

The Macroprudential Measures' Effects on the Korean Foreign Exchange Market*

In Huh[†]

Abstract Although capital market openness is a virtue to pursue, there are many reasons to control capital flows. Korean monetary authorities employed macroprudential measures after the global financial crisis (GFC). They intend to avoid the considerable accumulation of foreign capital inflows, which potentially causes a financial crisis in an economic downturn. Korean macroprudential measures enlengthened the maturity of foreign currency debts. This paper analyzes whether the macroprudential measures limit the supply of USD enough to change the price variables. The macroprudential measures did not cause the depreciation of the Korean won, and the Korean won's sensitivity to market volatility did not rise either. Although the cost of USD funding increased after the macroprudential measures, the F/X exchange rates did not seem to react. The interest rate arbitrage opportunity did not increase after implementing macroprudential measures. Because the investors have not fully explored the interest arbitrage opportunity, the increased USD funding cost of macroprudential measures did not show up as the increased gap between the Korean won bond interest rate and cross-currency rate. Korean monetary authorities introduced the macroprudential measure when capital inflows resumed after the GFC. The increased cost of USD funding did not reverse the capital inflows trend, only restructuring them.

Keywords Macroprudential measures, exchange rates, currency swap rates, interest rates arbitrages

JEL Classification E6, F3, E4

*We are grateful to the two anonymous reviewers for their thoughtful comments and suggestions.

[†]Department of Economics, The Catholic University of Korea, FAX: 02)2164-4785, E-mail: inuh@catholic.ac.kr

1. INTRODUCTION

One of an economy's virtues is its capital market's openness. The free capital flows make the economy more efficient. Especially, foreign capital flows improve capital allocations in the domestic financial markets. The optimization of capital allocation, in turn, improves productivity. The capital flows ease the income dependency of consumption, and the consumption smoothing improves the economy's welfare.

However, capital flows limit the effectiveness of the monetary policy on the domestic economy. When the capital flows freely, the center countries' monetary policies decide the business cycles of the peripheral countries' economies. The center countries' monetary policy affects the peripheral countries' economies more when the peripheral countries pursue exchange rate stability.

Capital controls and macroprudential measures could benefit the economy by preventing negative impacts. Capital controls and macroprudential measures could restore the effectiveness of the domestic monetary policy. They also can prevent excessive currency appreciation, hurting the exporting industries. Furthermore, they can prevent an excessive credit boom which results in a financial crisis. They directly prevent the capital flow reversal. Therefore, they eventually stabilize the output and inflation.

There still are warnings for using capital control and macroprudential measures. Capital controls and macroprudential measures can create an imbalance of capital flows into restricted sectors. Typically, the countries with capital restrictions experienced an unbalanced effect, which favored exporting and large firms. Therefore, capital controls and macroprudential measures can induce international capital flow imbalances.

The Korean economy has experienced two severe episodes of sudden stops since the 1990s. Both sudden stops happened in debt investment and led to the collapse of currency value. The first happened at the end of 1997, along with the Asian currency crisis. The monetary authority recognized the necessity of foreign reserves and adopted the free-floating exchange rate system after this crisis.

The second episode of sudden stop happened in 2008. The global financial crisis (GFC) hit the Korean economy as capital outflows. The free-floating exchange rate system did not prevent sudden stops. Korean monetary authority employed macroprudential measures afterward to prevent future sudden stops.

One of the macroprudential measures is the cap on the foreign exchange (F.X.) forward-to-capital ratio. The short-term foreign currency debts increased from 2004 until the GFC because banks increase the foreign currency debt to

hedge the foreign currency long position created by forward buying. This surge of short-term foreign currency debts caused the instability of the foreign exchange market during the GFC. The other is the macroprudential levy to tax foreign currency debts to banks. The macroprudential levy taxes short-term foreign currency debts more than long-term ones to make banks borrow in longer maturity.

Korean macroprudential measures enlengthened the maturity of foreign currency debts. Banks must borrow short-term foreign currency debts to hedge the forward buying position since the typical forward matures in less than a year. Therefore, the cap on the F.X. forward-to-capital ratio limits short-term liability. The macroprudential measure provides an incentive to borrow in the long term. According to Huh and An (2014), these macroprudential measures did not reduce banks' total foreign currency debts but enlengthened their maturities.

This paper analyzes whether the macroprudential measures limit the supply of foreign currency in the F.X. market. The analysis did not find a depreciating effect of the macroprudential measures, even though they restrict the supply of USD. Furthermore, they did not enlarge the interest rate arbitrage opportunity. Therefore, Korean macroprudential measures were not restrictive enough to affect the price variables in the foreign exchange market while lengthening banks' foreign currency debt maturities.

The rest of this paper is organized as follows. The second section has the literature reviews on capital controls and macroprudential measures and the introduction of the Korean macroprudential measures. The third section has the data description and empirical results. Then the fourth section concludes.

2. LITERATURE REVIEW AND KOREAN MACRO PRUDENTIAL MEASURES

2.1. LITERATURE REVIEW

Generally, we think that the openness of the capital market makes the economy more efficient. Reinhart *et al.* (2013) supported the Neoclassical views on capital flows, which advocate that free capital flows promote the economy's efficiency. Bau and Matray (2022) empirically showed that the open capital market in India reduced the misallocation of capital and increased productivity. Varela (2018) also showed that the frictions in the capital market restrict credit and eventually reduce productivity by restricting investment. According to Li and Dan (2022), productivity increased as the capital market opened.

