0.11%p in the loan rate to impatient households and a gap of 0.07%p in the loan rate to entrepreneurs, on average, during the first year after shock. This smaller response of loan rates induces a smaller change in loan and deposit demands, thus reducing output by a lower amount (0.07%p less). Consumption and investment also react less in BM than in AM1 by 0.07%p and 0.04%p respectively. This result indicates that MP shocks are weakened in international banking intermediation, particularly by the existence of foreign interest rate channels consistent with theoretical direction.

Second, according to the comparison between AM1 and AM2 regarding responses to MP shocks, although deposits shrink more in AM1 than in AM2 against policy rate increases, smaller loan responses are seen in the former than in the latter, with a gap of 0.03%p in loans to impatient households and a gap of 0.01%p in loans to entrepreneurs. Consequently, output drops by less than 0.03%p in AM1 compared to AM2. The responses of the variables confirm the existence of a foreign liquidity channel in line with much of the available

literature (e.g., Cetorelli and Goldberg, 2012, Morais et al. 2017, etc).

The findings verify that the attenuation effect of bank globalization after an MP shock is mainly due to the foreign interest rate channel, which dampens the response of loan rates, thereby hindering the decline of loans and aggregate demand. The impact of the foreign liquidity effect is limited, reflecting the opposite and mutually offsetting effects on the demand and supply of foreign liquidity. Due to foreign debt constraint, the amount of net domestic bank capital determines the availability of foreign capital, thus limiting the foreign liquidity channel if the bank deposit shrinks more than the loan on a negative MP shock.

2. Transmission of Foreign MP Shock

International banking intensifies the transmission of foreign MP shocks to domestic market rates, particularly loan rates. Conventional open economy models assume that foreign monetary shocks affect short-term rates in SOEs following the interest-parity relationship, and inevitably influence other market rates that are set based on the movement of the short-term rate. Another channel of international monetary spillover to domestic market rates is the policy response of a SOE central bank to the inflationary pressure caused by exchange rate pass-through (e.g., Aoki, Benigno, and Kiyotaki, 2016). Responding to a foreign monetary tightening shock, the real exchange rate depreciates (i.e. rises) while raising CPI inflation. Consequently, a central bank who concerns the inflation sets the policy rate higher, leading to an increase in market rates. Both channels implicitly assume the *indirect* transmission by the adjustment of domestic policy rate (referred to as indirect international monetary transmission).

In addition to the aforementioned indirect international monetary transmission channels, local banks' international banking induces bank rates to react *directly* to the change in foreign MP shocks. It is because local banks that import foreign intermediate loan contracts determine their loan rates by considering the cost of raising funds on both domestic and international interbank markets

Figure 8: Impulse Response to Contractionary Foreign MP Shock (25bp)

Notes: 1. BM: Baseline model,
 AM1: Alternative model 1(no foreign interest rate channel),
 2. IHs: Impatient households, Es: Entrepreneurs
 3. Horizontal axis: Quarters from the shock;
 Vertical axis: Percentage deviation from steady state.

(referred to as direct international monetary transmission). The effect of foreign monetary shocks through this direct channel is intensified by the response of real exchange rate (i.e. depreciation in the case of a rise in foreign interest rates), which is another important determinant of local loan rates, similar to Hofmann, Shim and Shin (2017).

The mechanism of international monetary transmission is studied by looking at the impulse responses of BM and AM1, as illustrated in the previous section.

Table 7: Comparison of the Impacts of Foreign MP Tightening (25bp)

(%, %p)

	R^{IB}	R_d	R_{bI}	R_{bE}	$R_d - R^{IB}$	$R_{bI} - R^{IB}$	$R_{bE} - R^{IB}$
AM1	0.04	0.04	0.04	0.03	-0.0001	-0.0030	-0.0143
	(Indirect transmission)				(Frictions)		
BM	0.01	0.01	0.05	0.05	-0.0000	0.0335	0.0381
	(Indirect transmission)		(Indirect/Direct transmission)		(Frictions)		

Notes: Average impulse responses in the first year.

I compare only the responses from BM with those from AM1 to focus on the direct impact of foreign MP shocks on the domestic loan rates. Note that, for simplicity, foreign liquidity is not considered in modeling foreign sector. See Section 3.7 and Appendix A-1 further.

Figure 8 shows the impulse responses from an unanticipated 25bp increase in the foreign policy rate. Table 7 summarizes the average impulse response of key variables in the first year.

Overall, in the two models, the response of domestic interest rates, including policy rates, is positive against negative foreign MP shock and leads to a fall in output. However, compared to a model lacking a foreign interest rate channel (AM1, red line), the interest rates, particularly loan rates, in the baseline model (black line) show more sensitive responsiveness to foreign monetary surprises. To gain intuition from the results, it is useful to discuss how local banks' international banking modifies the international transmission channels of foreign MP shocks.

