



Macroprudential Policies: Korea's Experiences

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Introduction

Korea has good experience in using macroprudential policies to address financial risks in the housing and foreign exchange markets. These two markets have been key sources of the systemic risk in Korea with high market volatility and susceptibility to bubbles, and with significant potential to wreak havoc on the broader economy in case of market dislocation. Indeed, following the precipitous fall during the 1997–98 financial crisis, house prices rose at a rapid pace in the first half of the 2000s, aided by strong expansion of credit to households. Similarly, the foreign exchange market experienced an extended period of large inflows and exchange rate appreciation prior to the global financial crisis, both of which were then reversed sharply after the crisis.

It was considered inappropriate to contain the looming financial risks in the housing or foreign exchange market by using monetary policy alone, which affects the broader economy and therefore may be too blunt a tool to address localized financial risks. More targeted policy was called for, in addition to monetary policy, to achieve both price and financial stability. As such, Korea resorted to macroprudential policies while at the same time adjusting the stance of monetary policy—but with an eye on the developments in the broader economy.

For housing market risks, loan-to-value (LTV) and debt-to-income (DTI) regulations were deployed with a view to limiting the volume of bank financing of home purchases. Since their respective introductions in 2002 and 2005, they have been adjusted in a broadly countercyclical manner. As regards foreign exchange (FX)-related risks, Korea learned valuable lessons from the global financial crisis about the danger of currency and maturity mismatches. As capital inflows resumed in 2009 and afterward on the back of highly accommodative monetary policy in advanced countries, there was a need to prevent such mismatches from developing again in the banking sector. To that end, macroprudential measures were imposed, including leverage caps on FX derivatives positions and a macroprudential stability levy on noncore FX liabilities of banks.

This report reviews Korea’s experiences in using macroprudential policies, evaluates their effects, and discusses remaining challenges in the design and implementation of macroprudential policies.

Background

Korea’s housing market had gone through dramatic price adjustment in the aftermath of the 1997–98 financial crisis, possibly overcorrecting its previous price increases. It began to recover in the early 2000s but the pace of recovery soon accelerated (Figure 1). House prices increased at an annual average rate of 8.9 percent during the period of 2000–02. Underlying such steep increases in house prices was households’ greatly improved access to bank financing for home purchases, combined with self-fulfilling market expectations of further price increases.¹ Household loans including bank mortgage loans increased at an annual average rate of 13.9 percent during the same period.

As house prices and mortgage loans had increased sharply, there were growing concerns over potential overheating in the housing market and related financial vulnerabilities that could translate into systemic risk. Bank financing for home purchases was in large part offered in the form of variable-rate bullet loans (with a maturity of three years or shorter) that are vulnerable to rollover risks particularly if house prices fall. Although monetary policy had been tightened from 2005 to 2007 partly to cool down the overheated housing market, its effects remained limited as the rapid pace of house price increases continued.

Capital flows to Korea—in particular, bank flows—have been volatile and procyclical on the back of high trade and financial openness (Figures 2 and 3). For instance, about half of the bank borrowings that had flowed in over the two-year period immediately prior to the Lehman crisis flowed out within just five months after the crisis hit. Moreover, large currency and maturity mismatches emerged on the balance sheets of banks—particularly foreign bank branches—in the mid-2000s (Figure 4). For the entire banking sector, currency and maturity mismatches peaked at US\$68 billion and US\$85 billion, respectively, just prior to the global financial crisis.

¹ After the 1997 financial crisis, domestic banks shifted their business strategy to household lending from corporate lending. The deregulation of the banking industry, the privatization of the Housing and Commercial Bank in 1996 (whose main business was long-term home mortgage lending), and the reduced loan demand by large corporations induced commercial banks to aggressively enter the mortgage loan market.

The main driver of such mismatches was the swollen hedging demand from major ship-builders amid strong market expectations of currency appreciation. Ship-builders and other exporters sold dollars forward to banks. Then, banks hedged their overbought position by foreign currency borrowing, mostly at short maturity. The consequence was a surge in banks' short-term external debt and rollover risks. The global financial crisis was a testing ground for such risks and Korean banks failed the test.

Capital inflows resumed from the second half of 2009 on the back of ample global liquidity and two-speed recovery between advanced and emerging economies (Figures 5 and 6). While a welcome development for economic recovery, policy concerns were raised as to their implications for financial stability since short-term external borrowings by banks began to rise again and portfolio inflows also surged.

Macprudential Policy Measures

Housing Sector–Related Measures

Two major policy instruments were used: LTV and DTI regulations. They were introduced in September 2002 and August 2005, respectively, in the midst of a housing market boom. They have since been adjusted in a broadly countercyclical manner—tightened or relaxed as warranted by cyclical developments in housing markets and bank lending (Table 1 and Figure 7).

LTV ratios were adjusted a total of nine times (six times for tightening and three times for relaxing) within a 40 percent to 70 percent range, and also differentiated depending on loan structure and across areas, with tighter standards being applied where the real estate market is suspected to be plagued by speculation. DTI ratios were similarly adjusted a total of eight times (six times for tightening and two times for relaxing) between a 40 percent to 75 percent range, and also differentiated according to borrower characteristics such as marital status, house prices, and geographic location of the property, among others.

FX-Related Measures

Specific measures to address FX risks were designed reflecting new thinking and evidence on the underlying causes of the global financial crisis and Korea's past experiences as well. Two policy measures were imposed on banks: (1) leverage caps on banks' FX derivatives positions, which requires banks to limit their FX derivatives position at or below a targeted level (as

specified in percent of bank equity capital of the previous month), and (2) macroprudential stability levy (MSL) on non-core FX liabilities of banks.²

Leverage caps were first introduced in October 2010 at 250 percent for foreign bank branches and 50 percent for domestic banks. Since then, they have been tightened twice—in July 2011 and January 2013—to remain at present at 150 percent and 30 percent respectively for foreign bank branches and domestic banks (Figure 8). The MSL was first imposed on banks in August 2011 and has remained unchanged. The levy rate varies from 2 basis points to 20 basis points with a lower levy being applied to longer-maturity liabilities (Figure 9).

Policy Effects

Cursory Look

A cursory look at financial and economic indicators suggests that macroprudential policies deployed thus far have produced the intended policy effects on house prices, mortgage lending by banks, and capital flows, at least in the short run.

