Assessing the Impact of FX-related Macroprudential Measures in Korea†

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Abstract

This paper examines the impact of the FX-related macroprudential measures introduced in Korea since 2010 aimed at moderating the procyclical fluctuations in capital flows to the banking sector. We quantify these effects by focusing on the impact of these measures on the maturity structure of foreign currency denominated liabilities of the banking sector. We use Bayesian vector autoregression models to estimate the impact of each measure on capital flows to foreign bank branches and domestic banks respectively. We find evidence that the macroprudential measures caused a sizeable reduction in short-term bank capital inflows, while causing much smaller or nearly no reduction in long-term bank capital inflows. These results suggest that the macroprudential policies may have helped to mitigate vulnerabilities to external financial conditions by improving the foreign currency funding structure of the banking sector.

Keywords: Capital flows, macroprudential policy, conditional forecasts

JEL Classification: F32, F33, F47

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1. Introduction

In the periods leading to and during the global financial crisis, Korea experienced an unprecedented scale of surges and reversals in capital flows. The costs of such volatile capital flows were brought to light when about 50 billion dollars of portfolio and other investments – amounting to 5.2 percent of nominal GDP in 2008 – outflowed from the financial system in three months following the Lehman Brothers failure in September 2008, pushing the Korean economy close to another currency crisis. A main factor driving the excessive volatility of capital flows over this period was the procyclical fluctuations in cross-border capital flows through the banking sector, especially short-term non-core FX liabilities.[2)] In recognition of these vulnerabilities, Korea introduced a new set of macroprudential policy measures since 2010 aimed at moderating the procyclicality of cross-border capital flows through banks.

Our purpose in this paper is to provide a preliminary empirical test of two of these macroprudential measures – the leverage cap on FX derivatives position and the macroprudential stability levy on non-core FX liabilities. The leverage cap is intended to limit banks' FX derivatives position at or below a targeted level which is specified in percent of bank equity capital, and the macroprudential stability levy applies an extra cost for holding non-core FX liabilities.[3)] The two measures lie at the core of the FX-related macroprudential policy initiatives implemented since 2010, and our focus is to estimate the impact of each measure on the maturity structure of banks' foreign currency funding.

Our empirical assessment is based on the conceptual framework of cross-border banking flows developed in Bruno and Shin (2013) and Cetorelli and Goldberg (2011) in which the fluctuations in global liquidity conditions are driven by the interplay between the international capital markets, global banks, and regional banks in emerging market economies (EMEs). With reference to our objective, we center on the role of the regional banks in EMEs in transmitting

[2] In a normal time, the increase in the bank balance sheets is funded by core liabilities such as retail deposits of household savers. In a lending boom, however, core liabilities tied to the aggregate wealth of the household sector are not sufficient to finance a rapid asset growth, so banks resort to non-core liabilities such as borrowings from domestic financial intermediaries and cross-border loans from foreign creditors. In open emerging economies, cross-border wholesale funding (i.e. non-core FX liabilities) often plays a significant role in driving the fluctuations in the bank balance sheets. See Shin and Shin (2011) and Hahm et al. (2012).

[3] These measures will be discussed in more detail in section 2.

global financial conditions to domestic financial markets through the cross-border funding operations. Considering the heterogeneity in the FX balance sheet structure, the regional banks in Korea are divided into branches of foreign banks and domestic banks. For each bank group, the macroprudential measures are assumed to influence FX borrowings by inducing adjustments in the FX balance sheet management by banks via the change in leverage ratios (in case of the leverage cap) or price incentives (in case of the macroprudential stability levy).

Our approach to assessing the policy effects is to conduct counterfactual analysis associated with the implementation of each macroprudential measure. Specifically, we ask what would have happened to banks' external borrowings if a macroprudential measure had not been implemented, and then compare it with a prediction conditional on its implementation. The analysis is conducted within a Bayesian vector autoregression (BVAR) model consisting of FX borrowings and other financial variables, and this exercise is applied to foreign bank branches and domestic banks respectively. The sample is in quarterly frequency, and spans the period from the first quarter of 2003 to the second quarter of 2012. We use quarterly data as the baseline sample because of the availability of disaggregated data on FX borrowings by foreign bank branches and domestic banks, but we also use monthly data based on alternative variables in a sensitivity analysis. Structural shocks are identified by using both sign and exclusion restrictions as suggested by economic theory and institutional features.

The estimation results suggest that the leverage cap led to a sizeable reduction in short-term FX borrowings, while causing much smaller effects on long-term FX borrowings. The size of reduction in long-term borrowings was less than a half of short-term borrowings. The effects on foreign bank branches were larger than those on domestic banks because foreign bank branches were more tightly constrained by this measure than domestic banks were. Meanwhile, the estimation results suggest that the macroprudential stability levy reduced short-term FX borrowings in the main with no noticeable effect on long-term FX borrowings. The effects on foreign bank branches were comparable to those on domestic banks.

This paper contributes to the empirical studies on the effects of the macroprudential policies. The crisis has underscored the role of macroprudential policy in achieving financial stability, and yet empirical evidence on their effectiveness is scant. Notably, the impact of FX-related macroprudential measures in Korea is also covered in Bruno and Shin (2014) from a broad perspective. Using a cross-country panel study, the authors find that the sensitivity of aggregate bank inflows to global conditions reduced following the introduction of a range of the macroprudential policies. Our approach is different from this paper in that we apply a time series model of bank capital inflows disaggregated into foreign bank branches and domestic banks, and focus on the impact of an individual macroprudential measure on the maturity structure of FX liabilities.

The rest of the paper proceeds as follows. Section 2 provides the background for the FX-related macroprudential measures in Korea, and discusses the FX balance sheet structure of banks in tandem with the assumption about the transmission of the macroprudential measures. Section 3 then describes the econometric specification, data and some basic properties of estimated models. Section 4 discusses counterfactual assumptions, and presents empirical results. Section 5 finally concludes.

2. Background

2.1. FX-related Macroprudential Measures

In the aftermath of the global financial crisis, the Korean economy was hit hard by a sudden stop in capital flows and the associated disruptions to domestic financial conditions. As the international capital markets froze with the onset of the Lehman Brothers bankruptcy in September 2008, the Korean won depreciated rapidly, and the country risk premium rose dramatically on a scale not seen since the 1997 Asian financial crisis. The repercussions of the crisis were magnified because capital outflows and currency depreciation reinforced each other, amplifying the deleveraging dynamics.

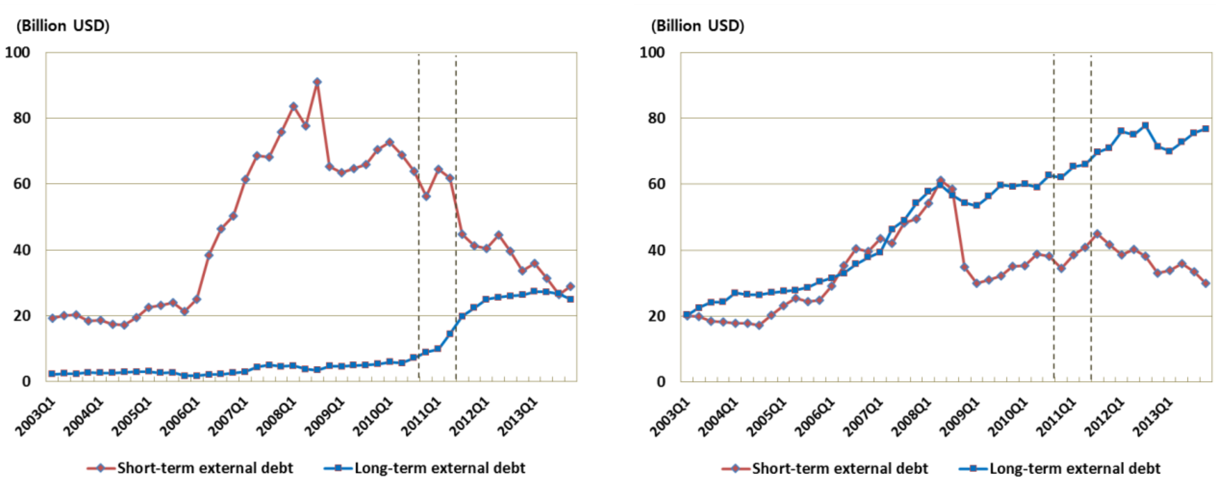
The seed of risks in the financial crisis was sown in the pre-crisis period when the banking sector saw a surge in liquidity and maturity mismatches in its FX balance sheets in conjunction with a rapid build-up of short-term non-core FX liabilities. One of the main causes was the excessive currency hedging demand from exporters and asset management corporations amid strong expectations of currency appreciation prior to the crisis. Exporters and asset managers who had dollar receivables sold dollar forward to banks in order to hedge risks of currency appreciation. Banks then hedged their long dollar positions with foreign currency borrowings, mostly through short-term cross-border borrowings. The consequence was a rapid increase in short-term FX liabilities and rollover risks, which left the Korean banking sector vulnerable to the crisis.