The benefits of capital flows could vary depending on the situation of the

recipient economy. Maggiori (2017) said that currency appreciation insulated consumption during a recession in reserve currency countries. Rangvid *et al.* (2016) indicate that capital market integration facilitates consumption smoothing, improving the economy's welfare. Islamaj and Kose (2016) empirically analyzed that consumption depended less on income as financial integration increased significantly in advanced economies.

The capital flows affect the effectiveness of domestic monetary policies. Rey (2013) said that the center countries' monetary policy decided the business cycle of the peripheral countries with large foreign debts and free capital flows. Banerjee *et al.* (2015) said that if the emerging market does not tighten when the U.S. tightens monetary policy, it results in capital outflows from emerging markets and reduced GDP. Aizenman *et al.* (2016) also empirically analyzed that the center countries affect the peripheral countries pursuing exchange rate stability and open capital market. Morais *et al.* (2019) showed that center countries' monetary easing increased Mexico's banks' lending and the real economy.

The capital flows could negatively affect the economy. Mian *et al.* (2017) showed that the countries with rigid exchange rate systems experienced a more severe business downturn after the surges in household debts. Broner and Ventura (2016) said that the globalization of the financial market could induce instability in the domestic capital market, and various aspects of the domestic economy decide the effects of capital flows. Bleck and Liu (2018) developed the general equilibrium model in which capital injection could result in capital misallocation and harm the macroeconomy. Caballero (2016) said that the surge in capital inflow increased the probability of a banking crisis. Ghosh *et al.* (2016) said that the debt capital inflow to the emerging market economy during the boom accumulated instability and increased the probability of recessions. Merrouche and Nier (2017) said that capital inflows create the wholesale-funded credit boom regardless of domestic monetary policies. According to Converse (2018), the capital flows shortened the firms' debt maturity and increased uncertainty, affecting productivity and output. Agosin *et al.* (2019) warned that the sudden stop of capital inflow hurt output and employment, especially in countries without foreign assets.

The policy that limits capital flows could benefit the economy. Basu *et al.* (2020) seek the optimal monetary policy, including capital controls, macroprudential measures, and foreign exchange interventions. Adrian *et al.* (2020) showed that foreign exchange intervention and capital control increase the trade-off of monetary policy. Yopez (2021) said that capital control benefits the economy by reducing the currency appreciation pressure when the exporting industry

has an externality by learning by doing. Caballero and Lorenzoni (2014) also justify the foreign exchange intervention to prevent the destruction of exporting industry by preventing excessive currency appreciation. Jung (2023) showed that the capital control improve welfare of small open economy with flexible prices.

Moreover, Nier *et al.* (2020) indicated that the macroprudential measures regulated the credit boom and limited currency appreciation. Fendoglu (2017) showed that the borrow-based tool and domestic reserve requirement are effective among macroprudential measures. According to Magud and Vesperoni (2015), the rigid exchange rate system creates a more significant credit boom in booms. The floating exchange rate system does not prevent credit reversal. Therefore, the macroprudential measures benefit the economy with the rigid exchange rate system. Bau and Matray (2022) developed the model with financial frictions and said that the sudden stop could justify the macroprudential measure. Brandao-Marques *et al.* (2020) advocate macroprudential measures as they reduce output volatility and inflations.

However, there are some considerations when the economy applies the policy limiting capital flows. Ahnert *et al.* (2019) mentioned that the macroprudential measures reduced the foreign currency debt in banks but increased the foreign currency debt in other sectors, so the macroprudential measure might not reduce overall risks in a macroeconomy. According to Andreasen *et al.* (2019) and Andreasen *et al.* (2021), Chilean capital controls negatively affected the output but benefited exports. Alfaro *et al.* (2017) analyzed that capital control increased the cost of capital, reducing the firms' cumulative abnormal return. They also mentioned that this negative impact is less severe on large and exporting firms. Forbes (2007) also showed the significant relationship between capital controls and financial constraints on listed firms in Chile. Chanda (2005) found a more negative impact of capital control on economic growth in countries with cultural and linguistic diversities. According to Bai and Wei (2001), we could find more capital controls in countries with more bureaucratic corruption. Aizenman and Pasricha (2013) said the government should give up the fiscal surplus when controlling capital outflows. Reinhart and Sbrancia (2015) also indicated that financial repression could be a way to reduce the fiscal deficit, such as setting the maximum interest rates, capital controls, and nationalization of financial institutes. The capital controls on the bond market in Brazil reduced the capital inflows into bond and stock markets. They impacted the capital flows into other countries, which could introduce the same controls, according to Forbes *et al.* (2016). Choi and Taylor (2017) said that capital control and foreign reserve accumulation depreciated the real exchange rate. Montecino (2018) also

mentioned that capital control impeded the real exchange rate from being back to equilibrium. Pasricha (2020) said countries use more capital controls when facing currency appreciation. Goel and Miyajima (2021) said that foreign debt investment was more sensitive to sudden stops, while foreign stock investment was sensitive to domestic economic situations. Caballero and Krishnamurthy (2003) mentioned that foreign investors invest more in reserve currencies as they invest in less financially developed countries.

2.2. KOREAN MACROPRUDENTIAL MEASURES

Korean economy experienced two episodes of the sudden stop of foreign investments. Both sudden stops caused a collapse of KRW. At first, the large corporates' foreign currency debts accumulated before the first sudden stop. IMF relief fund has required macroeconomy restructuring. IMF required Korea to open the financial market and adopt a free-floating exchange rate system. These remedies intend to increase capital allocation efficiency and prevent abnormal accumulation of current and financial deficits. Then, Korean monetary authorities started to accumulate significant amounts of foreign reserves.