Looking through a four-quarter window centered at the date of policy change, a tightening of LTV or DTI regulations tends to be associated with a statistically significant decline in the speed at which house price and/or mortgage lending increases (Figure 10). Specifically, the rate of increase in house prices fell on average by 1.7 percentage points after tightening of LTV regulations and by 0.8 percentage points after tightening of DTI regulations, compared with the corresponding rate of increases during the pre-tightening two-quarter period. Similarly measured effects on the volume of mortgage loans are also significant: the volume of increase in mortgage lending fell on average by 43.9 percent (6.2 trillion won) after a tightening of LTV regulations and by 44.4 percent (4.9 trillion won) after a tightening of DTI regulations.

Macroprudential policies targeted for FX risks also appear to have worked well by and large, although limited data availability (due to the short history of policy implementation) constrains statistical analysis. As regards the effects of leverage caps, banks—particularly foreign bank branches—have reduced their FX derivatives position and hence short-term borrowings by a significant amount since May 2010 when the introduction of leverage caps was first announced

² The “global banking glut” view expounded by Shin (2012), as opposed to the global savings glut view, was instrumental in the design and implementation of the MSL.

(Figures 11 and 12).³ MSL is a cost to banks and, therefore, *ceteris paribus* shrinks the arbitrage margin (Figure 13). A preliminary estimate suggests that the total levy collected could be as large as 12 percent of net profits for foreign bank branches while less than 1 percent for domestic banks (Figure 14). This is not surprising given that domestic banks' funding is predominantly in local currency while foreign bank branches fund mostly in foreign currency.

The maturity structure of external debt has also improved, particularly in the case of foreign bank branches following the introduction of leverage caps and MSL (Figure 15). During the two-year period after mid-2010, foreign bank branches' short-term borrowings decreased by US\$35 billion, while their long-term borrowings increased by US\$20 billion. To be specific, foreign bank branches have resorted more to long-term inter-office borrowings in order to reduce their MSL and also to increase their forward buying capacity in response to a tightening of leverage caps on FX derivatives position.⁴ Consequently, foreign bank branches reduced the share of short-term borrowings in total external borrowings from 93 percent to 58 percent during the period of 2010–12.

Formal Analysis

A more formal empirical analysis is undertaken to gauge the policy effects on targeted risks and variables. It should be noted at the outset, however, that the analysis discussed below is highly preliminary and subject to many caveats associated with the difficulty of unknown counterfactuals and limited data availability. Nevertheless, the empirical results appear promising for the effectiveness of macroprudential policies in achieving financial stability.

Effects of LTV and DTI regulations

A two-variable panel vector autoregression (PVAR) is estimated for the rate of increase in house prices and the volume of bank mortgage loans, controlling for the effects of LTV and DTI regulations and other relevant policies (See Annex 1 for model specification and full estimation

³ At the time of policy announcement, the average FX leverage ratio of foreign bank branches exceeded 260 percent of equity capital. The same ratio fell sharply to 87 percent by January 2013.

⁴ For foreign bank branches, part of their long-term borrowings (with a maturity longer than a year) from their head offices is recognized as bank capital (known as Capital B) and exempt from the MSL. Because leverage caps are defined as a percentage of bank equity capital, higher Capital B *ceteris paribus* enables foreign bank branches to buy dollars forward in greater amounts. Capital B of foreign bank branches increased to 16 trillion won by end-March 2012, up from 6.1 trillion won at end-March 2010.

results). Monetary policy tightening is estimated to have the intended effects while higher capital gains taxes also appear to have discouraged the demand for mortgage loans but raised house prices, suggesting a higher tax incidence on home buyers than on home sellers (which is partly attributable to the fact that the housing market was a seller's market rather than a buyer's market when high expectations of capital gains prevailed).

The coefficients of LTV and DTI dummies are negative as expected and highly significant in most cases; some DTI dummies included in the equation for mortgage loan growth are estimated imprecisely, indicating that LTV regulations may have been more effective than DTI regulations at least in Korea. Moreover, the estimated coefficients suggest that tighter LTV regulations (with a lower cap on LTV ratios) have stronger cooling effects on house prices and mortgage lending by banks. Last but not least, the actual effects of LTV and DTI regulations might be even stronger than estimated if the possible upward endogeneity bias in the estimated coefficients (stemming from an endogenous response of policies to developments in housing markets and bank lending) is taken into consideration.

Cumulative effects of LTV and DTI regulations on house prices and mortgage lending are simulated by using the estimated PVAR model. According to the results of dynamic simulation, house prices and the outstanding stock of mortgage loans would have been 75 percent and 137 percent higher than their respective actual levels by the second quarter of 2012 if there had been no regulations in place throughout the sample period (Table 2 and Figure 16).⁵ Although the estimated policy effects—especially, those on mortgage loans—may appear somewhat larger than one might expect, they are not unreasonable if viewed against the galloping pace of credit expansion observed in many housing booms of emerging economies.⁶

Effects of leverage caps and MSL

Policy effects of leverage caps and MSL are estimated by using a Bayesian VAR model for banks' foreign borrowings and other related financial variables such as VIX ⁷(see Annex 2 for model specifications and estimated impulse responses). The basic assumption is that leverage caps are quantitative restrictions and thus affect directly banks' foreign borrowings whereas

⁵ For the effects of LTV regulations, the scenario of “no regulations” refers to the case with LTV cap at 60 percent being in place (see Annex 1 for greater details).

⁶ An omitted variable bias is another possibility for the larger estimated policy effects, which warrants further scrutiny in future studies.

⁷ VIX implies volatility in S&P 500 stock index option prices.

MSL affects banks' foreign borrowings mainly through changes in funding cost or net returns.⁸ The estimated model was then used to produce two conditional forecasts of banks' foreign borrowings—one with macroprudential policies (policy scenario) and the other with no macroprudential policies (no policy scenario). The difference between the two scenarios is taken as the estimate of policy effects.

Leverage caps are estimated to have contributed to improving the maturity structure of banks' foreign liabilities. For foreign bank branches, leverage caps are estimated to have reduced short- and long-term foreign borrowings by about 0.6 percent and 0.2 percent of annual GDP, respectively, in cumulative terms over the one-year horizon from their introduction (Figure 17). For domestic banks, the effects are estimated to be only one tenth of those for foreign bank branches. Such a difference between foreign bank branches and domestic banks is not surprising since leverage caps were binding for the former at the time of their introduction but not for the latter.

The estimated effects of MSL on the maturity structure of banks' foreign liabilities are smaller than those of leverage caps but nonetheless moderate in light of the fact that the levy rate has been set at fairly low levels. In cumulative terms over the one-year horizon, MSL has reduced short-term borrowings of domestic banks and foreign bank branches alike by about 0.2 percent of annual GDP with no discernible impact on long-term borrowings (Figure 18).