Figure 1 plots the evolution of banks' external debt in the form of securities and loans from the Bank of Korea's international investment position statistics. In the run-up to the financial crisis, the increase in the short-term external debt outpaced the increase in the long-term external debt, and the acceleration in the short-term external debt was more pronounced in foreign bank branches than in domestic banks. Over the three-year period prior to the Lehman Brothers collapse, the short-term external debt of foreign bank branches increased almost fourfold, and the short-term external debt of domestic banks increased almost twofold. Chung et al. (2012) documents that the surge in banks' external borrowings over this period was accelerated by the feedback loop between the hedging demand and exchange rate changes.

Figure 1. External debt for foreign bank branches and domestic banks

A. Foreign bank branches

B. Domestic banks



Notes: The external debt consists of external funding through security issuance and loans. The broken vertical lines indicate the introduction of the leverage cap and the macroprudential levy respectively.
Source: International investment position statistics, Bank of Korea.

To address these vulnerabilities, the Korean authorities have introduced an array of the FX-related macroprudential policy measures since 2010. The rationale and sequences of these measures are provided in IMF (2012), and Bruno and Shin (2014) among others. In a nutshell, these macroprudential measures were aimed at mitigating the build-up of vulnerabilities to sudden reversals in bank capital flows by improving the maturity structure of foreign currency funding by banks, and their design reflects the institutional features of the Korean banking sector.

The first policy measure was the leverage cap on foreign currency denominated derivatives position of banks. The leverage cap puts explicit ceilings on the notional value of FX derivatives contract at or below a targeted level which is specified as a proportion of bank equity capital. The leverage cap was first introduced in October 2010 at 250 percent of equity capital for foreign bank branches and 50 percent of equity capital for domestic banks. Since then, the ceilings have been tightened twice. They were lowered to 200 percent for foreign bank branches and 40 percent for domestic banks in July 2011, and were further lowered to 150 percent and 30 percent in January 2013. As a variant of bank equity capital-based rule, the leverage cap was designed to limit short-term FX borrowings of banks by requiring them to put up more equity capital if they intend to increase FX derivatives position and the associated short-term FX debt.

The second measure was the macroprudential stability levy applied to the non-core foreign currency denominated liabilities of the banking sector. The macroprudential stability levy applies 20 basis point charge per year on the non-deposit FX liabilities of up to one year maturity. Lower rates are applied to longer-maturity liabilities: 10 basis point charge on liabilities of up to three year maturity, 5 basis point charge on liabilities of up to five year maturity, and 2 basis point charge on liabilities of over five year maturity. Shin (2012) highlights that the Korean macroprudential levy has been designed as a financial stability measure rather than as a fiscal measure. Addressing liquidity and maturity mismatches of bank balance sheets has been a primary goal, and collecting the revenues from the levy paid into a special foreign exchange stabilization account has been a secondary consideration. This is in contrast to the UK and France where the levy introduced in 2010 has a fiscal nature because the revenue is paid into the fiscal account.

Figure 1 can also be used to take a casual look at the influence of the macroprudential measures on banks’ external debt. The implementation of the macroprudential measures is marked as the broken vertical lines. We observe that following the introduction of these measures, the short-term external debt appeared to decrease, while the long-term external debt showed a steady increase. However, by examining the time series of the bank external debt, we do not control for other factors that may have a significant influence on the banking sector external borrowings. In order to identify the effects of the macroprudential measures from other forces, we need to conduct counterfactual simulations that are designed to isolate the policy effects.

Before delving into the estimation of the models used for counterfactual analysis, it is useful to review the FX balance sheet structure of banks, and to set out the assumptions about how each macroprudential measure may influence FX borrowings by banks.

2.2. Structure of Bank FX Balance Sheets

We now give an overview of FX balance sheets of the banking sector classified into domestic banks and foreign bank branches based on the conceptual framework of cross-border banking flows developed in Bruno and Shin (2013) and Cetorelli and Goldberg (2011). Our focus is to identify the key FX operations for each bank group, which can then be used to guide the subsequent discussion about the transmission of the macroprudential measures.

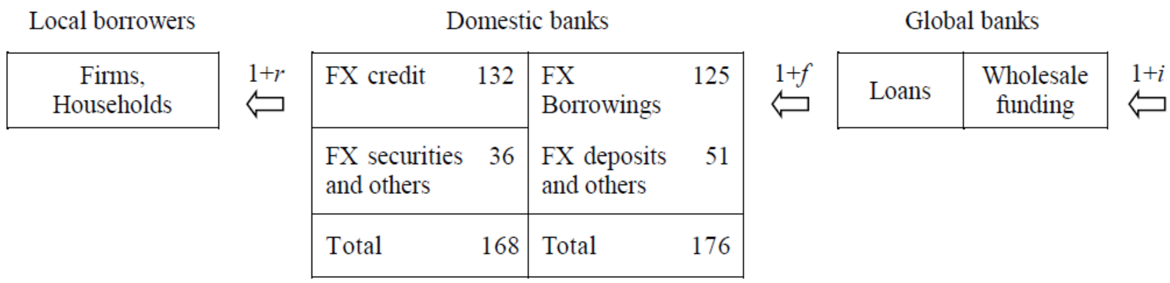
Figure 2 depicts the stylized foreign currency denominated balance sheets of domestic banks at the end of 2010 from the Bank of Korea's financial analysis information retrieval system.[4)] Locally owned Korean banks provide FX credit to private borrowers at the rate of $1+r$. FX credit includes FX loans, domestic import usance and bills bought provided to private borrowers, and they constituted 78 percent of total FX assets at the end of 2010. Most of FX credit is financed by non-deposit FX liabilities drawn from the global banks at the funding rate $1+f$. Non-deposit FX liabilities represent the short- and long-term wholesale funding in the form of loans, securities and money market instruments, and they constituted 71 percent of total FX liabilities. For the global banks, the cross-border lending to domestic banks is one component of their assets, and the funding rate $1+f$ is the return from this asset. The global banks finance asset purchases by drawing on the wholesale money-market funds at the interest rate $1+i$.

Viewed from the FX balance sheets, capital inflows to domestic banks are determined by the interplay between the supply and demand for non-core FX liabilities. Other things being equal, the demand for non-core FX liabilities by domestic banks depends negatively on the funding

[4] As our aim is to estimate the effects of the two macroprudential measures introduced in October 2010 and August 2011 respectively, we focus on the FX balance sheets as of the end of 2010 which lies between the two time periods.

rate *f*, positively on the loan rate *r*, while the supply of cross-border lending by the global banks depends positively on the lending rate *f*, and negatively on the international wholesale rate *i*. In practice, the interest rate *f* is decomposed into the international wholesale funding rate *i* such as the Libor rate and the FX borrowing spread β. Then, the borrowing spread β, which indicates the tightness of external borrowing conditions, appears in the supply and demand for FX borrowings by domestic banks. Hence, the borrowing spread is used as a key price measure in our empirical model for domestic banks.