The second sudden stop happened during GFC. Korean governments issue bonds that mature at the end of every quarter. Lehman Brothers went bankrupt on Sept. 15 of 2008, the most significant event spreading the financial crisis from the U.S. to the world. The timing of Lehman Brothers' bankruptcy coincided with the end of the 3rd quarter when a large quantity of KTB matured that month. Moreover, many foreign investors of KTB did not roll over their position. There were many short-term debts in the banking sector before the GFC. Banks also struggled to roll over these short-term debts during the GFC. The free-floating exchange rate system did not prevent these accumulations of debts.

After the GFC and the second sudden stop, Korean monetary authorities have implemented three measures to prevent a future stop. First, they resumed the tax on foreign investors on KTB. The tax exemption on foreign investors to KTB began in 2009 after the GFC to ease the outflows. The tax exemption lasted from May 2009 to Dec. 2010. Since 2010, capital inflows to KTB have increased, and the exemption was not an ordinary policy for the monetary authorities. So, they set the policy back to regular status.

Second, they also employed the cap on banks' forward-to-capital ratios. The cap has been 50% for domestic and 250% for foreign banks since Oct. 2010. When banks buy the F.X. forward, they accumulate foreign currency long position. Banks should borrow foreign currency to make a square position in foreign currency. Banks could avoid the foreign exchange rate risk by making a square

Table 1: Korean Macroprudential Measures

Measures	Contents	Effective date	Policy goals
Cap on the forward-to-capital ratios	50% (Domestic Banks) 250% (Foreign Banks)	Oct. 2010	To control short-term foreign currency debts of banks
	40% (Domestic Banks) 200% (Foreign Banks)	Jul. 2011	
	30% (Domestic Banks) 150% (Foreign Banks)	Jan. 2013	
	40% (Domestic Banks) 200% (Foreign Banks)	Jul. 2016	
	50% (Domestic Banks) 250% (Foreign Banks)	Mar. 2020	
Tax on foreign investment in bonds	14% (interest), 20% (trading)	Jan. 2011	To control the quantity of foreign investment in the bond.
Macroprudential levy	0.20% (~1 yr) 0.10% (1~3 yrs) 0.05% (3~5 yrs) 0.02% (5 yrs and more)	Aug. 2011	To lengthen the bank's foreign currency liabilities and collect the funds for emergency relief.

Notes: Source: Huh and An (2014) and Bank of Korea (2020).

position. So, banks borrow more in foreign currency if they buy more forward. The cap on the forward-to-capital ratios intends to limit banks' total foreign currency borrowings.

The last measure was the macroprudential levy on banks' foreign currency borrowing. Levy on debts is increasing as debt's maturity decreases. Levies are 0.2% for one year or less, 0.1% for one year to 3 years, 0.05% for 3 to 5 years, and 0.02% for five years and more. During the GFC, the Bank of Korea provided foreign currency liquidity for banks with foreign currency liquidity troubles. The supply of foreign currency liquidity prevented banks' default and currency crisis. However, banks could have a moral hazard incentive if the central bank provides liquidity when banks fail. Therefore, the monetary authorities introduce the macroprudential levy on banks' foreign currency liabilities to accumulate the fund to provide to banks for foreign currency shortages in banks.

The cap on the forward-to-capital ratios intends to limit the short-term foreign currency debts in banks. The other two measures' intentions are straightforward to understand; they directly increase the cost of debt investment. The

cap on the forward-to-capital ratios works indirectly to control short-term foreign currency debts. The forward buying has increased since export booms. Primarily the shipbuilders have sold the forwards. The increased forward sales of exporters caused the increase in short-term foreign currency debts in banks. At the dawn of the GFC, foreign investors were concerned about this surge of short-term debts as the Korean economy's potential problem as long as the current deficit and banks' loan-to-deposit ratios. The Korean government explained that increasing short-term debts due to increased exports would not be risky for the economy. However, this explanation could not prevent the outflows during the GFC. Therefore, the monetary authorities employed the cap on the forward-to-capital ratio to prevent another surge of short-term foreign currency debts of banks.

There have been adjustments to the cap on the forward-to-capital ratios. The monetary authority has tightened two times and then relaxed back to the original caps. According to Bank of Korea (2020), the monetary authorities are worried about foreign currency supply, especially in the currency swap market. Banks supply foreign currency when they have forwards buying positions. The cap on the forward-to-capital ratios and macroprudential levy can restrict the banks' ability to supply foreign currency by restricting forward buying and increasing the cost of borrowings. Therefore, the monetary authority elastically changed the caps of forward-to-capital ratios not to disrupt the currency swap market severely.

These measures naturally caused friction in the foreign exchange market. Foreign investors faced a reduction in after-tax earnings at the reintroduction of tax on foreign bond interest and trading earnings. In addition, the macroprudential levy increased the cost of foreign currency borrowings. The restriction on forward buying also reduced the need for foreign currency borrowings. Therefore, these measures might lead to a reduction in foreign bond investment, which means a reduction in foreign currencies in the F/X market.

