

Assessing the Effects of Macroprudential Policy Measures in Korea*

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Abstract

This paper presents a tentative empirical assessment of the impacts of two macroprudential measures introduced in Korea since 2010 - the leverage cap on banks' FX derivative positions (leverage cap) and the levy on banks' non-deposit foreign currency liabilities (macroprudential levy). These measures, introduced as alternative macroprudential policy tools to mitigate the volatile cross-border banking flows, entail imposing banks disincentives to the high reliance on short-term foreign borrowings, which proved to highly destabilizing in the wake of the global financial crisis. We attempt to gauge these impacts by estimating Bayesian VAR models of banks' foreign borrowings using the data over the period 2003-2011, and then quantifying the effects of these macroprudential measures on banks' foreign borrowings through counterfactual analysis based on conditional forecasts. Our empirical results suggest that both macroprudential measures have contributed to boosting resilience in the banking system, in that they have lengthened the maturity structure of banks' foreign liabilities. First, the estimates from the models for banks as a whole show that the leverage cap reduced short-term foreign borrowings more than long-term foreign borrowings. Second, the estimates using the models for domestic banks and foreign bank branches show that the macroprudential levy reduced banks' short-term foreign borrowings mainly, leaving their long-term borrowings almost unaffected. Taken together, our results suggest that both the leverage cap and the macroprudential levy have helped to mitigate the vulnerabilities associated with procyclical capital flows, because of their abilities to reduce maturity mismatches in the banking system. However, since the analysis in this paper is based upon limited data from the initial period of new policy measure implementation, it is possible that the results could change as more data become available over time. Nevertheless, this kind of model-based analysis helps to provide a tentative overview of the impacts of the new macroprudential policies, which could serve as a starting point for future policy analysis.

JEL Classification: F32, F41, F47

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1 Introduction

The global financial crisis has highlighted the fact that the economy can accumulate the financial imbalances vulnerable to crises even while maintaining the price stability and the soundness of individual financial institutions. This had led to a focus on macroprudential measures as an alternative policy tool to enhance the resilience of the financial system by fixing market failures. In particular, in emerging market economies with high capital market openness, volatile cross-border capital flows has been one of dominant factors causing systemic risks, and it has become a policy priority to improve the stability of financial system by mitigating the build-up of risks from procyclical cross-border capital flows.

Against this backdrop, Korea introduced two capital flow-related macroprudential measures since 2010 - the leverage cap on banks' FX derivative positions (leverage cap) and the levy on banks' non-deposit foreign currency liabilities (macroprudential levy) - to reduce banks' high reliance on short-term foreign borrowings which proved to highly destabilizing in the wake of the global financial crisis. The leverage cap was introduced to reduce the excessive firms' net FX forward selling and the associated increase in banks' short-term external debts. Specifically, the leverage cap was introduced to limit banks' FX derivative positions to 50 percent of capital for domestic banks and 250 percent for foreign bank branches in October 2010, and to limit banks' FX derivative positions further to 40 percent and 200 percent respectively in July 2011. On the other hand, the macroprudential levy in effect since August 2011 operates by charging 2-20 basis points per year on banks' non-deposit foreign currency liabilities in order to reduce banks' high reliance on the short-term non-core liabilities as funding source. Considering the potential contributions to systemic risks, the higher rates are imposed on shorter-term than long-term FX liabilities¹.

The purpose of this paper is to provide a tentative empirical assessment of the impacts of two macroprudential policies introduced in Korea since 2010 - the leverage cap and the macroprudential levy². These macroprudential measures are relatively new approach to managing capital flow-related risks, distinct from traditional capital control measures which discriminate on the basis of the residence of the investor. In this regard, though preliminary at the initial stage of new policy implementation, the evaluation of the effects of these macroprudential measures may nevertheless be necessary to draw the implications for policy-makers

¹Specifically, 20, 10, 5 and 2 basis points are applied to non-deposit FX liabilities with maturities of one year or less, less than three years, less than five years, and more than five years, respectively.

²The resumption of the taxation on foreigners' bond investment, introduced in January 2011, is not covered in this paper because it is intended to restore the withholding tax of 15.4 percent on the interest income from non-residents' bond investment to the same level as residents, thereby being outside the category of macroprudential policies to fix market failures defined in this paper.

around emerging market economies in particular.

The analysis proceeds in three steps. In the first step, we assume that macroprudential measures affect banks' foreign borrowings through the change in the key policy-related quantity or price variables. Specifically, the leverage cap is assumed to affect banks' foreign borrowings through the fall in the banks' FX derivation positions to capital ratio, while the macroprudential levy is assumed to affect foreign borrowings either through the rise in the borrowing spread or through the fall in the covered interest parity deviation. In the second step, we estimate the Bayesian VAR models of banks' foreign borrowings identified with sign restrictions. In the third step of the analysis, based on the estimated model, we quantify the impact of macroprudential measures on banks' foreign borrowing through counterfactual analysis using conditional forecasts. See Kapetanios et al. (2012) and Lensa et al. (2010) for the application of conditional forecasts to analyze the effects of quantitative easing by the Bank of England and the European Central Bank.

Our empirical results suggest that both macroprudential measures have contributed to boosting resilience in the banking system, in that they have lengthened the maturity structure of banks' foreign liabilities. First, the estimates from the models for banks as a whole show that the leverage cap reduced short-term foreign borrowings more than long-term foreign borrowings. Second, the estimates using the models for domestic banks and foreign bank branches show that the macroprudential levy reduced banks' short-term foreign borrowings mainly, leaving their long-term borrowings almost unaffected. Viewed as a whole, our results suggest that both the leverage cap and the macroprudential levy have helped to mitigate the vulnerabilities associated with procyclical capital flows, because of their abilities to reduce maturity mismatches in the banking system.

The previous studies on the effects of capital-related regulation can be classified in the followings two strands of literature. First, traditional studies examine whether capital control measures contributed to achieving macroeconomic policy objectives such as reducing total capital flows, changing the composition of capital flows and limiting the exchange rate pressures. While most studies find that capital controls are effective in altering the composition of capital flows, they find mixed results regarding the ability of capital controls to reduce total capital flows or to alleviate the appreciation pressures. See De Gregorio et al. (2000), Baba and Kokenyne (2011) and Magud et al. (2011) for the analysis in this direction. Second, a number of more recent studies investigate the extent to which capital controls or prudential regulations contributed to enhancing financial stability. Most studies find that these measures are associated with the decrease in credit growth and greater growth resilience during crises. See Ostry et al. (2010) and Ostry et al. (2011) among others. Perhaps, Bruno and Shin (2012) is the closest to our paper in that they study the effect of macroprudential measures in Korea.

However, while they study macroprudential measures in general with a focus on the sensitivity of banking flows to global financial conditions, we study two measures separately with a focus on direct impact of each measure on banks' foreign borrowings.

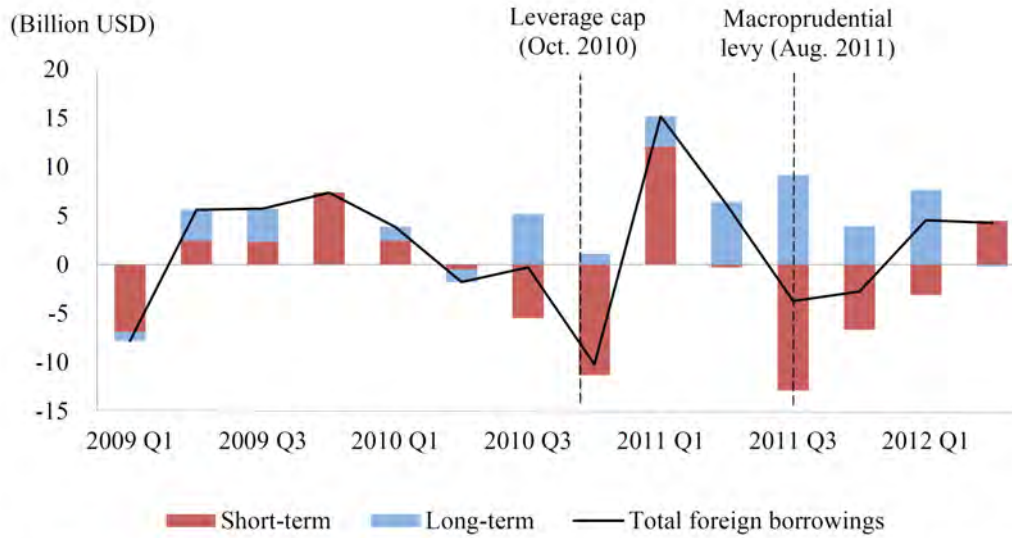
The remainder of the paper is structured as follows. In section 2, we review the institutional background of the market for banks' foreign borrowings, and then estimate the Bayesian VAR models of banks' foreign borrowings identified with sign restrictions. Based on the estimated models, section 3 quantifies the impact of macroprudential measures on banks' foreign borrowing through counterfactual analysis using conditional forecasts. Section 4 concludes.