Implications for Systemic Risk

Evidence for the effectiveness of macroprudential policies may have positive implications for systemic risk. Indeed, LTV and DTI regulations seem to have had significant effects in mitigating the credit risk of mortgage loans. For instance, delinquency rate and value-at-risk tend to fall after LTV or DTI regulations are tightened, and vice versa (Figure 19). DTI regulations, introduced in late 2005, also appear to have affected the composition of mortgage loans. The share of installment loans in total mortgage loans was less than 40 percent at end-2005. It began to rise from 2006 and stood at 65 percent by 2012 (Figure 20). The rising share of installment loans indicates the reduced rollover risks faced by borrowers and thus less default risk on mortgage lending.

⁸ Specifically, the borrowing spread over Libor is used as a proxy for domestic banks' borrowing costs whereas the covered interest parity deviation (CID) is used as a proxy for foreign bank branches' net returns. These two price variables are chosen in view of their centrality to banks' foreign asset and liability management.

But macroprudential policies may not always help reduce systemic risk. For instance, the share of long-term mortgage loans with a maturity of 10 years or longer has been on the rise since DTI regulations came into effect in late 2005. Accordingly, the duration of mortgage loans increased from 3.8 years to 5.5 years over the period of 2006–12 (Figure 21). Although a higher share of installment loans may help reduce default risk, the longer duration of mortgage loans may have increased banks' interest rate and liquidity risks.

Concluding Remarks

Preliminary evidence for Korea seems to offer strong support for the usefulness and effectiveness of macroprudential policies as a tool to achieve and ensure macrofinancial stability. LTV and DTI regulations have helped stabilize housing markets and keep credit expansion under proper control. Similarly, macroprudential policies targeting FX risks such as leverage caps and the bank levy appear to have contributed to improving the maturity structure of external debt owed by banks and reducing the likelihood of sudden stops.

Several policy issues and lessons are emerging from Korea's experiences. First, country-specific circumstances may matter in important ways for the effectiveness of macroprudential policies. For instance, the powerful role played by LTV and DTI regulations in Korea seems to have been aided by the large presence of short-term bullet mortgage loans, which are treated as new loans whenever rolled over. Second, the policy authorities should bear in mind and exercise vigilance concerning a variety of unintended consequences. LTV regulations could become pro-cyclical if adjustments in LTV caps lag far behind house price movements. Although DTI regulations have induced banks to offer more long-maturity installment loans, banks' funding maturity has failed to increase accordingly resulting in larger maturity mismatch and higher interest rate and liquidity risk as well.

Third, the issue of policy circumvention should be taken seriously because it could increase or even create systemic risk, not to mention undermine policy effectiveness. As LTV and DTI regulations were focused on banks, mortgage lending by (less regulated and less well capitalized) nonbanks increased rapidly. Last but not least, more research is called for to answer how best to combine macroprudential and monetary policies.

Reference

Shin. 2012. "Global Banking Glut and Loan Risk Premium," *IMF Economic Review* 60:155–192.

Table 1. Major changes in LTV and DTI regulations

Measures	Time	Policy
LTV	Sep. 2002	Limit LTV ratio to less than 60%
	Mar. 2004	Raise LTV ratio cap for installment loans (60% → 70%)
	Jul. 2009	Lower LTV ratio cap for Seoul metropolitan area (60% → 50%)
DTI	Aug. 2005	Limit DTI ratio to less than 40% for unmarried borrowers of age 30 or younger; and for married borrowers with existing loans by spouse for home purchase in speculative areas
	Nov. 2006	Expand the list of DTI-regulated areas to cover speculation-prone districts in Seoul metropolitan area
	Sep. 2009	Further expand the list of DTI-regulated areas to include nonspeculative districts in Seoul metropolitan area
	Aug. 2010	Temporary suspension of DTI regulations on nonspeculative districts in Seoul metropolitan area

Source: Bank of Korea.

Note: DTI = debt to income; LTV = loan to value.

Table 2. Simulated Mortgage Loans and House Prices by Scenario

	Level				Ratio		
	Actual (A)	No LTV in place (B)	No DTI in place (C)	Neither LTV nor DTI in place (D)	(B-A)/A	(C-A)/A	(D-A)/A
Mortgage Loans ¹	312 (2.2%)	702 (4.5%)	325 (2.3%)	739.1 (4.6%)	125.0%	4.2%	136.9%
House Prices ²	139.8 (0.9%)	241.9 (2.4%)	141.6 (1.0%)	244.8 (2.5%)	73.0%	1.3%	75.1%

1. In trillion won.

2. 2003.I = 100.

Note: Figures in the parenthesis indicate quarterly average growth rates over the period of 2003.I-2012.II.

Figure 1. Household Loans and House prices

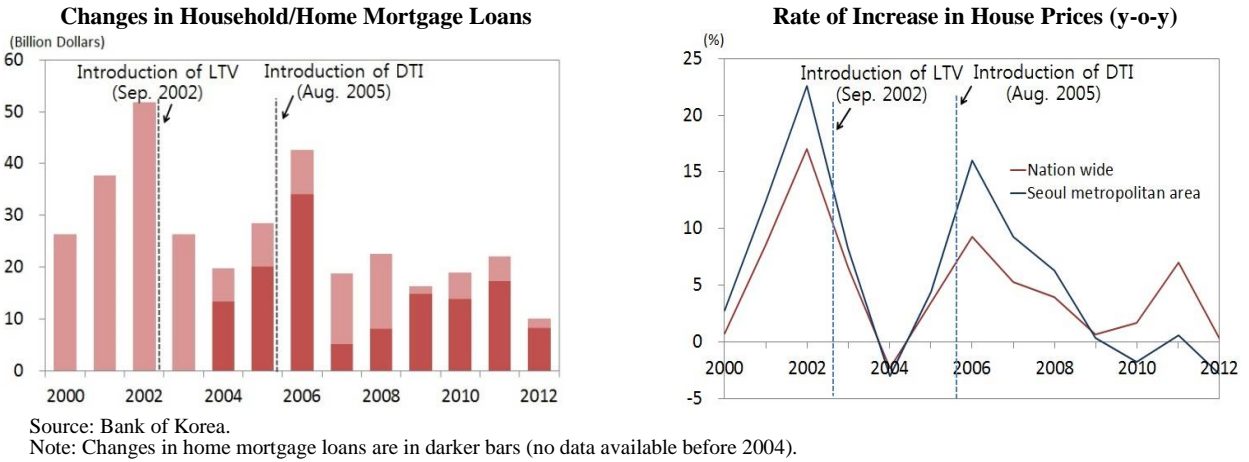
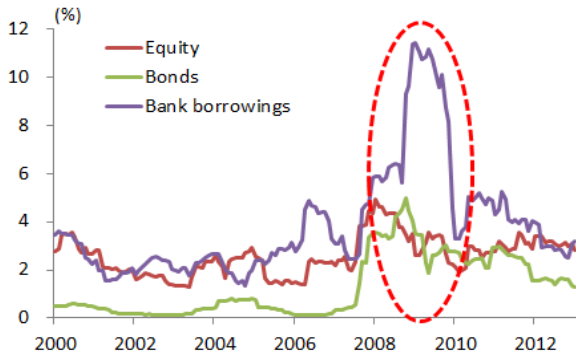
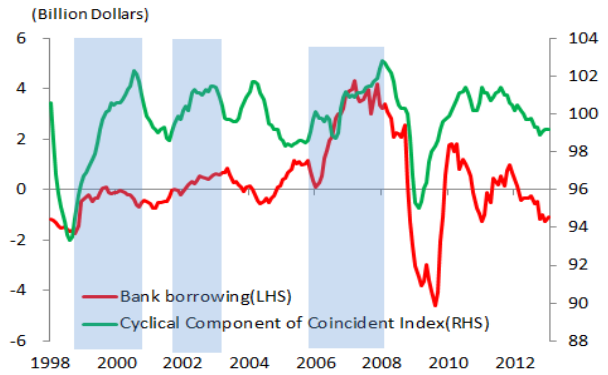