Figure 2. FX balance sheets of domestic banks at the end of 2010



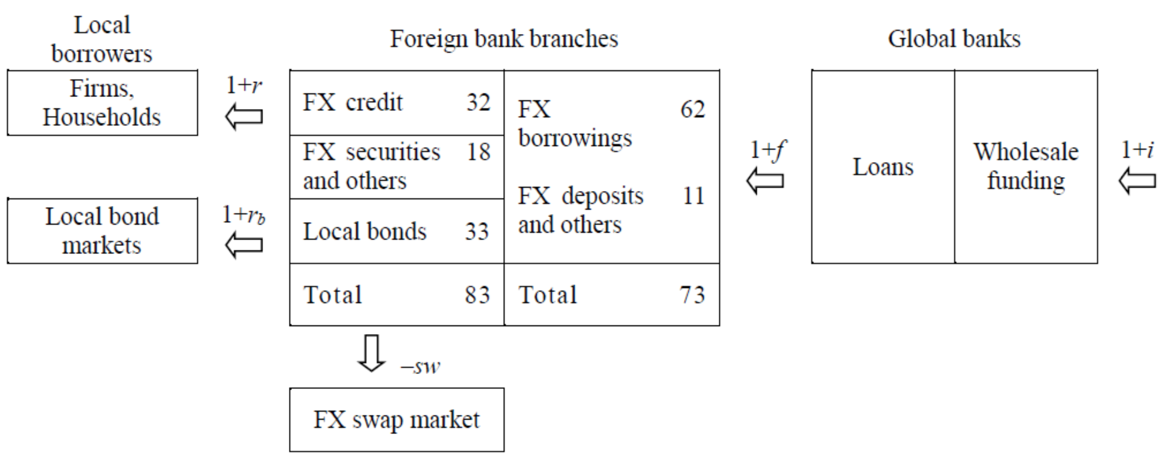
Notes: The amount shown in domestic banks' balance sheet is in units of billion US dollars.
Source: Financial analysis information retrieval system, Bank of Korea.

Turning to foreign bank branches, Figure 3 depicts the stylized FX balance sheets at the end of 2010. Branches of foreign bank provide FX credit to private borrowers at the rate of 1+*r*, and purchase the Korean won denominated bonds at the rate of $1+r_b$. At the end of 2010, FX credit and the local bond purchases constituted 38 percent and 40 percent respectively. A majority of asset purchases are financed by non-deposit FX liabilities drawn from the global banks at the funding rate 1+*f*, which constituted 85 percent of total FX funding at the end of 2010.

We focus on the Korean denominated bond purchases among other asset components because the changes in the local bond holdings feature a closer relationship with the fluctuations in non-core FX liabilities. The variance decomposition using FX balance sheets data over the period from the fourth quarter of 2002 to the fourth quarter of 2012 shows that about 55 percent of variations in FX borrowings are associated with changes in the local bond holdings, whereas only 27 percent of variations are associated with changes in FX credit.

It is important to recognize that non-core FX liabilities of foreign bank branches can be interpreted from two distinct viewpoints. On the one hand, according to the residence principle of balance of payments, foreign bank branches are perceived as being part of the aggregate banking sector. From this view, when foreign bank branches borrow the U.S. dollars at the funding rate f, swaps the U.S. dollars into the Korean won at the rate sw, and invest the proceeds in the local bonds at the rate of r_b, they demand FX funding from abroad as domestic banks do, and their net returns amount to the covered interest parity (CIP) deviation ($r_b - Libor - sw$).[5)] On the other hand, branches of foreign banks are often regarded as the outposts of the global banking organizations, so their FX liabilities are the main channel through which cross-border funding is provided to the Korean financial markets. From this view, the CIP deviation is the representative cost of cross-border funding required by the global banking organizations.

Figure 3. FX balance sheets of foreign bank branches at the end of 2010



Notes: The amount shown in foreign bank branches' balance sheet is in units of billion US dollars.
Source: Financial analysis information retrieval system, Bank of Korea.

As in Kim, Shin and Yoon (2013), our subsequent analysis adopts the latter interpretation because it captures the de facto role of foreign bank branches in channeling FX funding to the Korean financial markets, and is consistent with our identification scheme. In this regard, the

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[5] Here we have used the fact that the borrowing spread over the Libor rate is close to zero for foreign bank branches in practice.

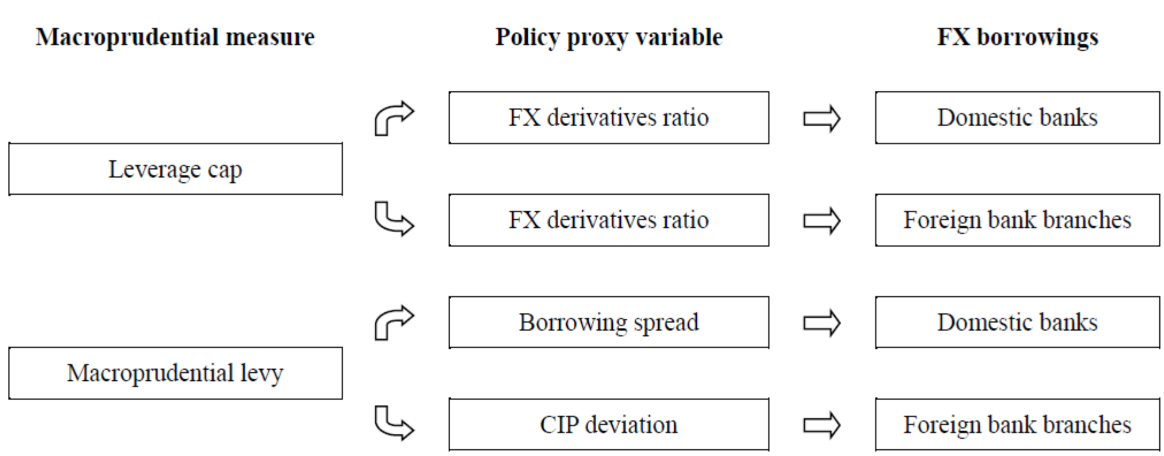
CIP deviation, which indicates the tightness of FX funding, is used as a key price measure in our empirical analysis of foreign bank branches.

2.3. Transmission Channel of Macroprudential Measures

While the FX-related macroprudential measures could influence banks' FX borrowings through multiple channels, we focus on the transmission channel outlined below considering the structure of bank FX balance sheets.

Figure 4 provides a schematic description of the transmission channel used in our subsequent empirical analysis. As the leverage cap applies the ceilings on the notional value of FX derivatives contracts in percent of equity capital, this measure is assumed to influence banks' FX borrowings by inducing adjustments in the size and composition of FX balance sheets. Specifically, banks whose ratio of FX derivatives position to equity capital (FX derivatives ratio) was above a regulatory limit would lower this ratio at least to a target level. In response, these banks would change FX borrowings as part of the overall FX balance sheet adjustments.

Figure 4. Transmission of FX-related macroprudential measures



Meanwhile, the macroprudential stability levy is a price-based measure applied to non-core FX liabilities, and hence is assumed to influence FX borrowings of banks mainly through the rise in funding costs or the fall in net returns. Based on the FX balance sheet structure of banks, the borrowing spread over the Libor is used as a key price measure for domestic banks, while the covered interest parity deviation is used as a key price measure for foreign bank branches.

While the macroprudential measures are in principle expected to reduce banks' FX borrowings, it is an empirical issue to what extent they cause a differential influence on short- and long-term borrowings and how the impact might differ across domestic banks and foreign bank branches. To investigate these issues, we turn to the empirical analysis in the subsequent sections.

3. Empirical Strategy

3.1. Econometric Specification

Our baseline model for banks' FX borrowings is a four-variable Bayesian vector autoregression (BVAR) model as:

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

where the variable vector *Y* includes external borrowings by banks (k^d for domestic banks and k^f for foreign bank branches) and other financial variables that are deemed to influence FX risks. Other financial variables are the borrowing spread (β), FX derivatives ratio (fd^d) and the VIX index (*vix*) for domestic banks, while they are the CIP deviation (*cid*), the FX derivatives ratio (fd^f), and the VIX index (*vix*) for foreign bank branches. As noted previously, the choice of variables are dictated by the FX balance sheet structure, the availability of data and the identification scheme. As an alternative specification, we also estimate a three-variable BVAR model where the VIX index is excluded from the variable vector. As a three-variable BVAR allows for parsimonious identification, it provides a sensitivity check of the results to the alternative identification scheme.

Use of VAR is aimed at capturing the dynamic interrelationship between banks' FX borrowings and other financial variables. As described in the FX balance sheets of banks, the cross-border wholesale funding is influenced by various supply push and demand pull factors, and banks' FX borrowings could in turn have feedback effects on other financial variables. In this regards, we employ VAR to give a proper account of the dynamics underlying banks' FX borrowings.