3. DATA AND EMPIRICAL RESULTS

3.1. ESTIMATION MODEL AND DATA

USD is the most traded currency in the Korean foreign exchange market. The triangular trade decides the exchange rates of the other currencies. The interest rates affect the exchange rates in high frequency; the current and trade account affects the exchange rates in low frequency. Investors consider the Korean won an industrial currency since it is sensitive to stock prices. Especially,

the volatility increases in the stock market typically reduce the Korean won value to USD since the investors hold their investment in the Korean stock market with increased volatility. Data in the analysis is the daily data from Oct. 12th, 1999, to Nov. 13th, 2020, so it is high-frequency data. The trade account's effect on the exchange rate may not be relevant in high-frequency data, and there are not any statistics representing trades daily. So, the linear model set as

$$KRW_t = \alpha + \beta_1 Intdiff_t + \beta_2 VIX_t \quad (1)$$

where KRW , $Intdiff$, VIX are the variables defined in Table 2.

The macroprudential measures could restrict the foreign currency supply in the foreign exchange market. So, they can depreciate the Korean won. If a structural break increases the exchange rates around the introduction of macroprudential measures, we could say that the macroprudential measures restrict the foreign currency supply in the F.X. market. Then we can verify the macroprudential measures' effect on the F.X. market by checking whether the intercepts change. If intercepts increased after the introduction of macroprudential measures, they depreciated KRW by restricting USD supply. If there is the possibility that the sensitivity to financial volatility could change with macroprudential measures, there could be structural breaks in β_2 .

An interest arbitrage opportunity can exist if the U.S. dollar is scarce in the Korean financial market. The financial institutes with an interest arbitrage position borrow USD, exchange into KRW, invest in KRW bonds, and sell forwards to avoid exchange rate risks. They can simplify this arbitrage investment process using the currency swap market. They swap the borrowed USD into KRW, then pay cross-currency rates and receive LIBOR during the swapping period. They can use a swap market instead of spot and forward exchange markets. Therefore, the interest rate difference between cross-currency rates and KRW bond interest rates shows the possibility of interest rate arbitrage. There is no interest rate arbitrage opportunity using borrowed USD if the cross-currency rates are higher than KRW bond interest rates. Since cross-currency rates have been lower than KRW bond interest rates, we can say there has been an interest rate arbitrage opportunity in the Korean financial market.

The financial institutes will not fully exploit the interest arbitrage opportunity if there is a shortage in USD in the global financial market. They need to borrow in USD to exploit the interest rate arbitrage. If there is a USD shortage in the global financial market, they cannot borrow enough capital in USD to exploit the interest arbitrage opportunity. We use the TED spread to proxy the USD supply condition in the global financial market. If there is a shortage in the

Korean exchange market, the financial institutes cannot fully exploit the interest arbitrage opportunity. We use the VIX index to proxy the USD supply condition in the Korean exchange market since KRW is known to fluctuate as the industry does.

The estimate equation for the interest arbitrages is as follows.

$$Arbitrage_t = \alpha + \beta_1 TED_t + \beta_2 VIX_t \quad (2)$$

where *Arbitrage*, *TED*, *VIX* are variables defined in Table 2.

Macroprudential measures can restrict interest arbitrage activity. The macroprudential levy increases the borrowing cost of USD for financial institutes in Korea. The cap on the forward-to-capital can restrict the USD supply in the exchange market. Moreover, the tax on foreign bond investment lowered the after-tax yield on KRW bonds. So, the macroprudential measures burden the financial institutes to exploit the interest rate arbitrages. We can expect a more considerable interest arbitrage opportunity after the macroprudential measures if these measures effectively increase the cost of USD borrowing and lower the after-tax earning in KRW bond investments. We can judge it by detecting the structural breaks in α if α increases after the introduction of macroprudential measures. If the macroprudential measures make the investors more sensitive to country risks, we also can expect the structural breaks in β_2 as well.

Table 2 explains the variables in the analysis and their sources and

Table 2: Variables in analysis and their sources

Variables	Descriptions	source
KRW	Log of KRW exchange rate against USD	Bank of Korea
Arbitrage	Interest rate difference of MSB and cross-currency with 1-year maturity (MSB1-CRS1)	Bank of Korea
Intdiff	Interest rate difference between U.S. government bond, Korean government bond 3-year maturity (DGS3-KTB)	Bank of Korea
TED	TED spread	St. Louis FED
VIX	Stock volatility index	St. Louis FED

Table 3 has each variable's means, standard deviation, minimum and maximum.

KRW reached its maximum of 7.36 which is 1573.6 won per dollar on Mar. 3, 2009, as the Korean won depreciated sharply during the GFC. KRW recorded

Table 3: Main summary statistics

Variables	Mean	Standard deviation	Minimum	Maximum
KRW	7.025	0.091	6.805	7.361
Arbitrage	0.838	0.770	-0.220	5.785
Intdiff	-1.458	1.203	-4.080	1.084
TED	0.430	0.404	0.090	4.580
VIX	19.99	8.99	9.14	82.69



Figure 1: Log of Korean won exchange rates

its minimum of 6.08 which is 902.2 won per dollar on Nov. 2, 2007, before the GFC, as KRW had lowered most of the 2000s before the GFC. There seems to be no significantly unusual movement after the macroprudential measures' introduction.

shows the interest differences between U.S. treasury bonds and Korean treasury bonds. KTB yields were higher than DGS on most days. Before the GFC, the world economy had been booming, so the interest rates of DGS have increased more than KTB interest rates. In addition, U.S. monetary policy during the boom tightened more than Korean monetary policy. Therefore, Intdiff fluctuated adversely to economic fluctuation. The maximum of 1.08 was recorded on November 8, 2018, and the minimum of -4.08 was recorded on October 6, 2008.