Figure 2. Capital Flow Volatility¹



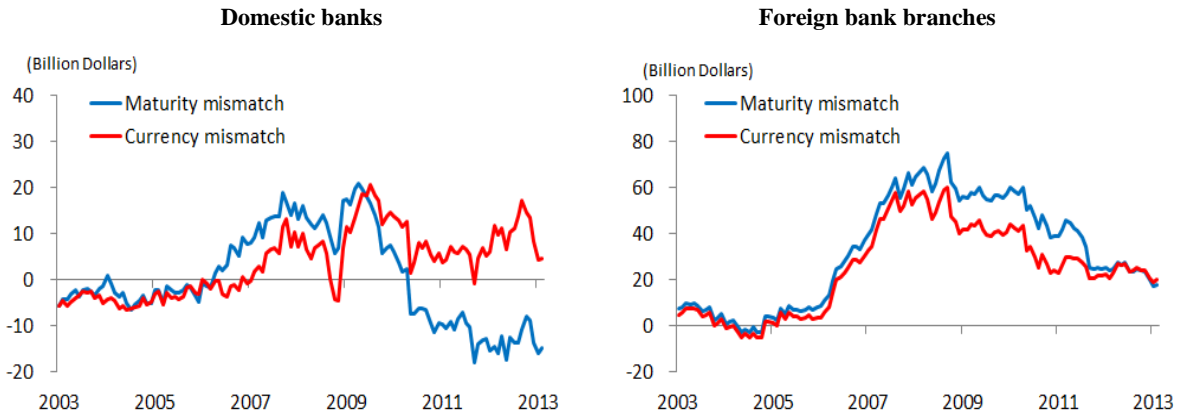
Source: Bank of Korea.
1. 12-month moving standard deviation of capital flows as a percentage of GDP (annualized).

Figure 3. Bank Borrowings¹ and Business Cycle



Source: Bank of Korea.
1. 12-month moving average.
Note: Shaded area indicates cyclical upswings.

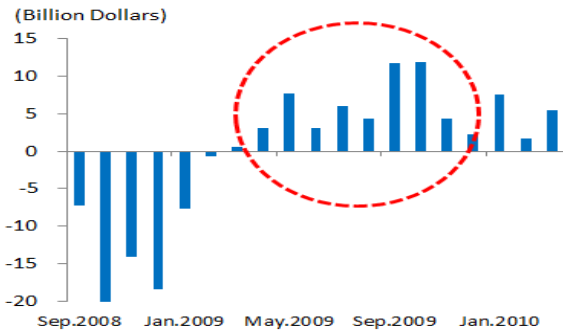
Figure 4. Currency and Maturity Mismatches



Source: Bank of Korea.
Notes: Currency mismatches = foreign liabilities - foreign assets.

Maturity mismatches = short-term foreign liabilities - short-term foreign assets.

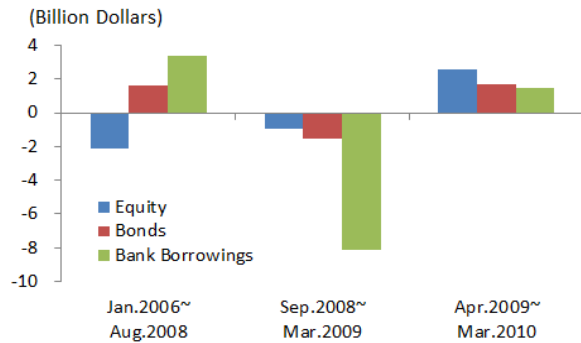
Figure 5. Net non-FDI Capital Flows



Source: Bank of Korea.

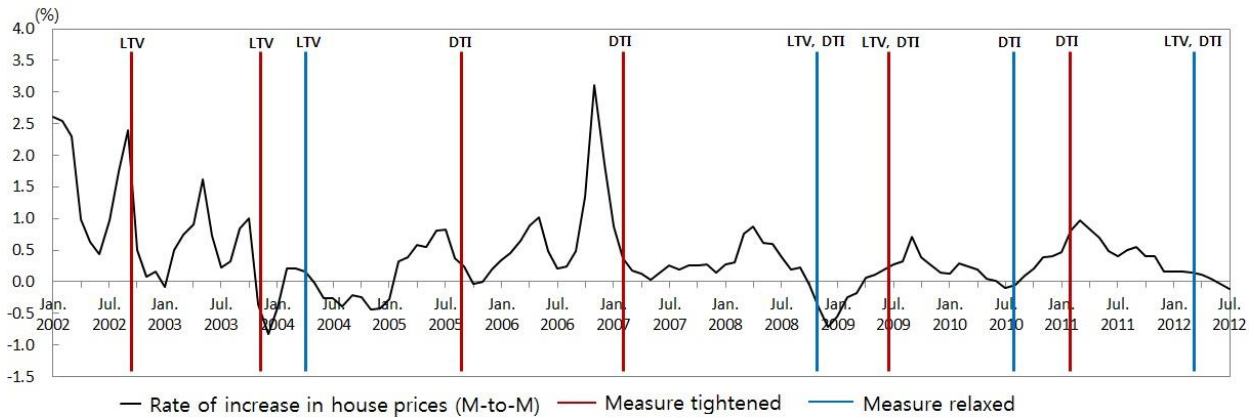
Note: FDI = Foreign Direct Investment.