In AM1, loan rates are determined based on the domestic policy rate (RIB) and past and future rates, as in Gerali et al. (2010). The only channel through which foreign interest rates can affect the movement of loan rates is that of a SOE's policy rate adjustment (0.04%p on average in the first year) after a foreign shock. As discussed above, this policy rate change is triggered by interest-parity condition and exchange rate pass-through. However, due to the

presence of frictions between policy rates and loan rates in the models, this transmission channel may exert limited impacts on loan rate movement. The responses of loan rates to impatient households and entrepreneurs are smaller than those of domestic policy rates by 0.003%p and 0.014%p, respectively.

However, when we introduce a banking sector that imports foreign loan accounts (BM), loan rates are set based on both domestic (R^{IB}) and foreign (R^{IB*}) policy rates, as shown in equations (51) and (52). Additionally, the real exchange rate depreciates (i.e. rises) in response to a contractionary foreign monetary shock. This situation adds a stronger propagation mechanism: in addition to indirect transmission channel through policy rate adjustment (0.01%p on average in the first year), foreign monetary shocks can also directly influence the loan rates in this process. Thus, loan rates respond even more (0.05%p in loan rates to entrepreneurs and impatient households) than domestic policy rates. However, as in Aoki, Benigno, and Kiyotaki (2016), output can initially increase as net export goes up against a contractionary international monetary shock, following the depreciation of real exchange rate. Output responds negatively after one year as the shocks also pass through to domestic interest rates. On the other hand, loans to households and firms temporarily increase due to a rise in exports caused by exchange rate pass-through as well as a decline in relative cost for raising liquidity at home.

For ease of comparison, each panel in Figure 9 plots the joint response of both loan rates and domestic policy rates to a foreign monetary shock. In Panel A, which describes the responses of variables in AM1, loan rates react to foreign monetary surprises by a lower amount than to the domestic policy rate for the initial four quarters. However, for BM in Panel B, loan rates respond more to a contractionary foreign MP shock than do domestic policy rates for the period. Similar results are found in Morais et al. (2017) that foreign monetary shocks can affect local rates significantly because of globalized banks' reach-for-yield incentives.

Figure 9: Comparison of Impulse Responses of Interest Rates to Foreign MP Shock (25bp)

A. AM1

B. BM

- Notes: 1. BM: Baseline model,
AM1: Alternative model 1(no foreign interest rate channel)
2. IHs: Impatient households, Es: Entrepreneurs
3. Horizontal axis: Quarters from the shock;
Vertical axis: Percentage deviation from steady state.

VI. Conclusions

This paper studies the conventional topic about the transmission of local and international monetary shocks in SOEs, but sheds light on how well domestic and international MP shocks propagate through banking sectors and whether such transmission channels are altered by bank globalization. To that end, the model in this paper is a first attempt to investigate the channels through which international banking influences MP transmission under the general equilibrium framework. Furthermore, to disentangle the complex workings of bank globalization, I introduce two common sets of bank globalization factors in the model: imported loan contracts and foreign operating funds.

The study's findings are twofold. First, bank globalization attenuates MP transmission. Compared to the financial autarky model, loan rates increase less in response to a negative monetary shock, thereby exerting a foreign interest rate effect. This channel alleviates the strength of the real rate effect and financial accelerator effect. However, through a foreign liquidity channel, banks that face capital requirement constraints can also avoid negative policy effects to some extent by expanding credit through foreign bank capital. The impulse response of output to a contractionary MP shock (25 basis point increase in policy rate) declines by 0.07%p due to the foreign interest rate effect and by 0.03%p due to the foreign liquidity effect in the first year, respectively. Second, international banking amplifies international monetary spillovers. In addition to the indirect channels through domestic policy rate adjustment, international banking activities directly link foreign interbank rates and domestic loan rates. Thus, compared to the model without bank globalization, the impulse response of loan rates to foreign MP shock shows that the direct international monetary transmission channel accounts for approximately 0.03~0.04%p of loan rate responses.

The results indicate that policy effects are not always driven in the ways that central banks intend under the globalized banking system. In my analysis, transmission of home MP shocks is attenuated whereas international monetary transmission is substantially intensified by bank globalization. Central bankers are

confronted with an expanded need for taking into consideration the role of international banking intermediation in MP transmission when determining the scale and timing of policies.