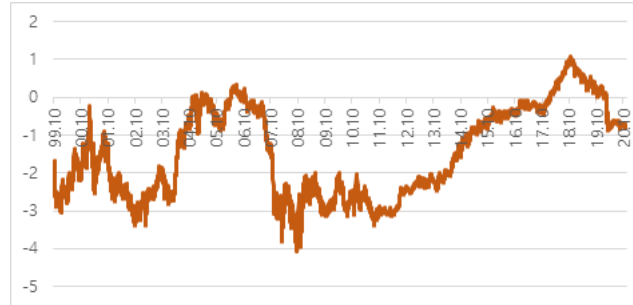


Figure 2: Interest rate differences between DGS and KTB

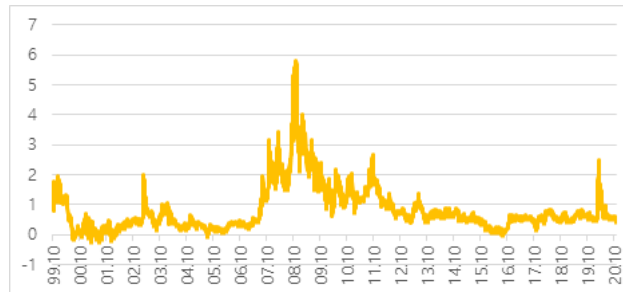


Figure 3: Arbitrage opportunity

Figure 3 shows Arbitrage variable. Interest rates of MSB bonds have generally been higher than the cross-currency rates. Arbitrage has gotten significantly higher during the GFC, with a maximum of 5.76 recorded on Nov. 24, 2008. The US dollar liquidity shortages made the investors not explore the interest arbitrage opportunity. The average of Arbitrage is higher after the GFC than before the crisis.

Figure 4 shows the TED spread. It also increased sharply during the GFC, the maximum of 4.58 on Oct. 10, 2008. The US dollar liquidity was limited in the euro market during the GFC. However, it has subsided more quickly than Arbitrage has after the GFC thanks to the quantitative easing (QE) of the Federal Reserve. Its minimum of 0.09 was recorded on March 15, 2010.

Figure 5 shows the VIX index. It has reached its maximum of 82.69 on Mar. 16, 2020, during the COVID pandemic. During the GFC, it also has been significantly high. The spikes generally matched with KRW depreciation and an increase in Arbitrages.

Table 4 shows the correlation coefficients between variables. It confirms the

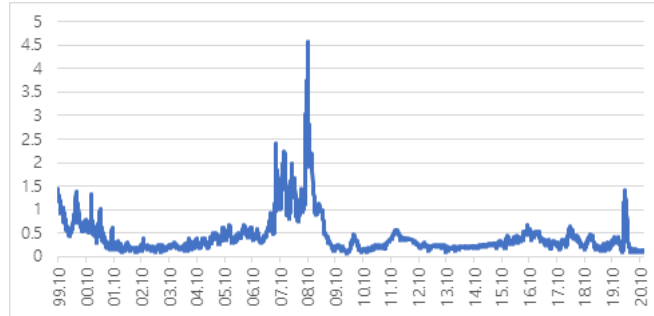


Figure 4: TED spread

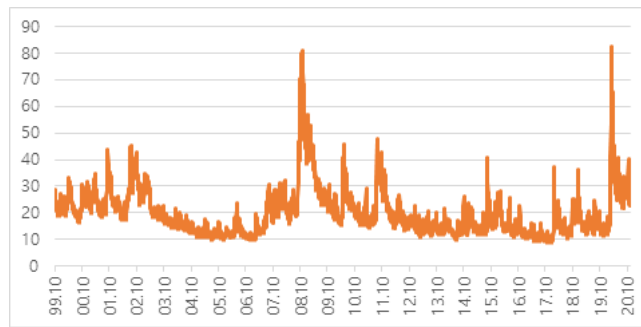


Figure 5: VIX index

Table 4: Correlations Coefficients between variables

	KRW	Arbitrage	Intdiff	TED	VIX
KRW	1	0.1961	-0.2759	-0.0750	0.5242
Arbitrage		1	-0.5263	0.5995	0.6272
Intdiff			1	-0.1874	-0.4563
TED				1	0.4652
VIX					1

Notes: 5% critical value (two-tail test) = 0.0279.

significant linear relations between variables. Intdiff and VIX are the top two variables showing the strongest linear relation with KRW. TED and VIX are the top two variables showing the strongest linear relationship with Arbitrage.

4. ESTIMATION RESULTS

Table 5 has the estimation result of the KRW equation with structural breaks in constant terms. The Bai and Perron (1998) test finds the structural breakpoints by setting the maximum number of breaks as 5. The first period was from Oct. 12, 1999, to Nov. 18, 2004. Korea experienced a currency crisis just before this period and a domestic financial market crisis due to increased personal debts. Therefore, investors might avoid the Korean financial market due to the country-specific risks. The estimated constant was the second highest during the sample periods.

The second period was until Aug. 26, 2008. This period includes the so-called Goldilocks economy with relatively low inflation and high growth. Korean export has been resilient during most of this period, and domestic demand has recovered steadily from the personal debt problem in the early 2000s. Therefore, the Korean financial market regained investors' confidence. As a result, the estimated constant was the lowest during this period.