2 Models of Banks' Foreign Borrowings

As illustrated in Figure 1, the implementation of macroprudential measures appears not only to have slowed the increase in banks' foreign borrowings but to have lengthened the maturities of foreign borrowings. Looking into the evolution of banks' foreign borrowings around the period of introducing new policy measures, we observe that banks' foreign borrowings increased during the period 2009Q2-2010Q1 due to the low risk perceptions and the ample global liquidity emanating from advanced economies, and then turned to decrease during the period 2010Q2-2010Q4 because of the introduction of the leverage cap and the onset of the European debt crisis. In the year 2011, banks' short-term foreign borrowings exhibited a temporary surge due to the strong demand for FX funds in the first half, while they turned to decrease because of the escalating European crisis and the implementation of the macroprudential levy in the second half. Meanwhile, banks' long-term foreign borrowings showed a steady increase throughout the year 2011.

This observation suggests that the change in banks' foreign borrowings after the introduction of macroprudential measures is determined by macroprudential measures as well as various domestic and foreign factors such as liquidity conditions, the global risk perceptions and domestic business cycles. In order to isolate the impacts of macroprudential measures from other factors, we need the models of banks' foreign borrowings in which we can conduct counterfactual analysis associated with the policy implementation. In the remainder of this section, we begin by reviewing the institutional features of the markets for banks' foreign borrowings, and then estimate the models of banks' foreign borrowings using the data over the period 2003-2011 that incorporate the key institutional ingredients, and finally investigate the determinants of banks' foreign borrowings using the estimated models.

Figure 1: Change in foreign borrowings for banks as a whole



Note: Foreign borrowings denote the total stock of external funding through loans, money market instruments and bonds. (Source: External debt/asset statistics from the Bank of Korea)

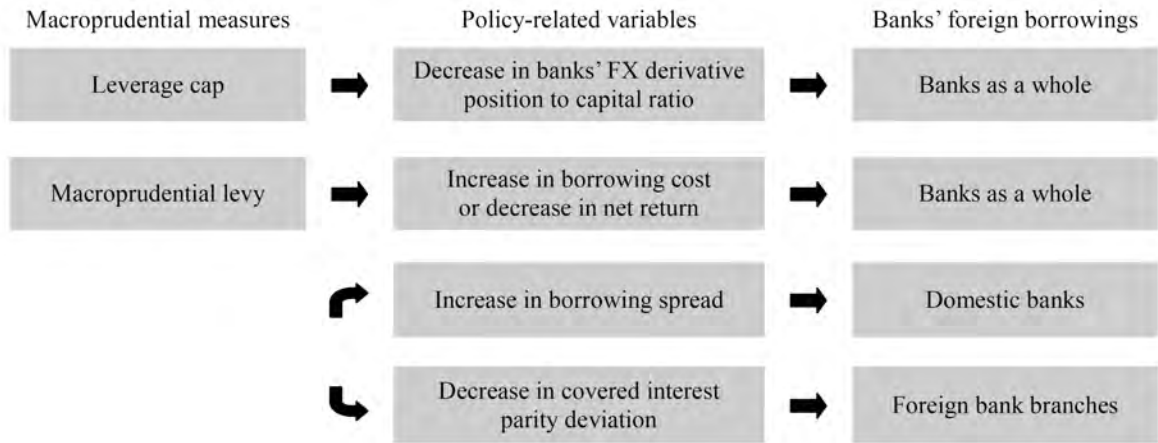
2.1 Institutional Background

In this subsection, we provide our assumptions about the transmission channels of macroprudential policies, and present the market structure for banks' foreign borrowings which form the basis for the transmission channels and the specifications of our models.

Figure summarizes our assumption about the transmission channels of macroprudential policies where macroprudential policies affect banks' foreign borrowings through the changes in the key policy-related quantify and price variables. First, the leverage cap is assumed to affect banks' foreign borrowings through the fall in banks' FX derivative positions to capital ratio (FX derivative ratio). Specifically, this channel posits that those banks whose FX derivative ratio were above the regulatory limit had to lower this ratio at least to the upper limit, thereby reducing foreign borrowings in the process of balance sheet adjustments. Since the data on the FX derivative ratio is only available at the level of banks as a whole, we employ the models for banks as a whole to estimate the impact of the leverage cap.

Second, the macroprudential levy is assumed to affect banks' foreign borrowings through the rise in the borrowing cost or the fall in the net return. In general, banks' borrowing costs and net returns can be represented in several different ways depending on the pattern of banks' management of assets and liabilities. In our discussion of the channel of the macroprudential levy, we use banks' borrowing spread over Libor rate as a proxy for the borrowing cost and the covered interest rate parity (CIP) deviation as a proxy for the net return because these price

Figure 2: Transmission channels of macroprudential policies



variables are associated with a lion's share of banks' fund raising and asset management³. In principle, these price variables can affect foreign borrowing activities of domestic banks and foreign bank branches alike. However, given the structure of foreign borrowings and the data availability we assume that the transmission of the macroprudential levy through the change in the borrowing spread operate mainly on domestic banks, while the transmission of the levy through the change in the CIP deviation operates mainly on foreign bank branches⁴. For this reason, the models for domestic banks are employed to estimate the impact of the macroprudential levy through the borrowing spread channel, and the models for foreign bank branches are employed to estimate the impact of the macroprudential levy through the CIP deviation channel. Then, the total impacts of the macroprudential levy on foreign borrowings for banks as a whole is measured as the sum of two separate impacts - one transmitting to domestic banks through borrowing spread channel and the other transmitting to foreign bank branches through the CIP deviation channel.

Although there are several possible channels through which macroprudential measures influence banks' foreign borrowings, we focus on the above channels because of the data availability and the market structure for banks' foreign borrowings which we turn to the next.

In order to provide institutional footings to the aforementioned transmission channels of macroprudential measures, we examine the specific market structure of banks' foreign borrowings. Figure 3 depicts the foreign borrowings market for domestic banks, where domestic banks borrow from global banks at the Libor plus the borrowing spread ($i^* + \alpha$) in order to lend to local borrowers at the lending rate (r). On the other hand, global banks raise wholesale

³The CIP deviation is defined as (3M CD rate - 3M Libor rate - 3M swap rate) for the three-month instrument and (1Y KTB - 1Y CRS rate) for the one-year instrument

⁴These assumptions will be explained in further detail when the market structure of banks' foreign borrowings are described below

funding at the Libor rate (i^*) and supply wholesale funding to local banks in other jurisdictions at the Libor rate plus the borrowing spread ($i^* + \alpha$). Then the net return for global banks is approximated as the borrowing spread (α) which is obtained by subtracting the borrowing cost from the revenue from supplying funds, while the net return for domestic banks is approximated as the difference between the lending rate (r) and the borrowing cost ($i^* + \alpha$). In this context, the borrowing spread functions as an important price variable in the foreign borrowings market for domestic banks.

Figure 3: Foreign currency assets and liabilities for domestic banks



Note: 1. r is the lending rate to local borrowers, i^* is the Libor rate, α is the borrowing spread over Libor rate paid by domestic banks.

2. The amounts shown in domestic banks' balance sheets are in units of billion US dollars as of December 2010, converted from Korean won-denominated amount in financial analysis information retrieval system from the Bank of Korea.

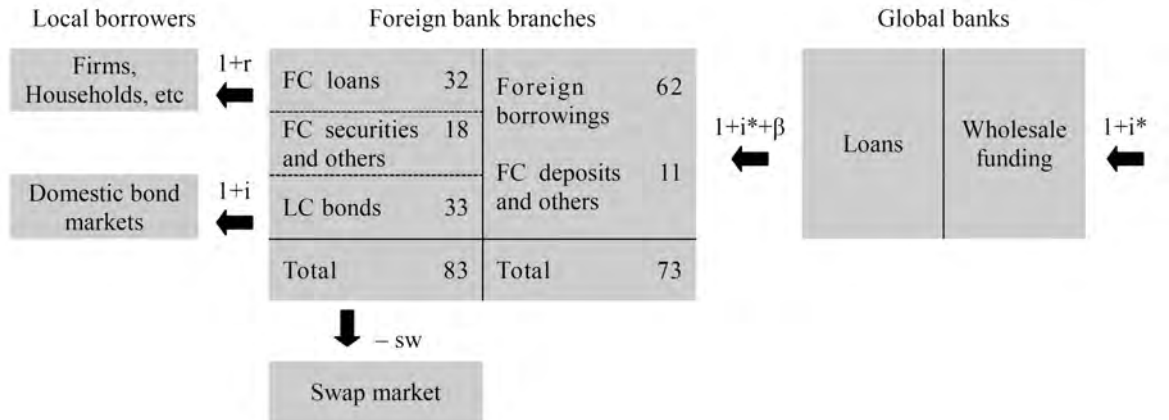
3. FC loans are the sum of foreign-currency lending, domestic import usance and bills bought, and FC borrowings are the external funding through loans, money market instruments and bonds by domestic banks.