The identification is achieved by imposing a combination of sign and exclusion type restrictions as suggested by economic theory and institutional features of banks' FX operations. The identification of VAR using sign restrictions is employed by a number of previous studies. Uhlig (2005) uses it to study the effects of monetary policy shocks in the U.S., Chadha, Corrado and Sun (2010) to examine the evolution of monetary aggregates in the U.S. and the euro area, and Kim, Shin and Yoon (2013) to analyze the determinants of non-core liabilities in the Korean banking sector. The identification scheme in our model closely follows Chadha, Corrado and Sun (2010) and Kim, Shin and Yoon (2013). Table 1 describes the identification restrictions for a four-variable BVAR model.

Table 1. Identification restrictions in a four-variable model

Shocks\Variables	*vix*	*β or cid*	k^d *or* k^f	fd^d *or* fd^f
Risk perception shock	*	*	*	*
Supply shock	0	≥	≤	≤
Demand shock	0	≥	≥	≥
FX derivatives ratio shock	0	0	0	*

Notes: For variable definitions, see discussion of variables used in a four-variable BVAR model.

First, a global risk perception shock is an innovation to the VIX index, and is identified by imposing the block exogeneity of the VIX index. In other words, the VIX index is orthogonal to the other variables in the current and subsequent periods. Second, a supply shock is assumed to move price (borrowing spread or CIP deviation) and quantity variables (external borrowings) in the opposite direction. This shock represents global push forces other than a risk perception shock. Third, a demand shock moves price and quantity in the same direction, and it represents domestic pull forces such as credit demand by final borrowers.

Finally, a FX derivatives ratio shock is an innovation to the ratio of FX derivatives position to bank equity capital that is orthogonal to the contemporaneous change in price and quantity variables. It captures an exogenous change in the FX derivatives ratio that is accompanied by adjustments in balance sheet components other than external borrowings. If the change in the FX derivatives ratio is mainly adjusted through the change in external borrowings, the FX derivatives ratio shocks will play a minor role in driving banks' FX borrowings.

In case of a three-variable model, we identify three structural shocks including the supply, demand, and FX derivatives ratio shocks. Here supply and global risk perception shocks in a four-variable model are lumped together as a supply shock.

3.2. Data

The sample used for the estimation is in quarterly frequency, and spans the period from the first quarter of 2003 to the second quarter of 2012. Quarterly data is used as the baseline sample because it provides disaggregated data on external borrowings by foreign bank branches and domestic banks. Though quarterly data allows for the assessment of the policy effects disaggregated by each bank group, data play a limited role in explaining the estimation results with a small sample size. Thus, we check the robustness of the results from quarterly data by estimating BVAR models using monthly data with a larger sample size although it only provides data on external borrowings for the banking sector as a whole. The Bayesian method is employed for the estimation.

As for external borrowings, we use the changes in the external debt through loans, securities and money market instruments from the Bank of Korea's international investment position statistics for quarterly frequency, while we use capital inflows to the banking sector in the form of loans and securities from the Bank of Korea's balance of payment statistics for monthly frequency. As the valuation effect is negligible in case of banks' external borrowings, bank debt flows from the balance of payment statistics are a reasonable proxy for the changes in the bank external debt from the international investment position statistics.

As for price variables, the borrowing spread is the weighted average of the borrowing spreads over the Libor rate applied to eight major domestic banks, and the CIP deviation is the three-month CD rate subtracted by the three-month Libor rate and the three-month swap rate. The three-month swap rate is defined as the difference between the log of 3-month forward exchange rate and the log of spot exchange rate multiplied by four. The VIX index is the implied volatility on the S&P 500 index options, and the FX derivatives ratio is the net position of the notional value of FX derivatives contracts (including currency swaps and forwards) as a fraction of bank equity capital.

Bank's external borrowings are divided by nominal GDP of corresponding frequency, and the borrowing spread, the VIX index and the FX derivatives ratio are first differenced according to the unit root test results.[6)] The lags of VAR models are chosen to be two for quarterly data, and three for monthly data using three lag-length criteria of AIC, SIC and HQ.

3.3. Estimation Procedure

We now describe how to estimate BVAR models with sign and exclusion restrictions using a four-variable model as an illustration. We first estimate a reduced-form BVAR model as:

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

where e_t is a reduced-form error term, $E[e_t e_t']=\Sigma$ is the covariance matrix, and $\Phi(L)=\Phi_1+\Phi_2 L+\ldots+\Phi_p L^{p-1}$ assuming $\Phi_0=0$ for simplicity. We use the Minnesota priors as in Litterman (1986), and obtain the posterior distributions of the reduced-form parameters using the Gibbs sampling. Use of the Minnesota priors is based on the observation that many macroeconomic and financial variables are highly persistent, and simple autoregressive or random walk models produce reasonable forecasts for these variables.

The model is then written as the reduced-form moving average form as:

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

In order to identify the structural shocks, we assume that the contemporaneous impulse responses satisfy the sign and zero restrictions shown in Table 1. The identification of structural

[6] The monthly nominal GDP series are constructed as follows. First, the monthly real GDP estimates are taken from Kang (2010) who estimates Kalman Filter model by using various monthly data sources. Second, following the smoothing method developed in 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 constraint that the weighted averages of the monthly GDP deflators are equal to the corresponding quarterly GDP deflator. Finally, the monthly nominal GDP series are computed by multiplying the monthly real GDP series by the GDP deflator series.

shocks is achieved by finding the rotation matrix P that satisfies these restrictions as well as the relation $\Sigma = PP'$. This matrix P is found as follows.

In the first step, we consider an arbitrary lower-triangular matrix R by applying the Cholesky decomposition to the reduced-form shocks Σ as:

$$Y_t = [I - \Phi(L)L]^{-1} R\varepsilon_t,$$

Though this vector is orthogonal by construction, the sign restriction part of the identification restrictions does not hold in general. To find the rotation matrix consistent with the sign restrictions, the second step is to consider the following orthonormal matrix $Q(\theta)$ such that $Q(\theta)'Q(\theta) = Q(\theta)Q(\theta)' = I$ as:

$$Q(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

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

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

In the third step, the valid rotation matrix $P=RQ(\theta)$ and structural shocks $u_t = Q(\theta)'\varepsilon_t$ are found for the values of θ that satisfy the sign restrictions.

The values of θ satisfying the sign restrictions are generated within the Bayesian estimation framework. For each posterior distribution of the reduced-form parameters, the model is estimated following the above steps. If the estimated impulse responses satisfy the sign restrictions, we keep those impulse responses in conjunction with conditional forecasts, and discard the ones that fail to do so. We keep generating posterior distributions until we collect 5000 valid impulse responses and conditional forecasts. Finally, based on the collected results, we use the median values as parameter estimates and use 16th and 84th percentile confidence bands which correspond to one standard deviation confidence bands.

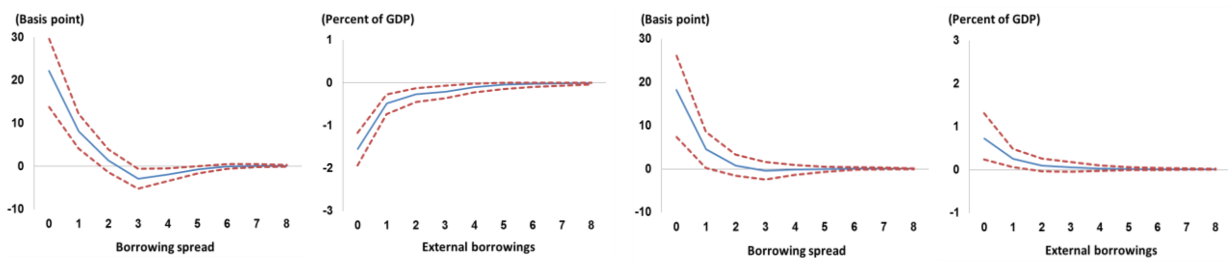
3.4. Impulse Responses and Forecast Error Variance Decompositions

Figure 5 plots the impulse responses of domestic banks' external borrowings to the supply and demand shocks based on a four-variable model estimated using quarterly data. For both short- and long-term external borrowings, a supply shock leads to the increase in the borrowing spread and the decrease in external borrowings, whereas a demand shock leads to the increase in both the borrowing spread and external borrowings.[7)]