The third period was until Sept. 28, 2010. This period includes the GFC. The Lehman Brothers bankruptcy on Sept. 15, 2008, marked the most significant event, resulting in a severe crunch in USD liquidity in the global financial market. The Fed employed the zero-interest rate policy and quantitative easing to ease the credit crunch. These efforts eased the USD liquidity crunch and volatility in the stock market, but investors did not have enough liquidity to normalize their international positions. As a result, the estimated constant was the highest during the sample periods.

The fourth period was until July 6, 2015. This period includes the macroprudential measures' introduction and the Southern Europe fiscal crisis. There have been concerns about Southern Europe's fiscal conditions. However, the global financial market has slowly recovered from the global financial market, so capital flows into the Korean bond market have increased. The Korean monetary authorities were worried about the potential sudden stops, so they decided to control the foreign liabilities through macroprudential measures. As a result, the estimated constant was smaller than the previous period's.

The last period was from July 6, 2015, to Nov.23, 2020. This period includes the COVID-19 shock in the economy. There have been bigger VIX on average

Table 5: Estimation of KRW equation with structural breaks in constant

Estimation periods	~2004.11.18	~2008.8.26	~2010.9.28	~2015.7.6	~2020.11.23
const	7.035*** (0.009421)	6.841*** (0.007434)	7.040*** (0.01238)	6.961*** (0.007528)	6.997*** (0.006520)
Intdiff	0.004258 (0.003177)				
VIX	0.002865*** (0.0003561)				
n	4947				
R2	0.7638				

Notes: Standard errors in parentheses, *, **, *** means significant at the 10, 5, 1 percent level respectively.

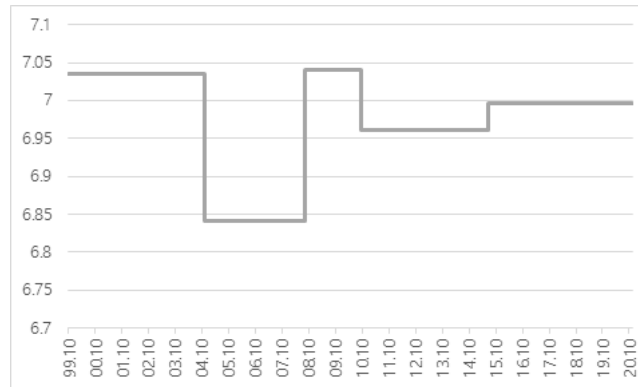


Figure 6: Estimated constants for KRW equation

than that of the previous period. Investors became more risk-aware during this period. The estimated constant increased. Figure 6 has the estimated constant trends for the whole sample period.

In sum, the estimated constants did not rise after the macroprudential measures. It means there is no significant restriction on USD liquidity due to the macroprudential measures. Table 6 shows the estimation results if the sensitivity to VIX has structural breaks along with constants. The detected break points in Table 6 differ from those in Table 5. However, the main economic booms and crises are in the same interval as in Table 5. Therefore, we can compare the third and fourth periods to verify the effect of macroprudential measures. The estimated constant was bigger in the fourth than in the third period. However,

Table 6: Estimation of KRW equation with structural breaks in constant and VIX

	~2004.11.22	~2008.8.22	~20011.1.13	~2015.6.8	~2020.11.23
const	7.024*** (0.01565)	6.920*** (0.01599)	6.939*** (0.01899)	6.949*** (0.01349)	7.014*** (0.005588)
Intdiff	-0.006324* (0.003333)				
VIX	0.002347*** (0.0007014)	0.002692*** (0.0009823)	0.005051*** (0.0006840)	0.002022*** (0.0007483)	0.001801*** (0.0002786)
n	4947				
R2	0.7873				

Notes: Standard errors in parentheses *, **, *** means significant at the 10, 5, 1 percent level respectively.

the difference was only 0.01, and the F-test statistic for no difference was 0.23 with a p-value of 0.63. Therefore, the F-test cannot reject the null hypothesis of no difference. The KRW sensitivity to VIX has changed in the fourth period from the third period. It has been less sensitive to VIX than in the third period. Korean won has been more resilient from VIX shocks in the fourth period. The macroprudential measures were not restrictive enough to depreciate KRW.

Table 7 has the estimation result from the Arbitrage equation with structural breaks in constant. The detected breakpoints by the Bai-Perron test are different from the KRW equation. Nevertheless, each period's main economic events are in the same periods. Therefore, we can also compare the third and fourth periods to verify the effect of macroprudential measures. The estimated constants decreased in the fourth period from the third period. Figure 7 shows the estimated constants. The estimated constants continued to decrease after the third period. The arbitrage opportunity has decreased even with macroprudential measures.

Table 8 shows the Arbitrage equation estimation results with structural breaks in constant and VIX. The structural breakpoints differ slightly from Table 7, but the main economic events are in the same period. Furthermore, the estimated constant is lower in the fourth than in the third period. However, the sensitivity to VIX increased in the fourth period from the third period. The F-test of no difference in sensitivity to VIX is 0.245, with a p-value of 0.62. In conclusion, the estimated constant decreased when there were no sensitivity changes to VIX.

In sum, Arbitrage did not rise after the macroprudential measures. Therefore, although the macroprudential measures increased the cost of USD in the

Table 7: Estimation of Arbitrage equation with structural breaks in constant

	~2003.2.25	~2007.11.16	~2011.12.01	~2014,12,29	~2020.11.23
Const	-0.6123*** (0.1130)	-0.2376*** (0.06635)	0.7768*** (0.1010)	0.1829*** (0.06226)	-0.1838*** (0.06700)
TED	0.6097*** (0.06751)				
VIX	0.03002*** (0.003599)				
n	4947				
R2	0.8343				

Notes: Standard errors in parentheses *, **, *** means significant at the 10, 5, 1 percent level respectively.