Figure 6. Pre- and Post-crisis Capital Flows (Monthly average)



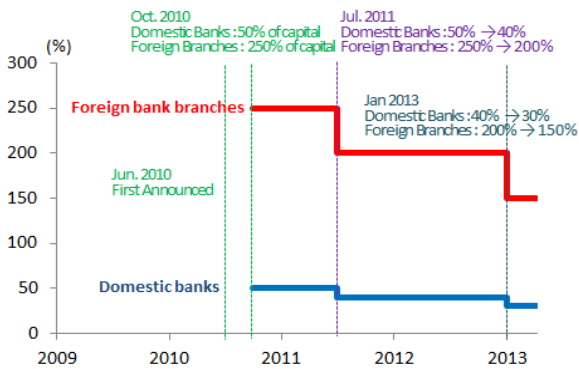
Source: Bank of Korea.

Figure 7. Changes in LTV and DTI Regulations and Rate of Increase in House Prices



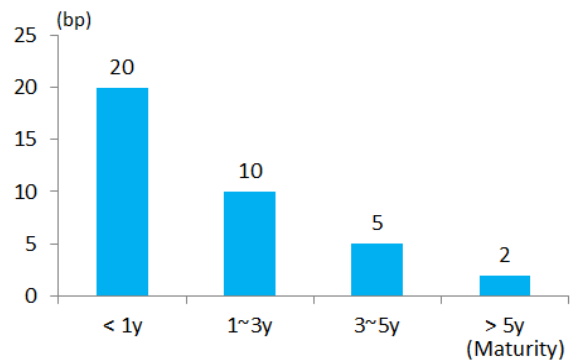
Source: Bank of Korea, Kookmin Bank.

Figure 8. Leverage Caps on FX Derivatives Position



Source: Bank of Korea.

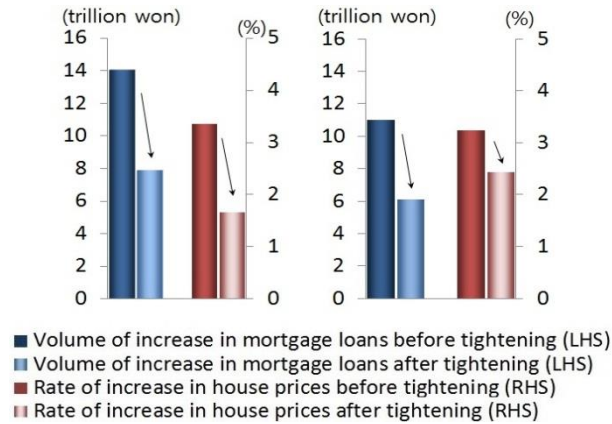
Figure 9. Macroprudential Stability Levy



Source: Bank of Korea.

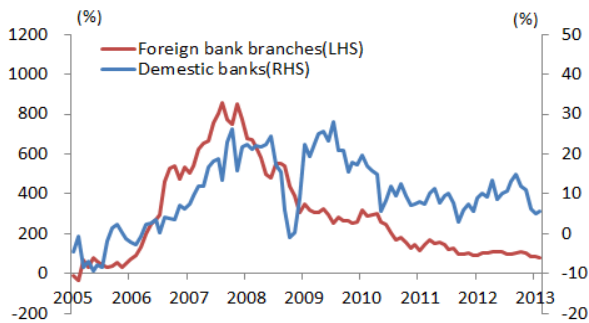
Figure 10. Effects of Housing Sector Related Policy Measures

Potential Effects of LTV Potential Effects of DTI



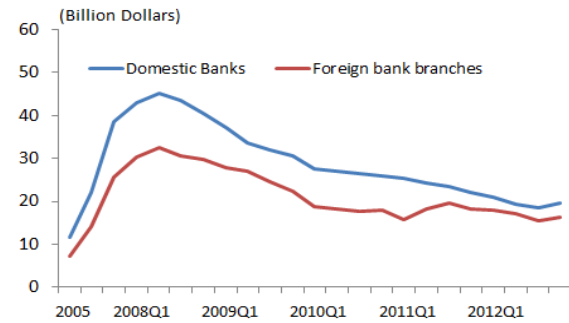
Source: Nice Credit Information Service DB, Kookmin Bank.
 Note: Darker (lighter) bars refer to cumulative changes over the two-quarter period before (after) the tightening of LTV or DTI regulations. The data are in quarterly frequency and span the period from 2003.II to 2011.III.

Figure 11. Total FX Derivatives Position (% of bank capital)



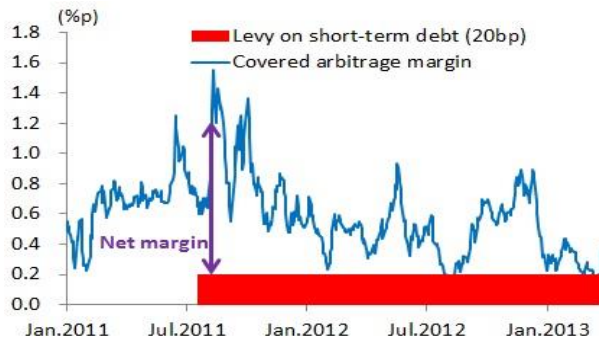
Source: Bank of Korea.

Figure 12. FX Derivatives Position (vis-à-vis Shipbuilders)



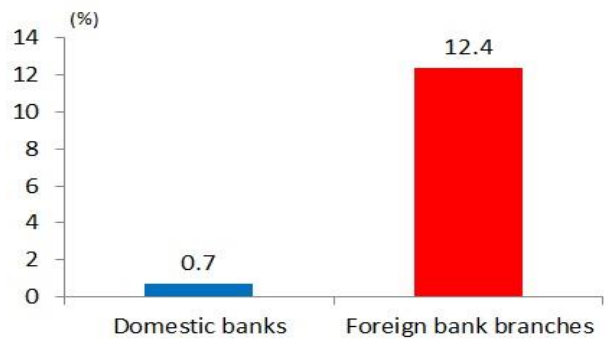
Source: Bank of Korea.
 Note: Annual data for periods prior to 2008.