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Appendix

1. VAR Estimation Results of the Rest-of-the-World

The structural shocks of a recursive VAR model of three variables ($\widehat{\pi}_t^*$, $\widehat{y}_t^*$, $\widehat{R}_t^{*IB}$; ordered as listed) are identified by using a standard Cholesky decomposition, as in Eq (A-1). I place the federal funds rate (FFR) last in the ordering as in Ghironi (2000), so that the output and inflation gap are restricted from simultaneously reacting to the interest rate shock, while FFR is allowed to react simultaneously to them.

$$AX_t = \sum_{i=1}^p B_i X_{t-i} + \varepsilon_t \quad (\text{A-1})$$

where X_t is a state vector, A and $B_i (\forall_i \geq 1)$ are nonsingular coefficient matrices, and ε_t is a structural disturbance vector.

Table A-1 reports the estimated coefficients. The results suggest that the signs and magnitude of the coefficients are in line with a generalized Taylor rule and Phillips curve.

Figure A-1 illustrates the responses of U.S GDP, inflation, and FFR to a 25bp increase in FFR. The output and inflation gap (deviation from the steady state) react with a lag of two or three quarters, and these results are in line with the literature. We can find that all variables return to their steady states over time.

Table A-1: Estimated Coefficients of U.S VAR

	$\hat{\pi}_t$		$\hat{y}_t$		$\hat{R}_t^{IB}$	
$\hat{y}_t$					0.470	(0.221)
$\hat{\pi}_t$			0.183	(0.143)	0.387	(0.145)
$\hat{\pi}_{t-1}$	-0.088	(0.094)	-0.165	(0.143)	-0.426	(0.233)
$\hat{y}_{t-1}$	0.097	(0.058)	0.970	(0.088)	-0.109	(0.143)
$\hat{R}_{t-1}^{IB}$	0.098	(0.041)	0.093	(0.062)	0.756	(0.101)
$\hat{\pi}_{t-2}$	-0.158	(0.096)	0.091	(0.146)	0.371	(0.237)
$\hat{y}_{t-2}$	0.017	(0.057)	-0.061	(0.087)	-0.090	(0.142)
$\hat{R}_{t-2}^{IB}$	-0.111	(0.041)	-0.286	(0.062)	-0.036	(0.100)

Notes: The numbers in parenthesis are standard errors.

Figure A-1: Impulse Response to Contractionary U.S FFR (25bp)

Notes: Horizontal axis: Quarters from the shock

Vertical axis: Percentage deviation from steady state.

2. Market Power in the Banking Sector and MP Transmission

The monopolistic power of banks is also an important source of the attenuation of MP transmission (see Gerali et al., 2010). I set up an alternative model (AM3) that blocks the bank attenuator channel. A comparison between AM2 (green line) and AM3 (purple line) allows for capturing the bank attenuator effect. In response to a contractionary MP shock, market power in a banking industry induces financial intermediaries to adjust interest rates by a lower amount (0.02%p in deposit rate, 0.02%p in loan rate to impatient households and 0.07%p in loan rate to entrepreneurs), thereby decreasing the response of output by 0.07%p on average in the first year.

<Abstract in Korean>

소규모 개방경제의 은행부문 개방이 통화정책 파급경로에 미치는 영향

소인환*

본고는 소규모 개방경제에서 은행부문 개방이 자국 및 해외 통화정책의 파급 경로에 미치는 영향에 대해 분석하였다. 분석을 위해 은행부문이 포함된 소규모 개방경제 DSGE 모형을 구축하였고, 은행부문 개방을 외화유동성 차입 및 외화대출 중개의 두 가지 유형으로 구분하여 고려하였다. 모형 분석 결과, 소규모 개방경제에서 은행부문이 개방되는 경우 자국의 정책금리 조정이 국내 금융경제에 미치는 효과는 약화되는 것으로 나타났다. 반면, 은행부문 개방으로 인해 해외금리 충격이 국내 은행의 자금중개 과정에 미치는 영향은 강화되는 것으로 분석되었다.

핵심 주제어: 은행개방, 통화정책, DSGE 모형, 소규모 개방경제

JEL Classification: E32, E44, E52, E58, F36, F62

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BOK 경제연구 발간목록

한국은행 경제연구원에서는 Working Paper인 『BOK 경제연구』를 수시로 발간하고 있습니다. 『BOK 경제연구』는 주요 경제 현상 및 정책 효과에 대한 직관적 설명 뿐 아니라 깊이 있는 이론 또는 실증 분석을 제공함으로써 엄밀한 논증에 초점을 두는 학술논문 형태의 연구이며 한국은행 직원 및 한국은행 연구용역사업의 연구 결과물이 수록되고 있습니다. 『BOK 경제연구』는 한국은행 경제연구원 홈페이지(<http://imer.bok.or.kr>)에서 다운로드하여 보실 수 있습니다.

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