At the end of the year 2010, the stock of domestic banks' foreign currency borrowings was 125 billion US dollars which amounted to 71 percent of total foreign-currency liabilities, while the stock of foreign-currency loans to local borrowers was 132 billion US dollars which amounted to 78 percent of total foreign currency assets. This suggests that the foreign currency loans to local borrowers using foreign currency borrowings from abroad is the dominant pattern of foreign currency balance sheet management for domestic banks.

On the other hand, Figure 4 depicts the foreign borrowings market for foreign bank branches where foreign bank branches borrow from global banks including their own parent banks in order to lend to local borrowers or invest in local bonds. In particular, when foreign bank branches make FX swap contracts and invest in local bonds using funds raised from global banks, they earn the net return equivalent to the CIP deviation. At the end of the year 2010, the stock of foreign-currency borrowings by foreign bank branches was 62 billion US dollars which amounted to 85 percent of total foreign currency liabilities, while their holdings of local bonds and the stock of foreign-currency loans to local borrowers were

33 billion US dollars and 32 billion US dollars respectively which amounted to 40 percent and 38 percent of total foreign currency assets respectively.

Figure 4: Foreign currency assets and liabilities for foreign bank branches



Note: 1. r is the lending rate to local borrowers, i^* is the Libor rate, β is the borrowing spread over Libor rate paid by foreign bank branches, sw is the swap rate defined by the difference between the log of three-month forward exchange rate and the log of spot exchange rate.

2. The amounts shown in foreign bank branches' balance sheets are in units of billion US dollars as of December 2010, converted from Korean won-denominated amounts in financial analysis information retrieval system from the Bank of Korea.

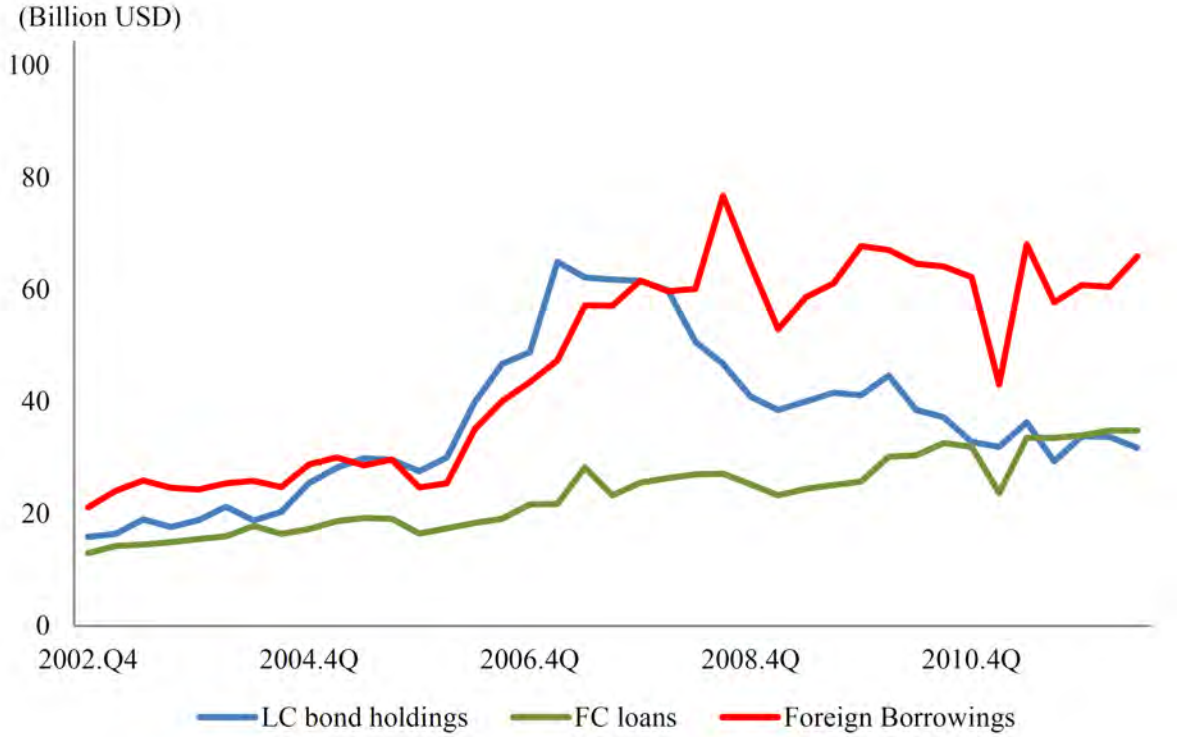
3. FC loans are the sum of foreign-currency lending, domestic import usance and bills bought, and FC borrowings are the external funding through loans, money market instruments and bonds by domestic banks.

Although the holdings of local bonds and foreign currency loans to local borrowers comprise the similar fraction of total foreign currency assets, we analyze the impact of macroprudential measures on foreign bank branches using the CIP deviation channel associated with the holdings of local bonds. We do so because for foreign bank branches foreign borrowings are more tightly linked to the local bond holdings than the foreign currency loans. This is illustrated in Figure 5 which depicts the evolution of foreign borrowings, the local bond holdings and the foreign currency loans for foreign bank branches over the period 2002Q4-2012Q2. Whereas foreign currency loans showed a steady growth over the entire period, the holdings of local bonds fluctuated markedly with a clear sign of procyclicality. Besides, over the period 2002-2007 most of the increase in foreign borrowings by foreign bank branches appear to have financed the increase in local bond investments, and even over the period 2008-2012 foreign borrowings still exhibited positive comovement with the local bond holdings.

5.

⁵The correlation between foreign borrowings and the local bond holdings by foreign bank branches still dis-

Figure 5: The evolution of selected components from foreign currency balance sheets by foreign bank branches



To give a formal assessment of the extent to which foreign borrowings are linked to each component of asset holdings, we consider the variance decomposition as

$$1 = \frac{var(k)}{var(k)} = \frac{cov(k, k)}{var(k)} = \frac{cov(k, bond)}{var(k)} + \frac{cov(k, loan)}{var(k)} + \frac{cov(k, other)}{var(k)}. \quad (1)$$

Here, third equality comes from the balance sheet identity of $k \approx bond + loan + other$, where k , $bond$, $loan$, and $other$ indicate foreign borrowings, local bond holdings, loans to local borrowers, and other asset holdings by foreign bank branches, respectively. The data show that 55 percent of changes in foreign borrowings are associated with changes in the local bond holdings, and only 27 percent is associated with changes in foreign currency loans to local borrowers.

In sum, the interplay of global banks, local banks including domestic banks and foreign bank branches, and local borrowers through the medium of price signals such as the borrowing spread and the CIP deviation is the key mechanism to determine the equilibrium in the market for foreign borrowings. When domestic or external shocks hit emerging market

played a relatively high level of 0.55 during the period 2002Q4-2012Q4 after displaying a very high correlation of 0.96 during the period 2008Q3-2012Q2. However, foreign borrowings and the local bond holdings moved in the opposite direction during the period 2008Q1 - 2008Q2 as foreign bank branches made adjustments in their foreign currency balance sheets in response to the changes in the insufficient capital tax system.

economies, the new equilibrium will be determined as a consequence of the adjustments in supply and demand decisions by market participants.⁶. Hence, we turn to constructing the models of banks' foreign borrowings and identifying the structural shocks driving banks' foreign borrowings which reflect the institutional features outlined above,

2.2 Models and Data

In this subsection, we provide the model specifications corresponding to each transmission channel of macroprudential measures, and explain the data used in the estimation. To construct the models for the policy analysis, we estimate the Bayesian VAR (BVAR) models of banks' foreign borrowings as

$$Y_t = \Phi_0 + \sum_{j=1}^p \Phi_j Y_{t-j} + e_t, \quad (2)$$

where $e_t = P\varepsilon_t$ with e , ε , and P indicating the reduced-form shocks, the structural shocks, and the rotation matrix transforming the reduced-form to structural shocks, respectively. The variable vector Y comprises bank's foreign borrowings and the associated price variable at a minimum, and contains additional variables depending the specific transmission channel under consideration. First, the models for banks as a whole are employed to examine the effects of the leverage cap because the data on banks' FX derivative positions to capital ratio is available only at the level of banks as a whole. We use the 4-variable model with the stock market volatility index (*vi*x), borrowing spread (*sp*), foreign borrowings for banks as a whole (*k*), and FX derivative ratio (*fp*) as the baseline, and use the 3-variable model with three variables (*sp*, *k*, *fp*) except for the VIX index as the alternative⁷.