Figure 13. Incentives for Arbitrage Transaction¹ (Foreign bank branches)



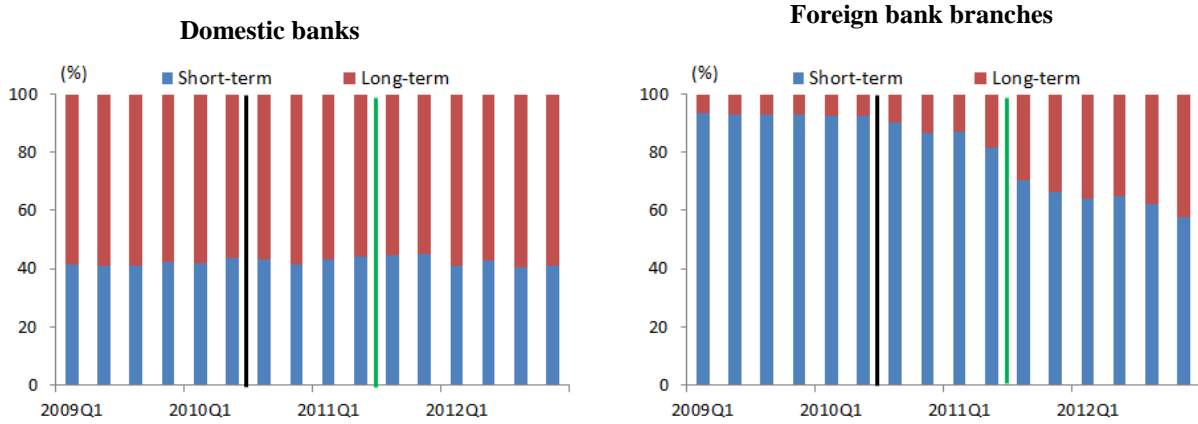
Source: Bank of Korea.
 1. Interest rate differential (3M)-Swap rate (3M).

Figure 14. Ratio of Levy to Net Profits¹ (As of end 2012)



Source: Bank of Korea.
 1. BOK staff estimates.

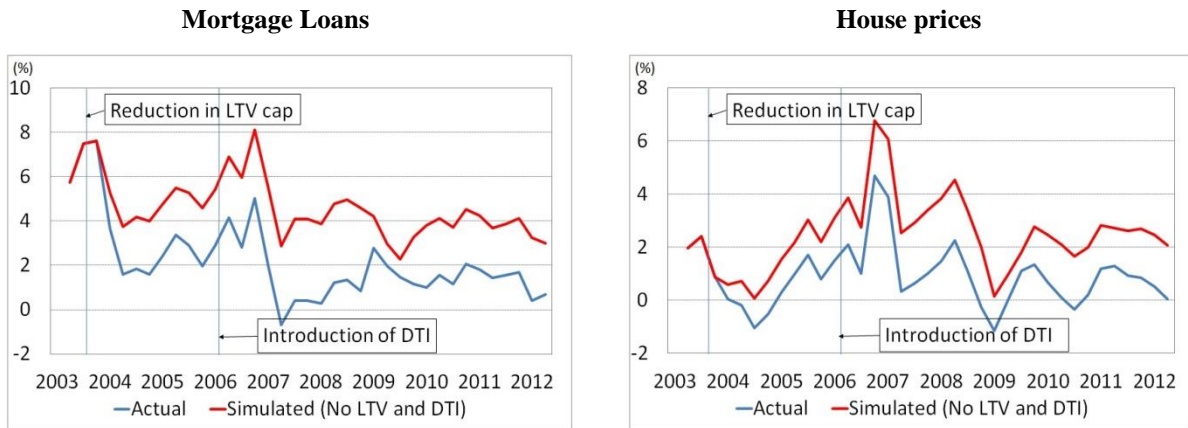
Figure 15. Maturity Composition of External Debt



Source: Bank of Korea.

Note: Black and green vertical lines indicate the dates of the introduction of Leverage Cap and Stability Levy, respectively.

Figure 16. Growth Rates of Mortgage Loans and House Prices (Actual vs. Simulated)

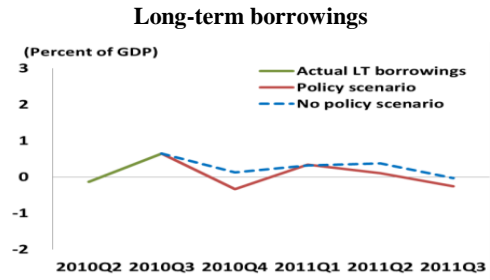
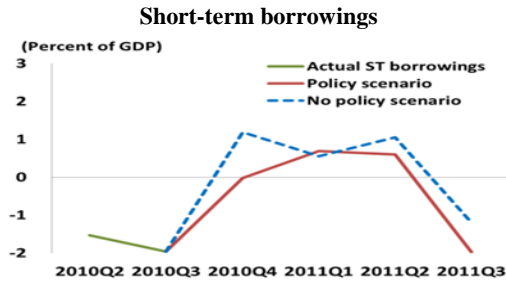


Source: Bank of Korea.

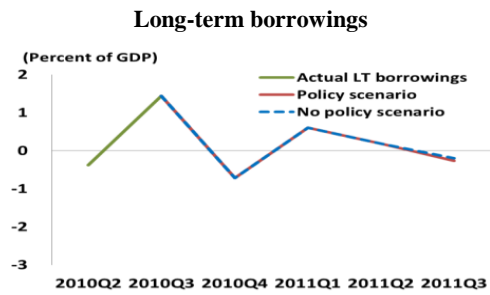
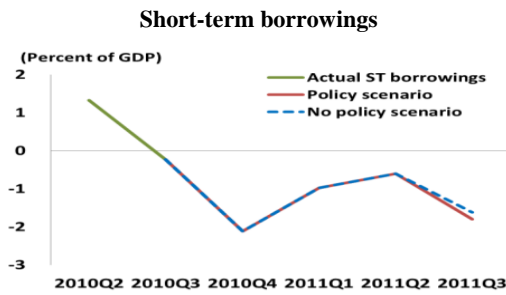
Source: Bank of Korea.

Figure 17. Impact of Leverage Caps on External Borrowings

A. Foreign bank branches



B. Domestic banks

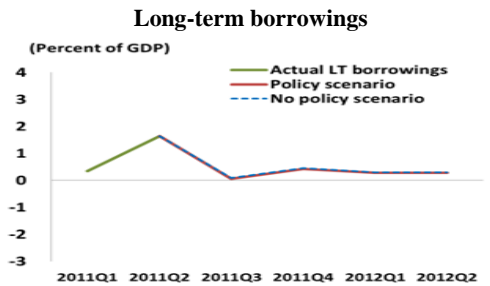
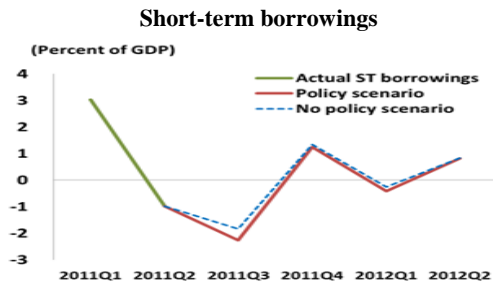


Source: Bank of Korea.