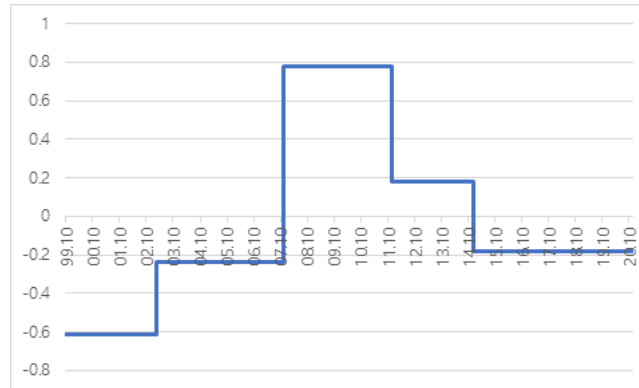


Figure 7: Estimated constants for Arbitrage equation

Table 8: Estimation of Arbitrage equation with structural breaks in constant and VIX

	~2003.3.4	~2007.11.9	~2009.12.16	~2014.12.9	~2020.11.23
const	0.09833	-0.5737***	0.5832***	-0.009138	0.1953***
	(0.1887)	(0.06156)	(0.1571)	(0.05998)	(0.04407)
TED	0.3378***				
	(0.06063)				
VIX	0.007115	0.05915***	0.05022***	0.05317***	0.01349***
	(0.006049)	(0.004094)	(0.005194)	(0.002987)	(0.002192)
n	4947				
R2	0.8643				

Korean financial market, they were not a significant factor in deciding interest arbitrage activity. In other words, the increased cost of USD funding of macroprudential measures did not show in the difference between cross-currency rate and KRW bond interest rates since investors did not exploit the interest rate arbitrages enough.

5. CONCLUSION

Korean monetary authorities employed macroprudential measures after the GFC. They are a cap on the forward-to-capital ratio, a temporary revival tax on foreign bond investors, and the macroprudential levy. They intend to avoid the considerable accumulation of foreign capital inflows, which causes a financial crisis when foreign investors stop investing in the Korean financial market.

Korean macroprudential measures enlengthened the maturity of foreign currency debts, according to Huh and An (2014). However, the total foreign debt in banks did not change with the macroprudential measures, but the maturity of foreign debts has gotten longer. This paper analyzes whether the macroprudential measures limit the supply of USD enough to change the price variables.

The macroprudential measures did not cause the depreciation of the Korean won compared with the previous period, and the Korean won's sensitivity to market volatility did not rise either. Although the cost of USD funding increased after the macroprudential measures, the F/X exchange rates did not seem to react. Korean monetary authorities introduced the macroprudential measure when capital inflows resumed after the GFC. Because the increased cost of USD funding did not stop the capital inflow trend, only slowing it, the Korean won did not

depreciate.

The interest rate arbitrage opportunity did not increase after implementing macroprudential measures. As Ryu and Park (2008) indicated, the interest arbitrage investor is concerned with credit and liquidity risks also. So, the investor does not explore the interest arbitrage opportunity fully measured by the interest differentials. Because the investors have not fully explored the interest rate arbitrage opportunity, the increased USD funding cost of macroprudential measures did not show up as the increased gap between the Korean won bond interest rate and cross-currency rate.

These results showed that macroprudential measures did not help the exporting of Korea. The macroprudential measure of Korea limit or increase the cost of foreign currency funding of banks. Ahnert *et al.* (2019) said that the restriction on banks' foreign currency liability increased the foreign currency liability in other firms. These analyses did not answer whether the macroprudential measures affected the other firm's liability in Korea. Andreasen *et al.* (2019) and Andreasen *et al.* (2021) showed that the Chilean regulations benefited the exporting companies. These analyses showed that there is no significant depreciation of KRW after macroprudential measures. So, the macroprudential measures in Korea are not likely to benefit the exporting companies.

REFERENCES

- Adrian, T., C. Erceg, J. Lindé, P. Zabczyk, and J. Zhou (2020). “A Quantitative Model for the Integrated Policy Framework,” *IMF Working paper*, 122.
- Agosin, M. R., J.D. Díaz, and M. Karnani (2019). “Sudden Stops of Capital Flows: Do Foreign Assets Behave Differently from Foreign Liabilities?,” *Journal of International Money and Finance*, 96, 28–36.
- Ahnert, T., K. Forbes, C. Friedrich, and D. Reinhardt (2019). “Macroprudential F.X. Regulations: Shifting the Snowbanks of F.X. Vulnerability?,” *Journal of Financial Economics*, 140, 145–174.
- Aizenman, J., and G.K. Pasricha (2013). “Why Do Emerging Markets Liberalize Capital Outflow Controls? Fiscal versus Net Capital Flow Concerns,” *Journal of International Money and Finance*, 39, 28–64.
- Aizenman, J., M.D. Chinn, and H. Ito (2016). “Monetary Policy Spillovers and the Trilemma in the New Normal: Periphery Country Sensitivity to Core Country Conditions,” *Journal of International Money and Finance*, 68, 298–330.
- Alfaro, L., A. Chari, and F. Kanczuk (2017). “The Real Effects of Capital Controls: Firm-level Evidence from a Policy Experiment,” *Journal of International Economics*, 108, 191–210.
- Andreasen, E., S. Bauducco, and E. Dardati (2019). “Capital Controls and Firm Performance,” *Working Papers Central Bank of Chile*, 852.
- Andreasen, E., S. Bauducco, and E. Dardati (2021). “Beware the Side Effects: Capital Controls Cause Misallocation and Reduce Welfare,” *NBER SI 2021 International Finance & Macroeconomics*.
- Bai, C.E. and S.J. Wei (2001). “The Quality of Bureaucracy and Capital Account Policies,” *World Bank Publications 2001*.
- Bai, J. and P. Perron (1998). “Estimation and Testing Linear Models with Multiple Structural Changes,” *Econometrica*, 66(1), 47–78.
- Banerjee, R., M.B. Devereux, and G. Lombardo (2015). “Self-oriented Monetary Policy, Global Financial Markets and Excess Volatility of International Capital Flows,” *NBER working paper*, 21737.