Figure 5. Impulse responses to supply and demand shocks for domestic banks

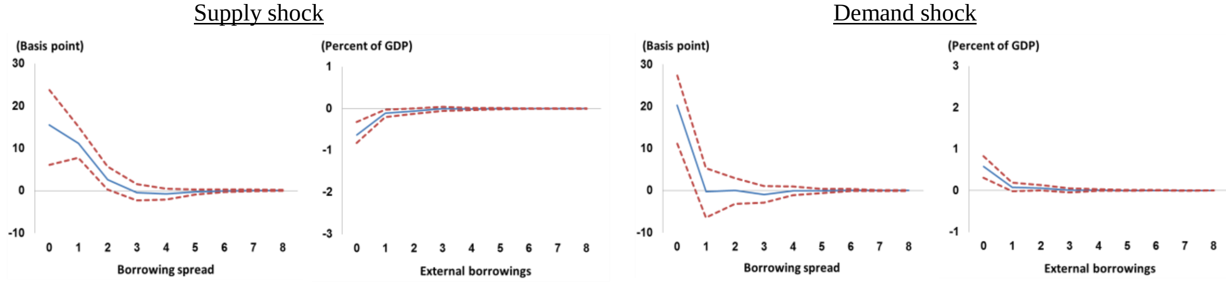
A. Short-term borrowings

Supply shock Demand shock



B. Long-term borrowings

Supply shock Demand shock



Notes: The impulse responses are based on a four-variable model for domestic banks estimated using quarterly data over the sample period (2003Q1-2012Q2). Blue solid lines indicate the median values of impulses responses to one standard deviation shocks, and broken red lines indicate 68 percent confidence bands.

However, there are some quantitative differences between short- and long-term external borrowings. In response to a unit increase in the borrowing spread, short-term borrowings display larger fluctuations than long-term borrowings do. In other words, the price (borrowing spread) elasticity of short-term borrowings is larger than that of long-term borrowings. Further,

[7] A global risk perception shock generates the impulses responses that are similar to a supply shock, and a FX derivatives shock has insignificant effects on the borrowing spread and external borrowings.

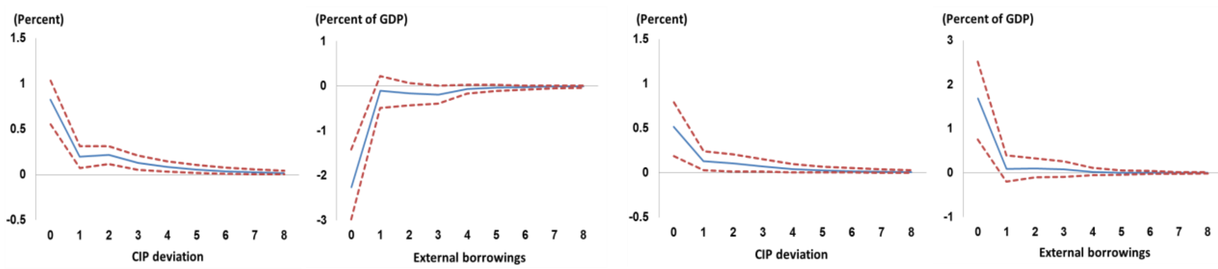
short-term borrowings show more persistent responses than long-term borrowings, particularly so following a supply shock.

Figure 6 plots the impulse responses of foreign bank branches' external borrowings to the supply and demand shocks. By design, a supply shock moves the CIP deviation and external borrowings in the opposite direction, whereas a demand shock moves price and quantity variables in the same direction. However, compared with domestic banks, the quantitative difference between short- and long-term borrowings are more pronounced. While short-term borrowings exhibit substantial fluctuations in response to a unit increase in the CIP deviation, long-term borrowings show no discernible responses.

Figure 6. Impulse responses to supply and demand shocks for foreign bank branches

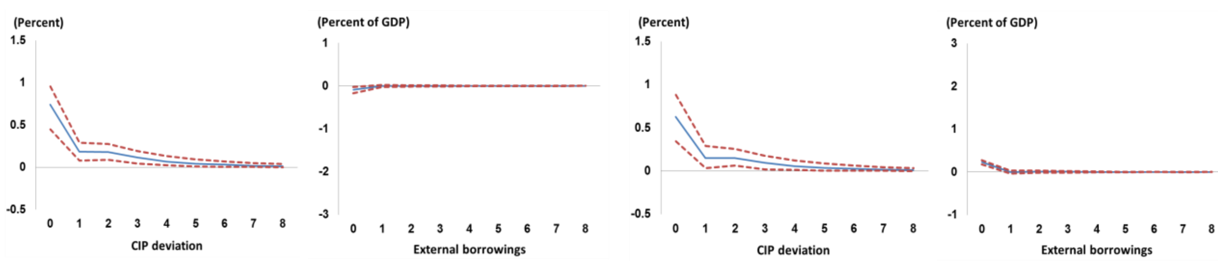
A. Short-term borrowings

Supply shock | Demand shock



B. Long-term borrowings

Supply shock | Demand shock



Notes: The impulse responses are based on a four-variable model for foreign bank branches estimated using quarterly data over the sample period (2003Q1-2012Q2). Blue solid lines indicate the median values of impulses responses to one standard deviation shocks, and broken red lines indicate 68 percent confidence bands.

As described previously, the key assumption about the transmission channel is that the macroprudential measures affect banks' external borrowings through policy proxy variables such as the FX derivatives ratio, the borrowing spread or the CIP deviation. As these variables are endogenously determined together with external borrowings, our counterfactual analysis is based on the relationship between a policy proxy variable and external borrowings shaped in response to the theory-motivated supply and demand shocks instead of being based on the reduced-form relationship between the two variables.

Table 2 shows the relative contribution of push and pull factors in explaining the fluctuations of short- and long-term FX borrowings based on a four-variable model. We assume that push factors consist of the supply and global risk perception shocks, while pull factors consist of the demand and FX derivatives ratio shocks.[8)] We find that the relative contribution of push and pull factors differ substantially depending on the maturity of the wholesale FX funding. While push factors are the dominant sources in driving the fluctuations of short-term external borrowings, pull factors gain more importance in explaining the fluctuations of long-term external borrowings.

Table 2. Forecast error variance decomposition of external borrowings

Forecast horizon	Short-term borrowings		Long-term borrowings	
	Push factor	Pull factor	Push factor	Pull factor
A. Domestic banks				
Q1	0.931	0.069	0.597	0.403
Q2	0.894	0.106	0.815	0.185
Q3	0.948	0.052	0.494	0.506
Q4	0.970	0.030	0.609	0.391
B. Foreign bank branches				
Q1	0.794	0.206	0.314	0.686
Q2	0.988	0.012	0.907	0.093
Q3	0.831	0.169	0.084	0.916
Q4	0.938	0.062	0.432	0.568

Notes: The results are based on four-variable models estimated using quarterly data over the sample period (2003Q1-2012Q2).

[8] The FX derivatives ratio shocks are classified into pull factors based on the presumption that it is the hedging demand of export firms and asset managers that is the main driver of the fluctuations in bank's FX derivatives position. However, the results on the relative contribution do not depend on whether the FX derivatives shocks are classified into pull or push factors because the share of forecast error variance due to a FX derivatives ratio shock is fairly small.

4. Empirical results

4.1. Counterfactual Assumptions

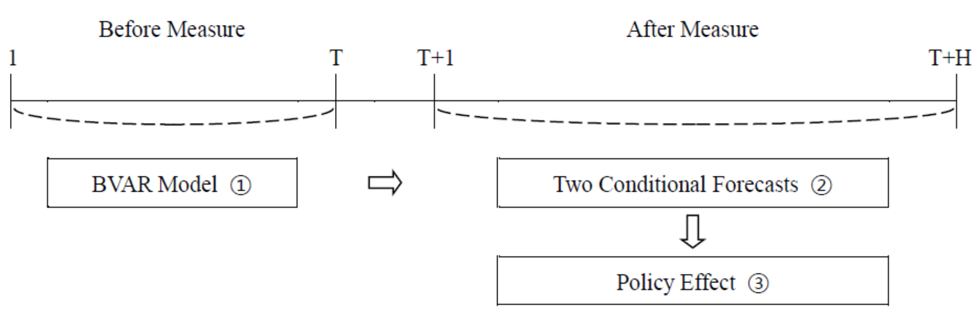
Our counterfactual assumption is based on the transmission channels of the macroprudential measures laid out in section 2. The leverage cap may have induced the downward adjustment of the FX derivatives position of banks whose ratio of this position to equity capital exceeded a regulatory target. We implement this impact by changing the FX derivatives ratio for each bank group where the size of change is calculated as the difference between the group-wide FX derivatives ratio prevailed prior to the introduction of the leverage cap and the ratio that would have been obtained if banks had made the necessary adjustments to meet the target at its introduction. Meanwhile, the macroprudential stability levy may have increased the costs of FX wholesale borrowings, and this impact is implemented by changing the borrowing spread or the CIP deviation. The resulting counterfactual simulations are the conditional forecasts of bank's FX borrowings. We examine two scenarios: a policy scenario and a no policy scenario.