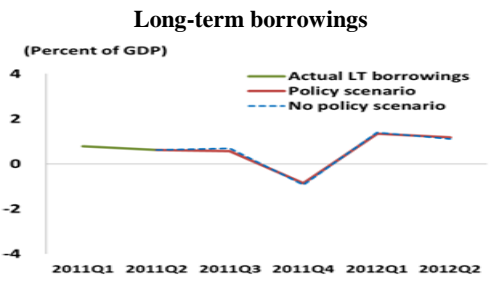
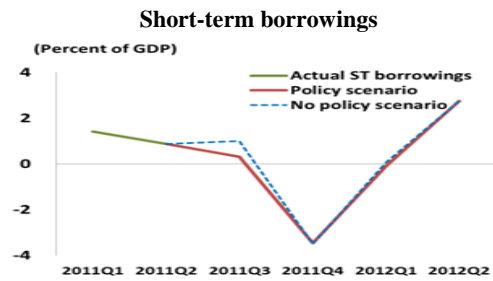
Note: Solid red lines (broken blue lines) refer to conditional forecasts under policy scenario (no policy scenario); solid green lines indicate actual values.

Figure 18. Impact of MSL on External Borrowings

A. Foreign bank branches



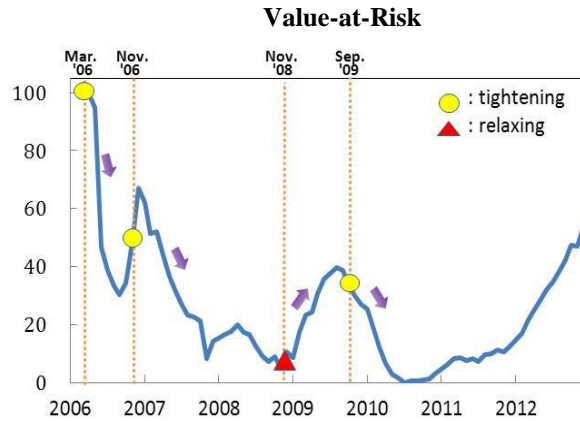
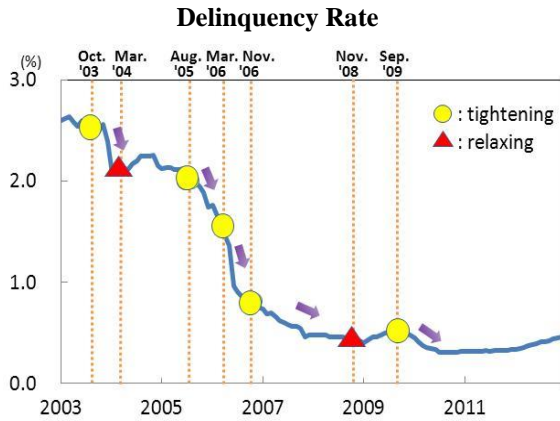
B. Domestic banks



Source: Bank of Korea

Note: Solid red lines (broken blue lines) refer to conditional forecasts under policy scenario (no policy scenario); solid green lines indicate actual values. MSL = macroprudential stability levy.

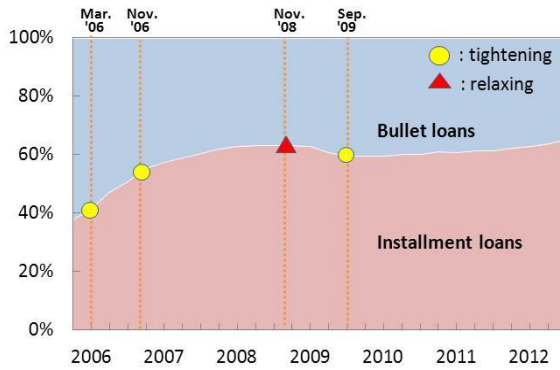
Figure 19. Credit Risk of Mortgage Loans



Source: Bank of Korea.

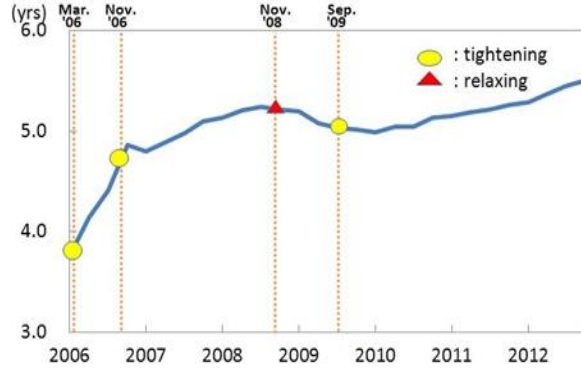
Note: Value-at-Risk is normalized to lie between 0 and 100.

Figure 20. Share of Installment Loans



Source: Bank of Korea.

Figure 21. Weighted Average Duration



Source: Bank of Korea.

Annex 1. Estimating the Effects of LTV and DTI Regulations: Panel VAR

Data and Specification

A panel vector autoregressive (PVAR) is estimated for house prices and the volume of mortgage lending by banks (both seasonally adjusted) controlling for the effects of LTV and DTI regulations. The sample used for the analysis is a balanced panel that covers 43 areas over the period of 2003.II-2012.II. The specification of the panel VAR is as follows:

$$X_t = A_0 + A_1 X_{t-1} + B P_{t-1} + C Z_{t-1} + \epsilon_t$$

where X is a vector of endogenous variables (house price and mortgage lending), P is a vector of policy variables, and Z represents other controls such as nominal GDP and dummies for speculative areas and the global financial crisis. Policy variables considered include the overnight call interest rate (as a proxy for monetary policy stance), dummies for LTV and DTI regulations and dummies for capital gains tax policy (see Table A.1 below).

As LTV regulations were first introduced with a cap set at 60 percent and have been in place throughout the entire sample period and across all areas, the estimated coefficients of LTV dummies included in the VAR—LTV4 and LTV5—capture the policy effects relative to the baseline case of LTV ratio being capped at 60 percent. For DTI regulations, three dummies—DTI4, DTI5, and DTI6—are used in the VAR as the sample includes the periods and/or areas of no DTI regulations in place. Therefore, their coefficients reflect policy effects relative to the baseline case of no DTI regulations. LTV dummies are constructed based on the cap level applied to mortgage loans of 3- to 10-year maturity which account for the bulk of mortgage lending by banks (LTV cap for loans with maturity of 10 years or longer was set to 70 percent but appears to be nonbinding). DTI dummies are relatively free from the coverage issue because DTI regulations are applied uniformly except for the first 10-month period, when DTI regulations were applied only to large mortgage loans exceeding 600 million won.