Second, considering the channels outlined in the previous subsection, we employ the models for domestic banks to estimate the impact of macroprudential levy through the borrowing spread channel, and estimate the models for foreign bank branches to estimate the impact of macroprudential levy through the CIP deviation channel. Specifically, for the models for domestic banks we use the 3-variable model with the VIX index (*vi*x), borrowing spread (*sp*), and domestic banks' foreign borrowings (*k^d*) as the baseline, and use the 2-variable model with borrowing spreads (*sp*) and domestic banks' foreign borrowings (*k^d*) as the alternative. Also, for models for foreign bank branches we use the 3-variable model with the

⁶In this sense, our approach is broadly consistent with Bruno and Shin (2012) and Kim et al. (2012) which examine the transmission of global liquidity conditions using the framework of cross-border banking flows.

⁷We use the borrowing spread as the price variable in the models for banks as a whole because foreign borrowings associated with the borrowing spread constitute a large fraction of total foreign borrowings.

VIX index (vix), the CIP deviation (cid), and foreign bank branches' foreign borrowings (k^f) as the baseline, and use the 2-variable model with the CIP deviation (cid) and foreign bank branches' foreign borrowings (k^f) as the alternative. As the data on banks' FX derivative ratio are not available at the level of domestic banks and foreign bank branches, we exclude it from the models for domestic banks or foreign bank branches.

The data used in the analysis comprise quantity and price variables associated with banks' foreign borrowings over the period 2003Q1-2012Q2. We take the quarterly data as the baseline sample and the monthly data as the alternative sample because the distinction of foreign borrowings into domestic banks and foreign bank branches is available only at the quarterly basis. For this reason, we choose the Bayesian VAR model to overcome the curse of dimensionality which traditional VAR models are likely to face given the small size of quarterly sample. However, as a robustness check to the estimation using the quarterly data, we also present the estimation results using the monthly data in the appendix A.2 where we use the relevant proxies when the original data is not available.

The data on banks' foreign borrowings are taken from external debt/assets statistics for the quarterly series, and are taken from balance of payment and local bond investment statistics for the monthly series. The borrowing spread is the weighted average of borrowing spreads over Libor rates for major domestic banks when they borrow abroad through loans and bond issuances, and banks' FX derivative ratio is the difference between the purchase and the sale of FX forwards by banks as a whole divided by capital. Banks' foreign borrowings are normalized by nominal GDP⁸ and the VIX index, the borrowing spread, and the FX derivative ratio are first differenced according to the unit root test results. The lags of VAR models are chosen to be 2 for quarterly data and 3 for monthly data, using the median values from three lag-length criteria like AIS, SIC and HQ criteria.

2.3 Identification

The identification of structural shocks driving banks' foreign borrowings depends on sign restrictions combined with zero restrictions. Sign restrictions identify structural shocks by

⁸Unpublished monthly nominal GDP series are estimated as follows. First, the estimates of monthly real GDP series are taken from Kang (2010), which estimates Kalman Filter models using the monthly supplementary data. Second, following the smoothing methods developed by Boot et al. (1967) and Denton (1971), the monthly GDP deflator series are estimated such that they minimize the sum of squared first difference of the monthly GDP deflators subject to the constraints that the weighted averages of monthly GDP deflators are equal to the quarterly GDP deflators. Finally, the monthly nominal GDP series are estimated by multiplying the monthly real GDP series by the estimated monthly GDP deflator series.

imposing specific signs for impulse responses of key variables based on the economic theory⁹ We rely on sign restrictions because we need to identify the relationships between the policy-related variables and banks' foreign borrowings based on the economic theory to conduct the economically meaningful policy analysis. The Cholesky orderings which assume an arbitrary causal relation among variables is fragile because both the policy-related variables and banks' foreign borrowings are highly endogenous variables whose contemporaneous relationships are elusive to pin down with ad-hoc restrictions.

Table 1 summarizes structural shocks identified for each model where the number of shocks are equal to the number of variables for each model to achieve the full identification. Below we explain the restrictions imposed to identify structural shocks and their economic meanings.

Table 1: Model specifications

Models	Variables	Structural shocks
4 variable for banks as a whole	[vix, sp, k, fp]	Supply/demand/exogenous FX derivative ratio/risk perception shocks
3 variable for banks as whole	[sp, k, fp]	Supply/demand/exogenous FX derivative ratio perception shocks
3 variable for domestic banks	[vix, sp, k^d]	Supply/demand/risk perception shocks
2 variable for domestic banks	[sp, k^d]	Supply/demand shocks
3 variable for foreign bank branches	[vix, cid, k^f]	Supply/demand/risk perception shocks
2 variable for foreign bank branches	[cid, k^f]	Supply/demand shocks

First, supply shocks are identified to move quantity (foreign borrowings) and price variables (the borrowing spread or the CIP deviation) in the opposite direction on impact, representing foreign push factors driving capital flows such as changes in interest rates in advanced economies. Second, demand shocks are identified to move quantity and price variables in the same direction on impact, representing domestic pull factors driving capital flows such as domestic business cycles. Both supply and demand shocks are common shocks identified in all kinds of models as they are the key drivers of banks' foreign borrowings motivated by the economic theory. Third, the global risk perception shocks are identified as the innovations to the VIX index which are orthogonal to all other domestic variables for all horizons, rep-

⁹A number of previous studies used sign restrictions to study the effects of monetary policy as in Uhlig (2005), the determinants of capital flows as in Fratzscher et al. (2010) and Kim et al. (2012), and the impacts of quantitative easing as in Kapetanios et al. (2012).

representing the changes in global risk appetite which are one of foreign push factors driving capital flows. These shocks are identified in the models including the VIX index in the system. Finally, the exogenous FX derivative ratio shocks are as the shocks to the FX derivative ratio that are orthogonal to the market for banks' foreign borrowings on impact. In other words, these shocks capture the changes in the FX derivative ratio which does not have a contemporaneous impact on banks' foreign borrowings and the associated price variables but may cause the adjustments in asset components or other liability components except for foreign borrowings¹⁰. The exogenous FX derivative ratio shocks are identified in the models for banks as a whole which contain the FX derivative ratio in the system.

In the remainder of this subsection, we explain how BVAR models are estimated with sign restrictions using the 2-variable model for domestic banks as an illustration. To begin with, we estimate the reduced-form BVAR model for domestic banks consisting of the borrowing spread and foreign borrowings as

$$Y_t = \Phi(L)Y_{t-1} + e_t, \quad (3)$$

where we assume that e is the reduced-form shocks and the covariance matrix of reduced-form shocks is $E[e_t e_t'] = \Sigma$. This model is rewritten as the reduced-form moving average form as

$$Y_t = [I - \Phi(L)L]^{-1} e_t. \quad (4)$$

In order to identify supply and demand shocks as structural driving forces, we assume that the contemporaneous impulse responses of the borrowing spread and foreign borrowings satisfy the sign restrictions shown in Table 2.

The structural shocks (ε) are assumed to be related to the reduced-form shocks as $e_t = P\varepsilon_t$ and $\Sigma = PP'$, the problem of identifying supply and demand shocks is equivalent to find the rotation matrix that satisfies both the sign restrictions and the relationship $\Sigma = PP'$. This rotation matrix P can be found through the following steps.

In the first step, consider creating an arbitrary lower-triangular matrix R by applying the Cholesky decomposition to reduced-form shocks Σ . Though we can generate structural shock vector whose shock elements are orthogonal to each other, there is no guarantee that this orthogonalization satisfies the sign restrictions. In the second step, to find the rotation

¹⁰The exogenous FX derivative ratio shocks are identified to achieve the full identification and examine the determinants of banks' foreign borrowings. However, in the policy analysis we use supply and demand shocks because they are more easily interpretable and are shown to be the dominant determinants of banks' foreign borrowings.

Table 2: Sign restrictions to identify supply and demand shocks

Models	Borrowing spread	Foreign borrowings
Supply push	+	−
Demand pull	+	+

matrix P satisfying the sign restrictions, we consider the orthonormal matrix $Q(\theta)$ such that $Q(\theta)'Q(\theta) = Q(\theta)Q(\theta)' = I$ as

$$Q(\theta) = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix}, \quad (5)$$

where $0 < \theta < \pi$. Using this matrix, we can write the structural moving-average form as

$$Y_t = [I - \Phi(L)L]^{-1} RQ(\theta)'Q(\theta)u_t. \quad (6)$$

In the third step, for the values of θ satisfying the sign restrictions, the rotation matrix P is defined as $P = RQ(\theta)'$, and structural shocks ε are defined by $\varepsilon_t = Q(\theta)u_t$.