Under the policy scenario, we produce a counterfactual forecast taking the actual levels of policy proxy variables (the FX derivatives ratio in case of the leverage cap, and the borrowing spread or the CIP deviation in case of the macroprudential stability levy) that were observed over the forecast horizon as our conditioning assumptions. This allows us to identify the assumed impact of each macroprudential measure on banks' external borrowings, and to disregard all the other forces influencing external borrowings. Consequently, the actual evolution of banks' external borrowings may be different from our model prediction which excludes the influence of other shocks.

For the no policy scenario, we assume that policy variables would have followed a different path. As for the leverage cap, our assumption is that the FX derivatives ratio would have been higher over the forecast horizon had the leverage cap measure not been implemented. The size of the increase in the FX derivatives ratio is assumed to be higher for foreign bank branches than for domestic banks, reflecting that the former was more constrained by the leverage cap than for the latter. As for the macroprudential measure, our assumption is that the borrowing spread or the CIP deviation would have been lower over the forecast horizon had the macroprudential measure not been implemented.[9] Reflecting the maturity-dependent levy rate structure, the size of the decrease is 20 basis points for short-term borrowings, and is 10 basis points for long-term borrowings.[10] We will discuss each policy scenario in greater detail in subsequent empirical results.

To approximate the impact of each macroprudential measure, we compare the conditional forecasts of FX borrowings under the policy scenario with those for the no policy scenario, and take the difference between the two as our estimate. We are therefore using the change in a specific policy proxy variable as our sole metric to determine the effects of each macroprudential measure on FX borrowings by banks. Kapetanios et al. (2012) and Lenza et al. (2010) use a similar approach to examine the macroeconomic impact of unconventional monetary policies undertaken by the Bank of England and the European Central Bank respectively. Figure 7 presents a schematic summary of how to estimate the policy effects.

Figure 7. Counterfactual analysis procedure



4.2. Empirical Results from Quarterly Data

4.2.1. Impact of Leverage Cap

Foreign Bank Branches

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[9] Lower CIP deviation under the no policy scenario is based on our interpretation of the CIP deviation as the cost of FX funding provided to domestic financial markets.

[10] Loan contracts have both price (interest rate) and non-price elements (collateral, maturity, loan standard, etc). It is known among bank practitioners that price element plays more important role in determining FX loan contracts than in determining local currency loan contracts. This provides some support for the transmission of the macroprudential levy through price measures assumed in our empirical analysis.

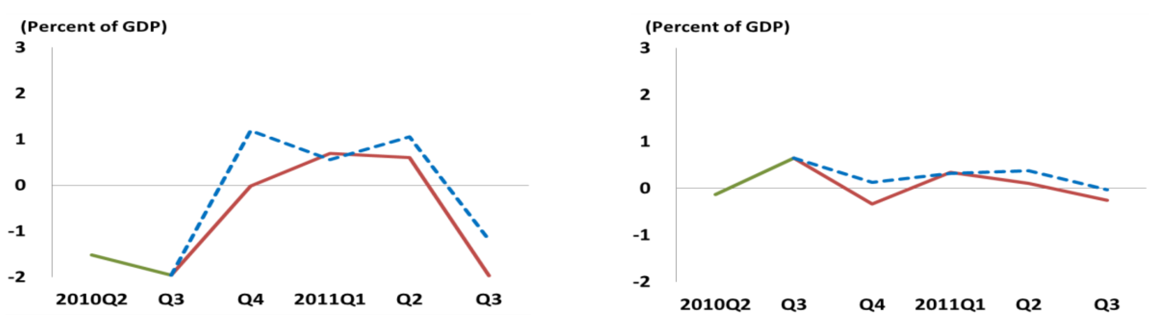
We estimate a four-variable model for foreign bank branches using data prior to the introduction of the leverage cap (2003Q1-2010Q3) to generate counterfactual forecasts for the one-year horizon from its introduction (2010Q4- 2011Q3). For these simulations, we assume that under the no policy scenario, the FX derivatives ratio would have been higher by 19.4 percentage points for the first three quarters of the forecast horizon (2010Q4-2011Q2), and by 27.5 percentage points in the last quarter (2011Q3). The size of the increase is computed as the difference between the FX derivatives ratio prevailed at the end of 2010Q3 and the FX derivatives ratio that would have been obtained if individual banks had made the necessary adjustments to meet a regulatory target. An additional increase in 2011Q3 reflects the tightening of the leverage cap in July 2011.

Figure 8 plots the counterfactual simulation of the effects of the leverage cap on foreign bank branches. The estimation results suggest that the leverage cap reduced short-term FX borrowings more than long-term FX borrowings, thereby helping to improve the maturity structure of FX wholesale funding by foreign bank branches. The decrease in the ratio of short-term borrowings to quarterly GDP amounted to 1.2 percentage points in 2010Q4, and the decrease was about 0.5-0.7 percentage points during 2011Q2-Q3. In contrast, the decrease in the ratio of long-term borrowings to quarterly GDP was 0.5 percentage points in 2010Q4, and the decrease was 0.2-0.3 percentage points during 2011Q2-Q3. The peak effect occurred in 2010Q4 for short- and long-term FX borrowings alike.

Figure 8. Impact of leverage cap on foreign bank branches – quarterly data

A. Short-term borrowings

B. Long-term borrowings



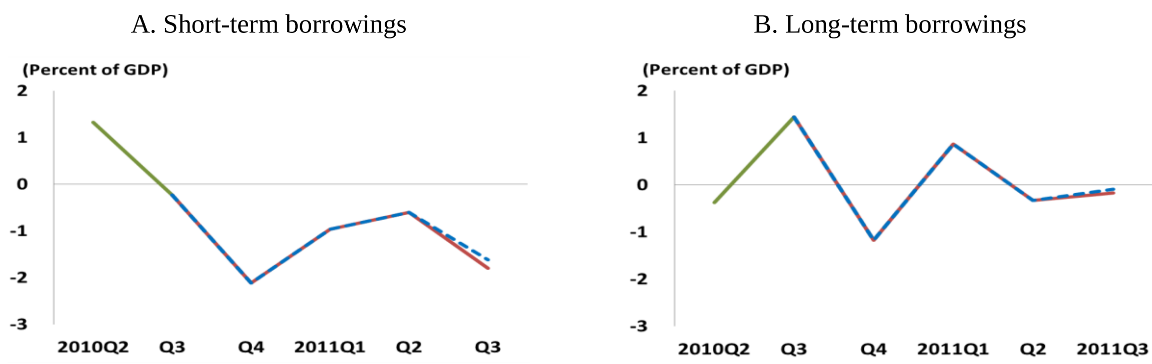
Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

Domestic Banks

A four-variable model for domestic banks is estimated using data prior to the introduction of the leverage cap (2003Q1-2010Q3) to produce counterfactual forecasts for the one-year horizon from its introduction (2010Q4- 2011Q3). We assume that under the no policy scenario, the FX derivatives ratio would have been the same as the policy scenario for the first three quarters of the forecast horizon (2010Q4-2011Q2), but would have been slightly higher by 0.3 percentage points in the last quarter (2011Q3). No change in the FX derivatives ratio for the first three quarters of the forecast horizon reflects the fact that the leverage cap was not binding for domestic banks at its introduction, and a small increase in the last quarter reflects that the leverage cap was binding for a few banks at its tightening in July 2011.