Table A.1. Variables Description

Name	Description
Loan	Quarterly growth rate of mortgage loans (s.a. ¹ , %)
Hprice	Quarterly growth rate of house prices (s.a. ¹ , %)
NGDP	Quarterly growth rate of nominal GDP (s.a. ¹ , %)
LTV4, LTV5	LTV4 (LTV5) equals 1 if the LTV cap is 40% (50%), 0 otherwise
DTI4, DTI5, DTI6	DTI4 (DTI5, DTI6) equals 1 if the DTI cap is 40% (50%, 60%), 0 otherwise
Call	Overnight call interest rate (%)
Tax	Tax equals 1 if capital gains tax rate is 50%, 0 otherwise
SPA	SPA equals 1 if the region is designated as speculative area, 0 otherwise
CS	CS equals 1 for the period of 2008.IV-2009.III, 0 otherwise

1. s.a. refers to seasonally adjusted data.

Estimation Results

The model is estimated by using Generalized Method of Moments (GMM). The over-identifying restrictions are not rejected for both equations if the Hansen test (which is more heteroskedasticity-consistent) is used. The estimated coefficients of LTV and DTI dummies are statistically significant and of the expected sign in most cases, although some DTI coefficients are imprecisely estimated in the equation for mortgage lending. Monetary tightening (as captured by the call interest rate) turns out to have been effective in curbing the housing boom and bank lending. The tax policy appears to have reduced mortgage loan growth but increased house prices.

Table A.2. Estimation Results

	Loan	Hprice
Loan	0.228*** (0.027)	0.042** (0.020)
Hprice	0.052 (0.038)	0.477*** (0.024)
NGDP	-0.373*** (0.056)	0.079** (0.039)
Call	-0.251** (0.104)	-0.255*** (0.069)
Tax	-1.650*** (0.352)	0.781*** (0.225)
LTV4	-3.157*** (0.805)	-1.587*** (0.468)
LTV5	-2.056*** (0.389)	-0.954*** (0.248)
DTI4	-0.346 (0.323)	0.178 (0.189)
DTI5	0.128 (0.335)	-0.370 (0.233)
DTI6	-0.191 (0.552)	-1.241*** (0.379)
SPA	2.211** (0.867)	1.694*** (0.493)
CS	-0.880*** (0.252)	-0.819*** (0.167)
Constant	5.152*** (0.602)	0.679* (0.385)
Observations	1,505	1,505
No. of areas	43	43
Sargan Stat. (<i>p</i> -value)	590.4(0.863)	1458.9(0.001)
Hansen J-Stat. (<i>p</i> -value)	40.8(0.999)	41.1(0.999)

Annex 2. Estimating the Effects of Leverage Caps and MSL: Bayesian VAR

The baseline model for the estimation is a four-variable Bayesian VAR model:

$$Y_t = \Phi_0 + \sum_{j=1}^p \Phi_j Y_{t-j} + e_t.$$

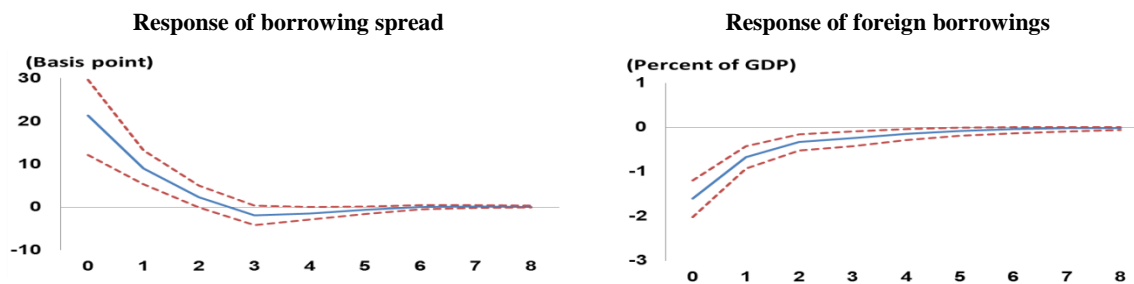
where Y is a vector of foreign borrowings by domestic banks or foreign bank branches and other financial variables (OFVs) that are deemed to have an influence on FX risks. For domestic banks, OFVs include FX derivatives position ratio (as percent of bank capital), VIX, and borrowing spread over the Libor. For foreign bank branches, OFVs include the same variables except that the borrowing spread over Libor is replaced by the covered interest parity deviation (CID).

The sample used for the estimation is in quarterly frequency and spans the period from 2003.I to 2012.II. Use of quarterly data is dictated by the availability of disaggregated data on foreign borrowings by domestic banks and by foreign bank branches (for a robustness check, however, the model is also estimated using monthly data on proxy variables).

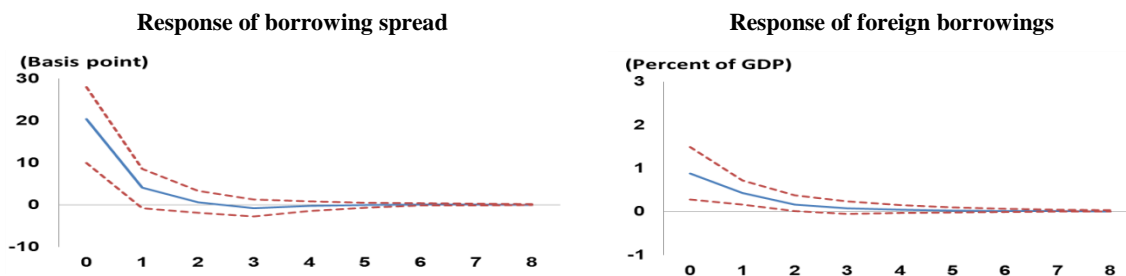
Four structural shocks of the model are identified by using both sign and exclusion restrictions as suggested by economic theory and institutional features. First, a global risk perception shock (or an innovation to VIX) is assumed to be orthogonal to other structural shocks. Second, a supply shock (or push factor) is assumed to move price (borrowing spread or CID) and quantity (foreign borrowings) in the opposite direction. Third, a demand shock (or pull factor) moves price and quantity in the same direction. Finally, a shock to the FX position ratio is assumed to be exogenous and orthogonal to contemporaneous shocks to price and quantity variables—capturing changes in the FX position ratio unrelated to foreign borrowings.

Figure A.1. Impulse Responses to Supply and Demand Shocks

A. Supply Shock



B. Demand Shock



Source: Bank of Korea.

Notes: Estimation results are for domestic banks. Solid blue lines indicate median values of impulse responses while broken red lines indicate 68 percent probability bands.