We generate the values of θ satisfying the sign restrictions by adopting the Bayesian approach as in Uhlig (2005) and Kim et al. (2012). In this approach, the distributions of reduced-form parameters are drawn from the posterior distributions of the parameter estimates of BVAR models. For each draw, a BVAR model is estimated by the estimation steps described above. If the estimated impulse responses are verified to be consistent with the sign restrictions, we retain those impulse responses, and discard the ones that fail to. We keep drawing parameter estimates until we collect 5000 valid draws. Finally, based on the collected 5000 draws, we use the median values as parameter estimates, together with the 16th and 84th percentile error bands which correspond to one-standard deviation confidence interval.

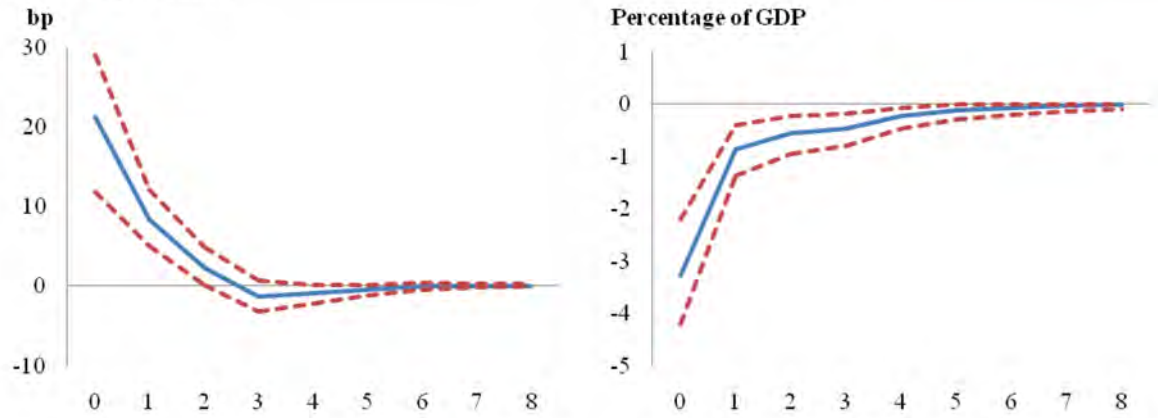
2.4 Estimation Results

The Figure 5 depicts the impulse responses of foreign borrowings for banks as a whole to supply and demand shocks using the 4-variable model as an illustration. As designed, supply

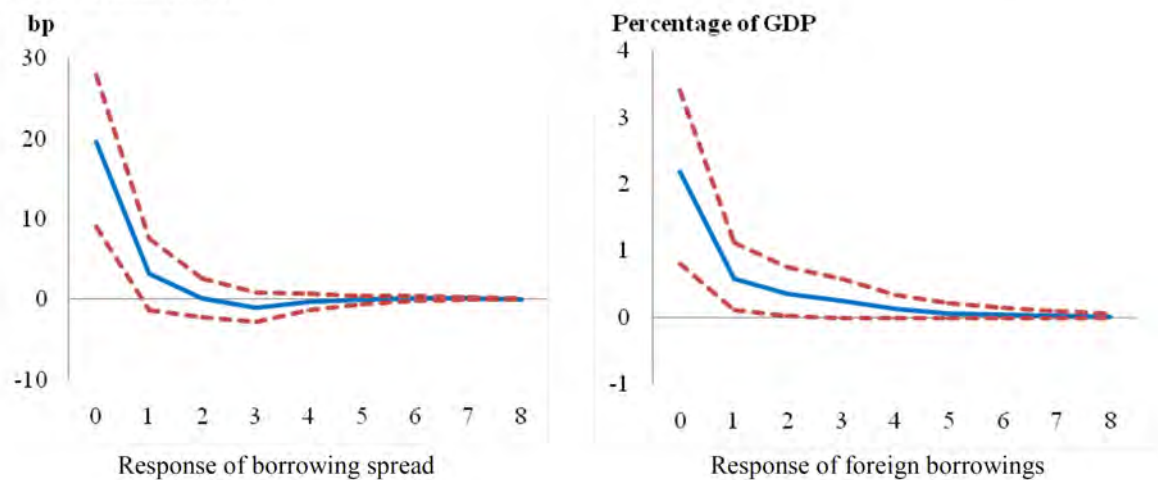
shocks induce the increase in the borrowing spread and the decrease in foreign borrowings, whereas demand shocks induce the increase in both the borrowing spread and foreign borrowings.

Figure 6: Impulse responses of banks' foreign borrowings to supply and demand shocks

Panel A. Supply Shock



Panel B. Demand Shock



Though not shown in Figure 6, the global risk perception shocks induce the borrowing spread and foreign borrowings in the opposite direction as the supply shocks do, while the exogenous FX derivative ratio shocks have little impact on both foreign borrowings and the borrowing spread. In addition, the models using different variables could potentially generate the distinct impulse responses to supply and demand shocks. However, it is notable that different models generate the similar qualitative pattern in the impulse responses to supply and demand shocks partly because of the same sign restrictions being imposed¹¹.

From the perspective of policy analysis, these results can be interpreted as follows. As de-

¹¹Also, the impulse responses estimated using the monthly data exhibit a similar pattern as those estimated using the quarterly data.

scribed in Figure 2, we assume that macroprudential policies affect banks' foreign borrowings through the change in the key policy-related variables such as the FX derivative ratio, the borrowing spread, the CIP deviation. As these policy-related variables are endogenous variables in the models of banks' foreign borrowings, we quantify the effects of macroprudential measures on foreign borrowings by identifying supply and demand shocks using theoretically motivated sign restrictions. Our focus lies in estimating the dynamic relationships among these endogenous variables shaped in response to these structural shocks rather than estimating the direct impact of the policy-related variables on foreign borrowings. We then conduct the counterfactual policy analysis by exploiting the estimated relationships between foreign borrowings and the key policy-related variables, which will be explained in more detail in the next section.

Turning to the analysis of the relative contributions of foreign push and domestic pull factors in driving banks' foreign borrowings, we estimate the forecast error variance decompositions of foreign borrowings using the 4-variable model for banks' as a whole. We classify the supply and global risk perception shocks push shocks, while the demand and exogenous FX derivative ratio shocks as pull shocks¹². As presented in Table 3, the majority of fluctuations in total foreign borrowings are driven by push factors, reflecting the fact that Korean banks tend to have hard a time in rolling over their short-term debts in time of financial turmoil. However, the relative contributions differ depending on the maturity of foreign borrowings. Whereas the majority of fluctuations in short-term foreign borrowings are driven by push shocks, the bulk of fluctuations in long-term foreign borrowings are driven by pull factors. The qualitative features on the relative contributions found in the models for banks as a whole more or less remain to be the same in the models for domestic banks or foreign bank branches.

Table 3: Forecast error variance decompositions of banks' foreign borrowings
(percentage)

	Total borrowings		Short-term borrowings		Long-term borrowings	
	Supply push	Demand pull	Supply push	Demand pull	Supply push	Demand pull
1Q	89.2	10.8	90.7	9.3	69.6	30.4
2Q	84.8	15.2	89.1	10.9	30.7	69.3
3Q	91.3	8.7	93.3	6.7	42.5	57.5
4Q	89.9	10.1	90.7	9.3	28.1	71.9

The relative contributions of push and pull shocks in determining capital inflows by foreign investors have the important policy implications for emerging market economies. If

¹²Though the exogenous FX derivative shocks have the elements of both push and pull factors, we classify it as domestic pull factors. However, as it explains a very small fraction of the fluctuations in foreign borrowings, the results on the relative contributions of push and pull shocks does not depend on the classification of the exogenous FX derivative ratio shocks

the bulk of capital flows are largely determined by foreign push shocks, emerging market economies may need to moderate the volatility of capital flows through prudential measures and measures to stabilize foreign exchange markets. Instead, if the bulk of capital flows are determined by domestic pull factors, emerging market economies need to focus on maintaining the stability of economic fundamentals through sound macroeconomic policies. Because push factors are shown to be the dominant sources in determining short-term banks' foreign borrowings in Korea, it appears critical to establish the policy framework to mitigate volatile capital flows such as macroprudential measures in effect since 2010.