Figure 9 plots the counterfactual simulation of the effects of the leverage cap on short- and long-term FX borrowings of domestic banks. We observe that the effects of the leverage cap on domestic banks are much smaller than those on foreign bank branches. The estimation results suggest that the effects on short-term borrowings are nevertheless larger than those on long-term borrowings. In the last quarter of the forecast horizon (2010Q3), the decrease in the ratio of short-term borrowings to quarterly GDP amounted to 0.2 percentage points, whereas the decrease in this ratio for long-term borrowings was only 0.1 percentage points.

Figure 9. Impact of leverage cap on domestic banks – quarterly data



Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

Summary

Table 3 provides the summary of the effects of the leverage cap on foreign bank branches and domestic banks. The effects are measured as the cumulative decline in FX borrowings over the one-year period from its introduction normalized by annual GDP. We also considered the policy effects using a three-variable model where the VIX index is excluded from the variable vector.

We see that for foreign bank branches and domestic banks alike, short-term borrowings reduced at least twice as large as long-term borrowings did following the introduction of the leverage cap. For foreign bank branches, the leverage cap is estimated to have reduced short- and long-term borrowings by 0.5-0.6 percent and 0.2 percent of annual GDP respectively. For domestic banks, the effects are estimated to be about one tenth of those for foreign bank branches, but the results nevertheless point to the lengthening of the FX funding structure. Overall, the estimation results suggest that the leverage cap may have helped to improve the FX funding maturity structure of both bank groups.

Table 3. Cumulative effects of leverage cap for one year – quarterly data

(Percent of annual GDP)

	Foreign bank branches		Domestic banks	
	Short-term borrowings	Long-term borrowings	Short-term borrowings	Long-term borrowings
Four-variable model	0.57	0.23	0.05	0.02
Three-variable model	0.50	0.24	0.04	0.02

Notes: Cumulative effects on FX borrowings are measured as the decline in FX borrowings cumulated over the one-year period divided by annual GDP.

4.2.2. Impact of Macroprudential Stability Levy

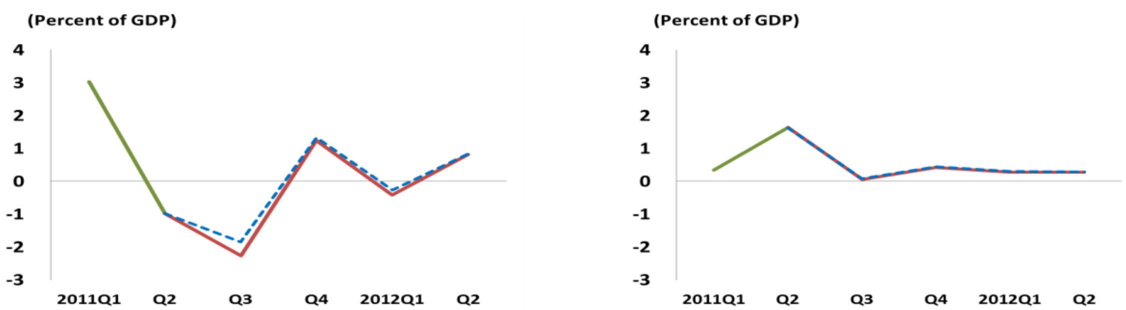
Foreign Bank Branches

We estimate a four-variable model for foreign bank branches using data prior to the introduction of the macroprudential stability levy (2003Q1-2011Q2) to generate counterfactual forecasts for the one-year horizon from its introduction (2011Q3- 2012Q2). We assume that under the no policy scenario, the CIP deviation would have been lower by 0.2 percentage points for short-term FX borrowings and by 0.1 percentage points for long-term FX borrowings over the entire forecast horizon. A different size between short- and long-term borrowings reflects the maturity-dependent levy rate structure in practice.

Figure 10 plots the counterfactual simulation of the effects of the macroprudential stability levy on short- and long-term FX borrowings for foreign bank branches. The estimation results suggest that the macroprudential stability levy reduced short-term borrowings in the main, while leaving long-term borrowings almost unaffected. The decrease in the ratio of short-term borrowings to quarterly GDP amounted to 0.4 percentage points in 2011Q3, and the decrease was 0.0-0.2 percentage points during 2011Q4-2012Q2. In contrast, the decrease in the ratio of long-term borrowings to quarterly GDP was much smaller with the magnitude being less than 0.1 percentage points over the entire forecast horizon. For short- and long-term borrowings alike, the peak effect occurred in 2011Q3.

Figure 10. Impact of macroprudential stability levy on foreign bank branches – quarterly data

A. Short-term borrowings B. Long-term borrowings



Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

Domestic Banks

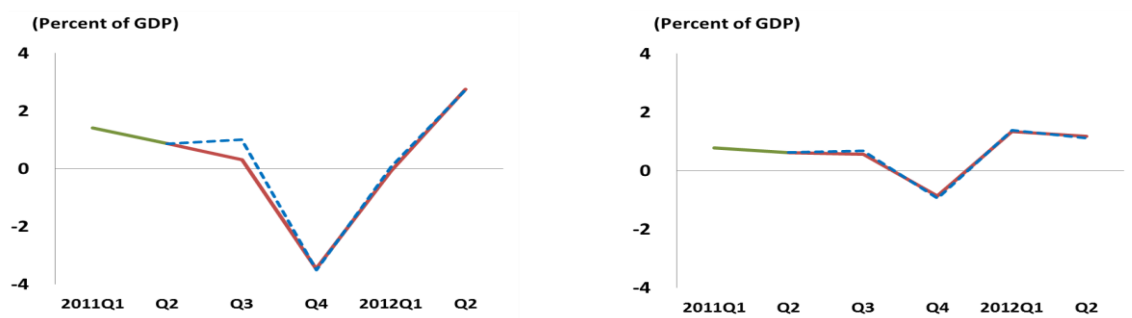
A four-variable model for domestic banks is estimated using data prior to the introduction of the macroprudential stability levy (2003Q1-2011Q2) to produce counterfactual predictions for the one-year horizon from its introduction (2011Q3- 2012Q2). We assume that under the no policy scenario, the borrowing spread would have been lower by 20 basis points for short-term borrowings and by 10 basis points for long-term borrowings over the entire forecast horizon.

Figure 11 plots the counterfactual paths for short- and long-term FX borrowings for domestic banks. The estimation results suggest that the macroprudential stability levy reduced short-term borrowings in the main with no significant impact on long-term borrowings. The decrease in the ratio of short-term borrowings to quarterly GDP amounted to 0.7 percentage points in 2011Q3, and the decrease was 0.2 percentage points in 2012Q1. On the other hand, the change in long-term borrowings was much smaller with slight decreases in some periods being offset by increases in other periods.

Figure 11. Impact of macroprudential stability levy on domestic banks - quarterly data

A. Short-term borrowings

B. Long-term borrowings



Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

Summary

Table 4 provides the summary of the effects of the macroprudential stability levy on foreign bank branches and domestic banks. The effects are measured as the decline in FX borrowings over the one-year period from its introduction normalized by annual GDP, and the policy effects are also estimated using a three-variable model.

We observe that the effects of the macroprudential stability levy on bank's external borrowings are smaller than those of the leverage cap reported in Table 3. Nonetheless, the effects seem to be moderate in light of the fact that the levy rate has been set at fairly low levels. Further, for both bank groups, the macroprudential stability levy caused a sizeable reduction in short-term FX borrowings, but had little impact on long-term FX borrowings. In cumulative terms over the one-year horizon, the macroprudential stability levy reduced short-term borrowings of both foreign bank branches and domestic banks by 0.1-0.2 percent of annual GDP, whereas it had no discernible impact on long-term borrowings. Overall, the estimation results suggest that the macroprudential stability levy may have helped to improve the maturity structure of FX funding by both bank groups.

Table 4. Cumulative effects of macroprudential stability levy for one year – quarterly data

(Percent of annual GDP)

	Foreign bank branches		Domestic banks	
	Short-term borrowings	Long-term borrowings	Short-term borrowings	Long-term borrowings
Four-variable model	0.18	0.02	0.20	0.01
Three-variable model	0.20	0.02	0.11	0.01

Notes: Cumulative effects on FX borrowings are measured as the decline in FX borrowings cumulated over the one-year period divided by annual GDP.

4.3. Empirical Results from Monthly Data

Data in different frequency face a tradeoff between the availability of disaggregated data on FX borrowings and the degree to which data speaks for the BVAR estimation results. Quarterly data allows for the assessment of the policy effects disaggregated by foreign bank branches and domestic banks, but data plays a limited role in explaining the BVAR estimates with a small sample size. However, monthly data with a larger sample size provides more room for data in accounting for the estimation results, but it only provide data on FX borrowings for the banking sector as a whole.