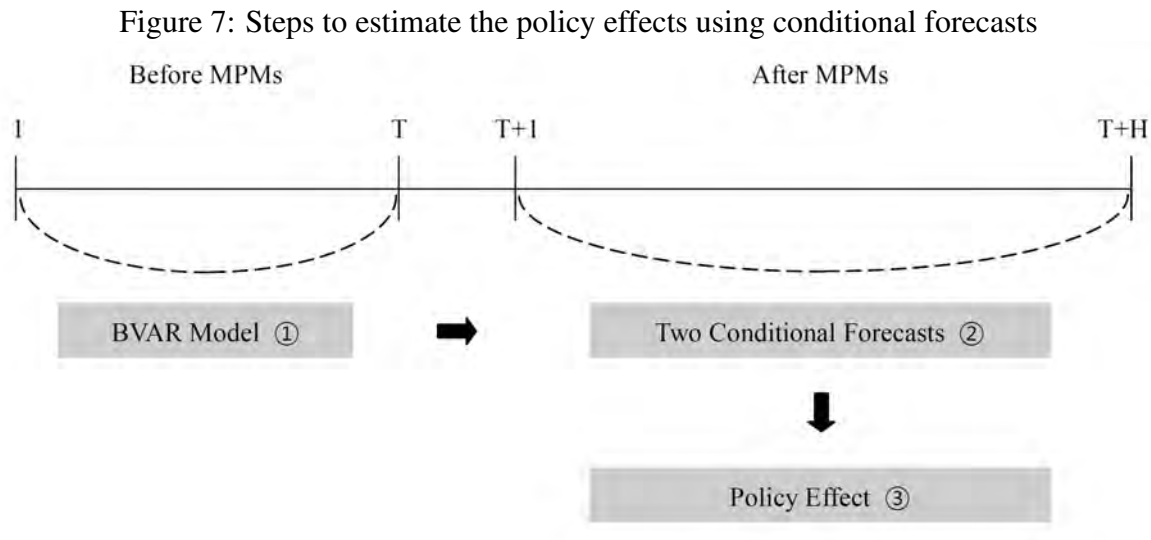
3 Impact of Macroprudential Measures

As structural shocks identified in the previous section are shown to influence banks' foreign borrowings with statistical and economic significance, we quantify the effects of macroprudential measures on banks foreign borrowing through the counterfactual analysis based on conditional forecasts within these estimated models.

3.1 Estimation Strategy

As various external and domestic factors jointly affect banks' foreign borrowings, we need to isolate the effects of policy measures from those of other factors by conducting the counterfactual analysis associated with the implementation of macroprudential measures. We do so by adopting the method of conditional forecasts which were used to assess the effects of the quantitative easing in the UK and EU (See Kapetanios et al., 2012; Lenza et al., 2010).

With this method, we generate two conditional forecasts for banks' foreign borrowings, one forecast under the assumption that macroprudential policies are implemented (policy scenario) and the other forecast under the assumption that these policies are not implemented (no policy scenario). Then, we compare the conditional forecasts under the policy scenario with those under the no policy scenario, and take the difference between the two as our estimates of policy effects.



This procedure is illustrated in Figure 7 in more detail. First, we estimate the BVAR models explaining banks foreign borrowings using the data before the introduction of policy measures (Step ①). Second, we generate two conditional forecasts based on two different assumptions about policy implementations. The conditional expectation of banks' foreign

borrowings under the policy scenario is computed given past observations of all variables and the future paths of policy-related variables in the policy scenario as

$$E \left[k_{T+h} | \Omega_T, z_{T+1}^P, \dots, z_{T+H}^P \right], \quad (7)$$

where k denotes bank's foreign borrowings relative to nominal GDP, Ω_T the information set available at time T , z^P the future paths of policy-related variables in the policy scenario, T the number of sample size before the policy implementation, and H the number of sample size after the policy implementation. Similarly, the conditional expectation of banks' foreign borrowings under the no policy scenario is computed given the future paths of policy-related variables in the no policy scenario as

$$E \left[k_{T+h} | \Omega_T, z_{T+1}^{NP}, \dots, z_{T+H}^{NP} \right], \quad (8)$$

where z^{NP} denotes the future paths of policy-related variables in the no policy scenario. Finally, the impact of macroprudential measures for banks' foreign borrowings (k) is defined as the difference between the policy and the no policy conditional expectations derived using the method outlined above.

In the remainder of this section, we present the results from estimating the policy effects using quarterly data, leaving the estimation results using monthly data as a robustness check in the appendix.

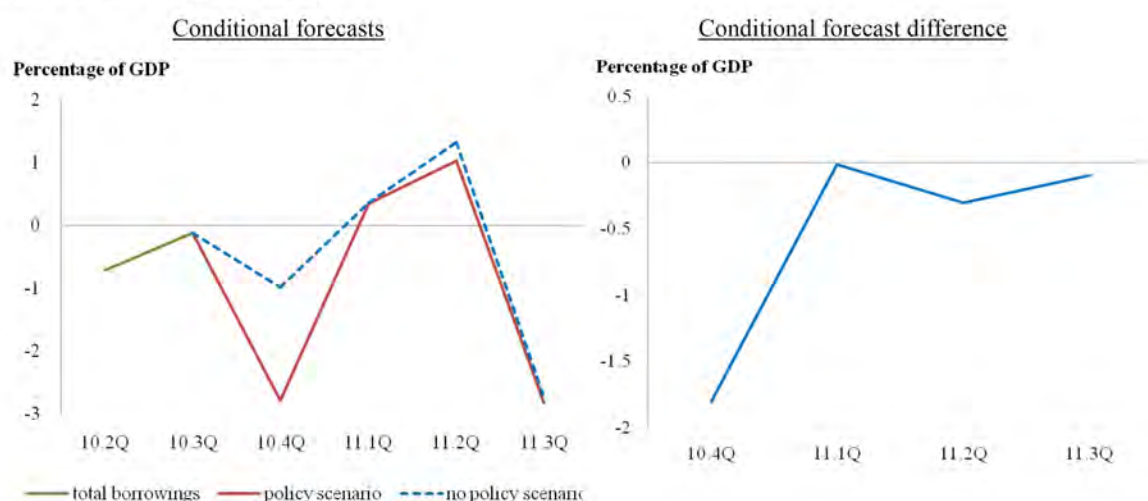
3.2 Impact of the Leverage Cap

To gauge the impacts of the leverage cap, we estimate the 4-variable foreign borrowings model for banks as a whole using the data over the period 2003Q1 - 2010Q3, and then generate two conditional forecasts based on each policy scenario using the data over the period 2010Q4 - 2011Q3. Under the policy scenario, we produce a counterfactual forecast taking the actual levels of the banks' FX derivative position ratio that were observed over the period 2010Q4 - 2011Q3 as our conditioning assumptions, which is depicted as a red straight line in the left of Panel A in Figure 8. On the other hand, under the no policy scenario, we produce a counterfactual forecast assuming that the banks' FX derivative position ratio would have been 3.6 percentage point higher over the period 2010Q4 - 2011Q3, which is depicted as a blue dotted line in the left of Panel A in Figure 8. The size of decrease in the FX derivative position ratio with the introduction of the leverage cap is computed by the degree to which this ratio falls for banks as a whole as foreign bank branches whose FX derivative ratios were above the regulatory limit had to lower this ratio at least to this limit.

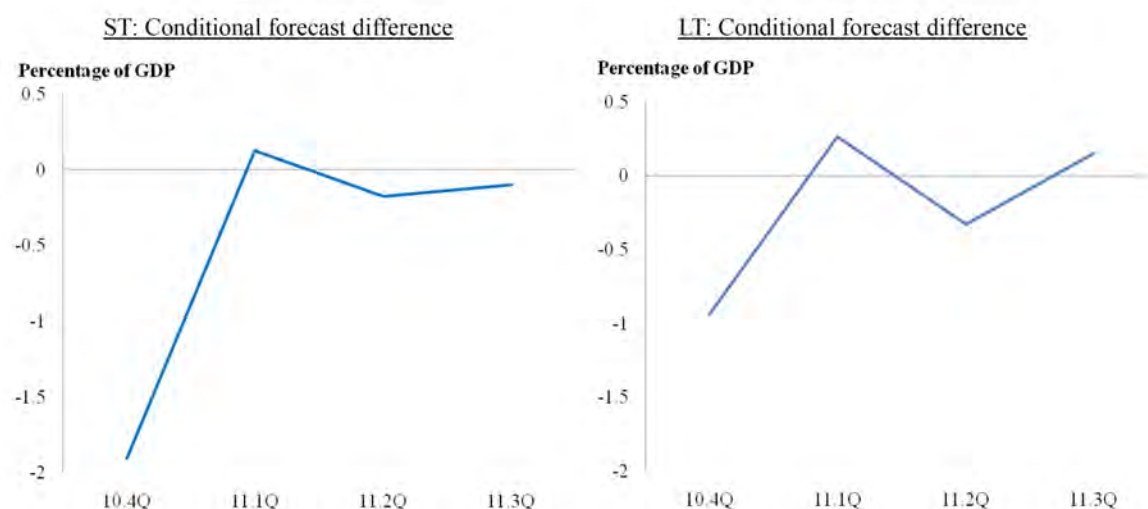
The estimation results show that the leverage cap reduces total foreign borrowings, and lengthens the maturity structure of foreign borrowings for banks' as a whole. Turning to the impact on total foreign borrowings, the path of total foreign borrowings under the policy scenario (the red straight line in the left of Panel A in Figure 8) moves downward relative to that under the no policy scenario (the blue dotted line in the left of Panel A in Figure 8), in particular during the initial post-policy period. The impacts of the leverage cap, measured by the difference between two conditional forecasts, are illustrated in the right of Panel A in Figure 8. It shows that the leverage cap reduces total foreign borrowings by 1.8 percent of quarterly GDP in the first quarter, and reduces by 0.1 to 0.3 percent of quarterly GDP in the remaining quarters.

Figure 8: Effect of the leverage cap on banks as a whole: quarterly data

Panel A. Total foreign borrowings



Panel B. ST vs. LT foreign borrowings



Turning to the impact on foreign borrowings by maturity, the leverage cap has a larger impact on short-term foreign borrowings than long-term foreign borrowings. The impacts of the leverage cap on short-term and long-term borrowings, measured by the difference between policy and no policy conditional forecasts, are illustrated in the Panel B of Figure 8. It shows that the leverage cap reduces short-term foreign borrowings by 1.8 percent of quarterly GDP in the first quarter and 0.0 to 0.3 percent of quarterly GDP in the remaining quarters, whereas the leverage cap has a relatively smaller impact on long-term foreign borrowings.

The total impact of the leverage cap on banks' foreign borrowing over one year after the introduction is presented in Table 4 in which the annualized effects are computed by summing up all four quarterly impacts. The results show that after the introduction of the leverage cap, total and short-term foreign borrowings for banks as a whole decrease by 0.5 to 0.6 percent of annual GDP, while long-term foreign borrowings decrease by 0.2 to 0.3 percent of annual GDP.

Table 4: Annualized effect of the leverage cap on banks as a whole: quarterly data
(Percentage point)

	Total borrowings	Short-term borrowings	Long-term borrowings
4-variable model for banks as a whole	-0.55	-0.54	-0.21
3-variable model for banks as a whole	-0.53	-0.51	-0.32

3.3 Impact of the Macroprudential Levy

In this subsection, we examine the effects of the macroprudential levy through two channels, one channel through the change in borrowing spreads and the other channel through the change in the CIP deviation. We use the models for domestic banks for the former channel, while we use the models for foreign bank branches for the latter channel.

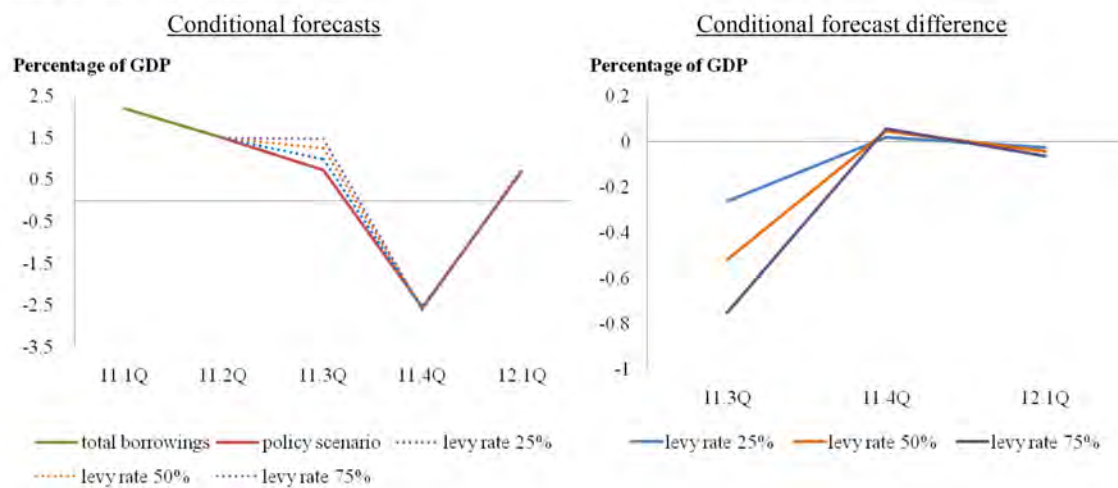
3.3.1 Borrowing Spreads Channel

To gauge the impacts of the macroprudential levy on domestic banks, we estimate the 3-variable foreign borrowings model for domestic banks using the data over the period 2003Q1 - 2011Q2, and then generate two conditional forecasts based on each policy scenario using the data over the period 2011Q3 - 2012Q1. Under the policy scenario, we produce a counterfactual forecast taking the actual levels of banks' borrowings spreads that were observed over the period 2011Q3 - 2012Q1 as our conditioning assumptions, which is depicted as a

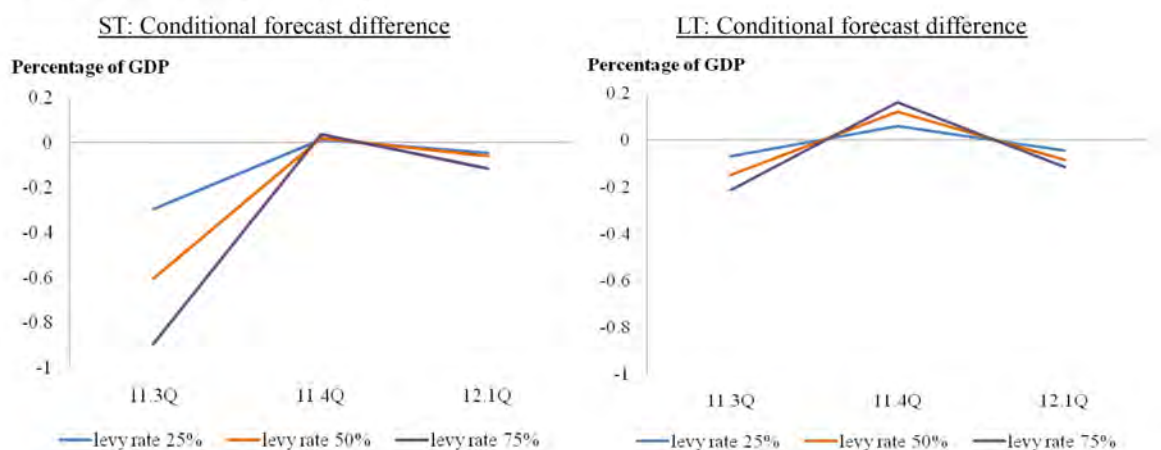
red straight line in the left of Panel A in Figure 9. On the other hand, under the no policy scenario, we produce counterfactual forecasts assuming that banks' borrowing spreads would have been 0.1 to 0.2 percentage point lower over the period 2011Q3 - 2012Q1, which is depicted as three dotted lines in the left of Panel A in Figure 9 depending on the assumption of how much of the levy burden is transferred to local borrowers. Specifically, a purple dotted line assumes that 25 percent of the levy is transferred to local borrowers, an orange dotted line 50 percent, and a blue dotted line 75 percent. By using higher borrowing spreads in the policy scenario, we simulate the situation in which the macroprudential levy causes the rise in borrowing costs or the fall in net returns associated with foreign borrowings for domestic banks.

Figure 9: Effect of the macroprudential levy on domestic banks: quarterly data

Panel A. Total foreign borrowings



Panel B. ST vs. LT foreign borrowings



The estimation results show that the macroprudential levy reduces total foreign borrowings a little, and lengthens the maturity structure of foreign borrowings for domestic banks.

Turning to the impact on total foreign borrowings, the path of total foreign borrowings under the policy scenario (the red straight line in the left of Panel A in Figure 9) moves downward relative to those under the no policy scenario (three dotted lines in the left of Panel A in Figure 9), in particular during the initial post-policy period. The impacts of the macroprudential levy, measured by the difference between two conditional forecasts, are illustrated in the right of Panel A in Figure 9. It shows that the macroprudential levy reduces total foreign borrowings for domestic banks by 0.0-0.5 percent of quarterly GDP in the first three quarters after the introduction.

Turning to the impact on domestic banks' foreign borrowings by maturity, the macroprudential levy has a larger impact on short-term rather than long-term foreign borrowings. The impacts of the macroprudential levy on short-term and long-term borrowings, measured by the difference between policy and no policy conditional forecasts, are illustrated in the Panel B of Figure 9. It shows that the macroprudential levy reduces short-term foreign borrowings by 0.0-0.6 percent of quarterly GDP over the three quarters, whereas leaving long-term foreign borrowings almost unaffected.

The total impact of the macroprudential levy on banks' foreign borrowings over one year after the introduction is presented in Table 5 in which the annualized effects are computed by summing up all four quarterly impacts. Here the impact of the macroprudential levy in the fourth quarter is assumed to be equal to that in the third quarter. The results show that after the introduction of the macroprudential levy, total and short-term foreign borrowings for domestic banks decrease by 0.1-0.2 percent of annual GDP, while long-term foreign borrowings remain to be almost unchanged.