Considering this tradeoff, we check the robustness of the results from quarterly data by estimating BVAR models using monthly data. We use capital flows to the banking sector in the form of loans and securities from the Bank of Korea's balance of payment statistics, and focus on the impact of the macroprudential measures on the aggregate banking sector. We provide a summary of the estimation results in Table 5, and leave the detailed description to the appendix.

The estimation results using monthly data suggest that both the leverage cap and the macroprudential stability levy may have helped to improve the FX funding maturity structure of the banking sector, which is in line with the evidence from quarterly data. Specifically, the leverage cap is estimated to have reduced short-term borrowings more than long-term borrowings. Further, the macroprudential levy is estimated to have had a sizable impact on short-term borrowings with no discernible impact on long-term FX borrowings.

Table 5. Cumulative effects of macroprudential measures on the banking sector – monthly data

(Percent of annual GDP)

	Leverage cap		Macroprudential levy	
	Short-term borrowings	Long-term borrowings	Short-term borrowings	Long-term borrowings
Four-variable model	0.37	0.24	0.29	0.02
Three-variable model	0.43	0.22	0.19	0.02

Notes: Cumulative effects on FX borrowings are measured as the decline in FX borrowings cumulated over the one-year period divided by annual GDP.

5. Concluding Remarks

This paper presents a tentative empirical assessment of the impact of the FX-related macroprudential measures introduced in Korea since 2010. To this end, we estimate Bayesian vector autoregression (BVAR) models using data from the first quarter of 2003 to the second quarter of 2012, and the model specification is based on the conceptual framework of cross-border bank capital flows and some institutional features of the Korean banking sector. We then use this model to conduct the counterfactual simulations regarding the implementation of each macroprudential measure, and quantify the effects of each macroprudential measure on short- and long-term FX borrowings by banks.

We find evidence that the macroprudential measures led to a sizeable reduction in short-term external borrowings by banks, while causing much smaller or nearly no reduction in long-term external borrowings. These results suggest that the macroprudential policies may have helped to mitigate vulnerabilities to external financial conditions by improving the foreign currency funding structure of the banking sector.

However, since our analysis is based on limited data from the initial period of new policy implementation, it may be too early to draw a definitive conclusion about the effectiveness of these policy measures. 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 preliminary overview of the impact of a new set of macroprudential policies, which could form a basis for future policy analysis. In addition, this paper contributes to the empirical literature on the effects of the macroprudential policies. While the crisis has highlighted the role of macroprudential policies in achieving financial stability, empirical evidence on their effectiveness is still limited.

Appendix. Detailed Description of the Estimation Results using Monthly Data

In this appendix, we describe the estimation results of the effects of the macroprudential measures on the banking sector using monthly data. We assume that the model specification for the banking sector is identical to domestic banks because domestic banks constitute a larger fraction of the aggregate FX borrowings than foreign bank branches do.[11)]

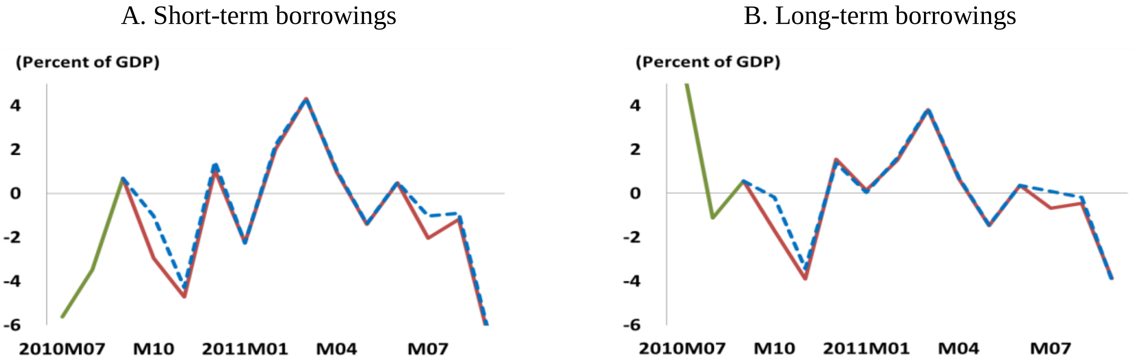
A.1. Impact of Leverage Cap

A four-variable model for the banking sector is estimated using data prior to the introduction of the leverage cap (2003M01-2010M09) to generate counterfactual predictions for the one-year horizon from its introduction (2010M10-2011M09). For these simulations, we assume that under the no policy scenario, the FX derivatives ratio would have been higher by 2.6 percentage points for the first nine months of the forecast horizon (2010M10-2011M06), and by 4.0 percentage points for the last three months of the forecast horizon (2011M07-M09). The size of the increase is computed as the difference between the FX derivatives ratio of the banking sector prevailed at the end of 2010M09 and the FX derivatives ratio that would have been obtained if individual banks had made the necessary adjustments to meet a regulatory target. An additional increase during 2011M07-M09 reflects the tightening of the leverage cap in July 2011.

Figure 12 plots the counterfactual simulation of the effects of the leverage cap on short- and long-term FX borrowings for the banking sector. The results suggest that the leverage cap reduced short-term borrowings more than long-term borrowings. The decrease in the ratio of short-term borrowings to monthly GDP amounted to 0.4-1.9 percentage points during 2010M10-M12, and the decrease was 0.2-1.0 percentage points during 2011M07-M09. In contrast, the decrease in the ratio of long-term borrowings to monthly GDP was 0.0-1.5 percentage points during 2010M10-M12, and the decrease was 0.0-0.8 percentage points during 2011M07-M09. The peak effect occurred in the first three months of the forecast horizon.

[11] According to the international investment position statistics, domestic banks hold 60 percent of total external debt at the end of 2010.

Figure 12. Impact of leverage cap on the banking sector – monthly data



Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

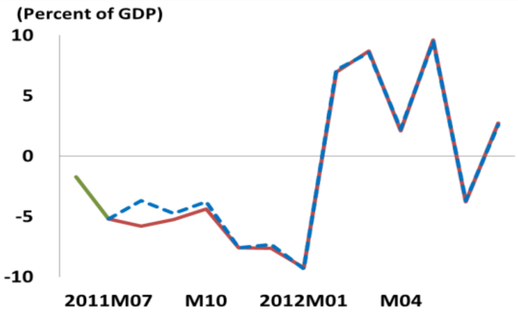
A.2. Impact of Macroprudential Stability Levy

A four-variable model for the aggregate banking sector is estimated using data prior to the introduction of the macroprudential stability levy (2003M01-2011M07) to generate counterfactual predictions for the one-year horizon from its introduction (2011M08-2012M07). For these simulations, we assume that under the no policy scenario, the borrowing spread would have been lower by 20 basis points for short-term borrowings and by 10 basis points for long-term borrowings over the entire forecast horizon.

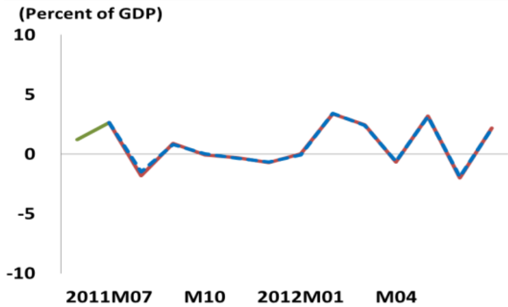
Figure 13 plots the counterfactual paths for short- and long-term FX borrowing for the banking sector. The estimation results suggest that the macroprudential stability levy reduced short-term borrowings in the main with no discernible impact on long-term borrowings. The decrease in the ratio of short-term borrowings to monthly GDP amounted to 0.5-2.1 percentage points over the period 2011M08-M10, whereas the decrease in the ratio of long-term borrowings to monthly GDP was indiscernible. For both short- and long-term borrowings, the peak effect occurred in the first three months of the forecast horizon.

Figure 13. Impact of macroprudential stability levy on the banking sector – monthly data

A. Short-term borrowings



B. Long-term borrowings



Notes: Solid red lines (broken blue line) represent conditional forecasts under the policy scenario (the no policy scenario): solid green lines represent actual values.

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