Table 5: Annualized effect of the macroprudential levy on domestic banks: quarterly data
(Percentage point)

	Total borrowings	Short-term borrowings	Long-term borrowings
3-variable model for domestic banks	-0.13	-0.17	-0.04
2-variable model for domestic banks	-0.11	-0.14	-0.02

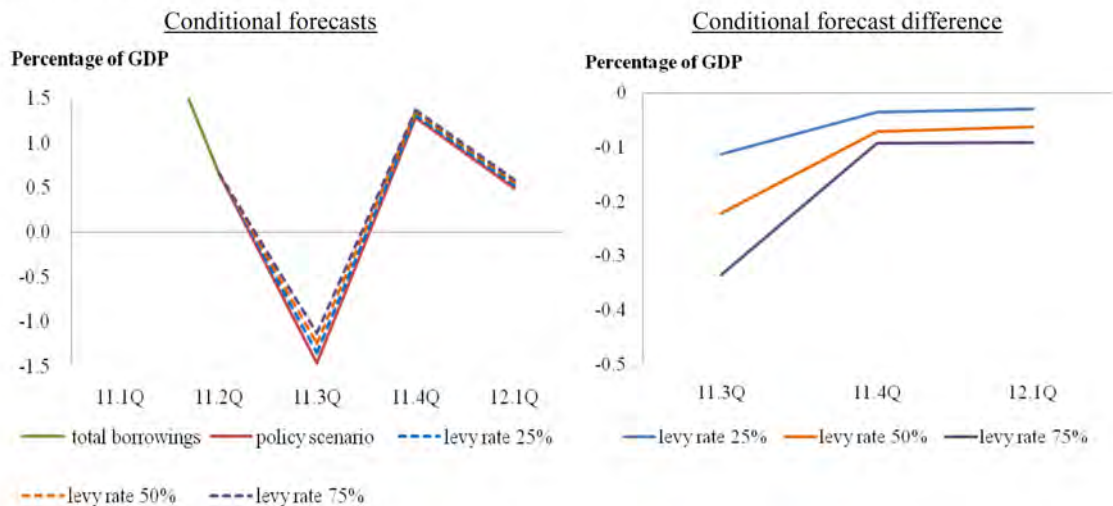
3.3.2 CIP Deviation Channel

To gauge the impacts of the macroprudential levy on foreign bank branches, we estimate the 3-variable foreign borrowings model for foreign bank branches using the data over the period 2003Q1 - 2011Q2, and then generate two conditional forecasts based on each policy scenario using the data over the period 2011Q3 - 2012Q1. Under the policy scenario, we

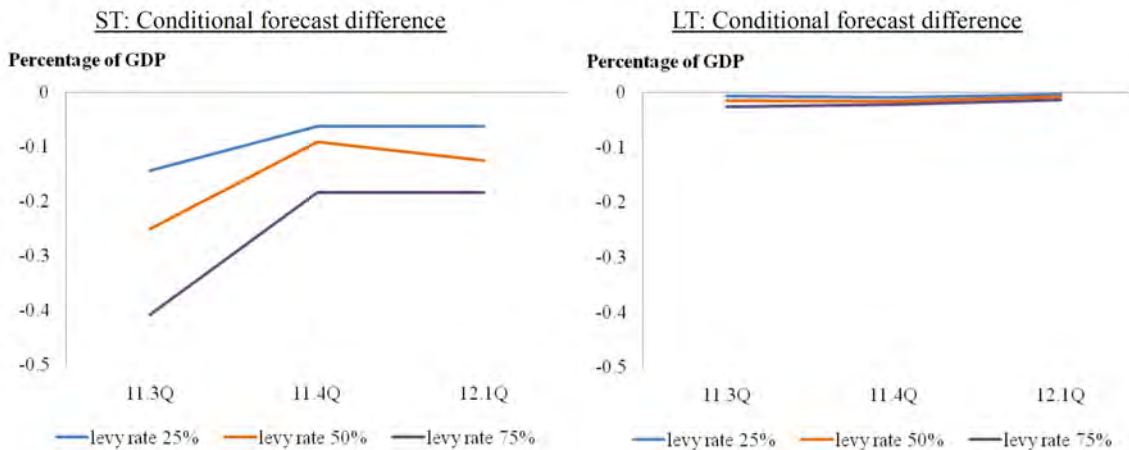
produce a counterfactual forecast taking the actual levels of the CIP deviations that were observed over the period 2011Q3 - 2012Q1 as our conditioning assumptions. This is depicted as a red straight line in the left of Panel A in Figure 10. On the other hand, under the no policy scenario, we produce counterfactual forecasts assuming that the CIP deviations would have been 0.1 to 0.2 percentage point higher over the period 2011Q3 - 2012Q1, which is depicted as three dotted lines in the left of Panel A in Figure 10 depending on the assumption of how much of the levy burden is transferred to local borrowers. Specifically, a purple dotted line assumes that 25 percent of the levy is transferred to local borrowers, an orange dotted line 50 percent, and a blue dotted line 75 percent. By using lower CIP deviations in the policy scenario, we simulate the situation in which the macroprudential levy causes the fall in net returns associated with foreign borrowings for foreign bank branches.

Figure 10: Effect of the macroprudential levy on foreign bank branches: quarterly data

Panel A. Total foreign borrowings



Panel B. ST vs. LT foreign borrowings



The estimation results show that the macroprudential levy reduces total foreign borrowings a little, and lengthens the maturity structure of foreign borrowings for foreign bank branches. Turning to the impact on total foreign borrowings, the path of total foreign borrowings under the policy scenario (the red straight line in the left of Panel A in Figure 10) moves downward relative to those under the no policy scenario (three dotted lines in the left of Panel A in Figure 10), in particular during the initial post-policy period. The impacts of the macroprudential levy, measured by the difference between two conditional forecasts, are illustrated in the right of Panel A in Figure 10. It shows that the macroprudential levy reduces total foreign borrowings for foreign bank branches by 0.1-0.2 percent of quarterly GDP in the first three quarters after the introduction.

Turning to the impact on foreign bank branches' borrowings by maturity, the macroprudential levy has a larger impact on short-term rather than long-term foreign borrowings. The impacts of the macroprudential levy on short-term and long-term borrowings, measured by the difference between policy and no policy conditional forecasts, are illustrated in the Panel B of Figure 10. It shows that the macroprudential levy reduces short-term foreign borrowings by 0.1-0.3 percent of quarterly GDP over the three quarters, whereas leaving long-term foreign borrowings almost unaffected.

The total impact of the macroprudential levy on banks' foreign borrowings over one year after the introduction is presented in Table 6 in which the annualized effects are computed by summing up all four quarterly impacts. Here the impact of the macroprudential levy in the fourth quarter is assumed to be equal to that in the third quarter. The results show that after the introduction of the macroprudential levy, total and short-term foreign borrowings for foreign bank branches decrease by 0.1-0.2 percent of annual GDP, while long-term foreign borrowings remain to be almost unchanged.

Table 6: Annualized effect of the macroprudential levy on foreign bank branches: quarterly data

	(Percentage point)		
	Total borrowings	Short-term borrowings	Long-term borrowings
3-variable model for foreign bank branches	-0.11	-0.15	-0.01
2-variable model for foreign bank branches	-0.12	-0.14	-0.01

4 Concluding Remarks

This paper give a preliminary empirical assessment of the impacts of two macroprudential measures introduced in Korea since 2010 - the leverage cap on banks' FX derivative positions (leverage cap) and the levy on banks' non-deposit foreign currency liabilities (macroprudential levy). We attempt to gauge these impacts by estimating Bayesian VAR models of banks' foreign borrowing using data from 2003 to 2011, and then quantifying the effects of these macroprudential measures on banks' foreign borrowing through counterfactual analysis based on conditional forecasts.

Our empirical results suggest that both macroprudential measures have contributed to boosting resilience in the banking system, in that they have lengthened the maturity structure of banks' foreign liabilities. First, the estimates from the models for banks as a whole show that the leverage cap reduced short-term foreign borrowings more than long-term foreign borrowings. Second, the estimates using the models for domestic banks and foreign bank branches show that the macroprudential levy reduced banks' short-term foreign borrowings mainly, leaving their long-term borrowings almost unaffected.

Our results suggest that both the leverage cap and the macroprudential levy have helped to mitigate the vulnerabilities associated with procyclical capital flows, because of their abilities to reduce maturity mismatches in the banking system. However, since the analysis in this paper is based upon limited data from the initial period of new policy measure implementation, it is possible that the results could change as more data become available over time. Nevertheless, this kind of model-based analysis helps to provide a tentative overview of the impacts of the new macroprudential policies, which could serve as a starting point for future policy analysis.

A Appendices

A.1 Estimation of BVAR Model

TO BE ADDED

A.2 Impact of Macroprudential Measures using Monthly Data

TO BE ADDED

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