- Bank of Korea (2020). "Increase the Cap on the Banks Forward Position," Bank of Korea.
- Basu, S., E. Boz, G. Gopinath, F. Roch, and F. Unsal (2020). "A Conceptual Model for the Integrated Policy Framework," *IMF Working paper*, 121.
- Bau, N. and A. Matray (2022). "Misallocation and Capital Market Integration : Evidence from India," *NBER Working Paper*, 27955.
- Bianchi, J., and E.G. Mendoza (2020). "A Fisherian Approach to Financial Crises: Lessons from the Sudden Stops Literature," *Review of Economic Dynamics*, 37, 254–283.
- Bleck, A., and X. Liu (2018). "Credit Expansion and Credit Misallocation," *Journal of Monetary Economics*, 94, 27–40.
- Brandao-Marques, L., G. Gelos, M. Narita, and E. Nier (2020). "Leaning Against the Wind: A Cost-Benefit Analysis for an Integrated Policy Framework," *IMF Working paper*, 123.
- Broner, F., and J. Ventura (2016). "Rethinking the Effects of Financial Globalization," *The Quarterly Journal of Economics*, 131(3), 1497–1542.
- Caballero, J.A. (2016). "Do Surges in International Capital Inflows Influence the Likelihood of Banking Crises?," *The Economic Journal*, 126, 281–316.
- Caballero, R.J., and G. Lorenzoni (2016). "Persistent Appreciations and Overshooting: A Normative Analysis," *IMF Economic Review*, 62(1), 1–47.
- Caballero, R.J., and A. Krishnamurthy (2003). "Excessive Dollar Debt: Financial Development and Underinsurance," *Journal of Finance*, 58(2), 867–893.
- Chanda, A. (2005). "The Influence of Capital Controls on Long Run Growth: Where and How Much?," *Journal of Development Economics*, 77, 441–466.
- Choi, W.J. and A.M. Taylor (2017). "Precaution Versus Mercantilism: Reserve Accumulation, Capital Controls, and the Real Exchange Rate," *NBER Working Paper*, 23341.
- Converse, N. (2018). "Uncertainty, Capital Flows, and Maturity Mismatch," *Journal of International Money and Finance*, 88, 260–275.

- Fendoglu, S. (2017). “Credit Cycles and Capital Flows: Effectiveness of the Macprudential Policy Framework in Emerging Market Economies,” *Journal of Banking and Finance*, 79, 110–128.
- Forbes, K.J. (2007). “One Cost of the Chilean Capital Controls: Increased Financial Constraints for Smaller Traded Firms,” *Journal of International Economics*, 71(2), 294–323.
- Forbes, K.J., M. Fratzscher, T. Kostka, and R. Straub (2016). “Bubble Thy Neighbour: Portfolio Effects and Externalities from capital controls,” *Journal of International Economics*, 99, 85–104.
- Ghosh, A.R., J.D. Ostry, and M.S. Qureshi (2016). “When Do Capital Inflow Surges End in Tears?,” *American Economic Review*, 106(5), 581–85.
- Gochoco-Bautista, M. S., J. Jongwanich, and J.W. Lee (2012). “How Effective Are Capital Controls in Asia?,” *Asian Economic Papers*, 11(2), 122–143.
- Goel, R., and K. Miyajima (2021). “Analyzing Capital Flow Drivers Using the At-Risk Framework: South Africa’s Case,” *IMF Working Paper*, 253.
- Gurnain, K.P. and E. Nier (2022). “Review of The Institutional View on The Liberalization and Management of Capital Flows — Background Note on Capital Flows and Capital Flow Management Measures — Benefits and Costs,” *IMF Policy Paper*, 9.
- Huh, I. and J. An (2014). “An Empirical Evaluation of Macro-Prudential Measures in Korea: Focusing on Debt Inflows,” *Asian Economic Papers*, 13(2), 68–85.
- Islamaj, E., and M.A. Kose (2016). “How Does the Sensitivity of Consumption to Income Vary over Time? International Evidence,” *Journal of Economic Dynamics and Control*, 72(C), 169–179.
- Jung, Y. (2023). “Capital Controls and Price Stability in a Small Open Economy with Habit Persistence,” *Journal of Economic Theory and Econometrics*, 34(2), 1–50.
- Li, X. and S., Dan (2022). “Total Factor Productivity Growth at the Firm-Level: The Effects of Capital Account Liberalization,” *Journal of International Economics*, 139, 103676.

- Maggiore, M. (2017). “Financial Intermediation, International Risk Sharing, and Reserve Currencies,” *American Economic Review*, 107(10), 3038–3071.
- Magud, N.E. and E.R. Vesperoni (2015). “Exchange Rate Flexibility and Credit during Capital Inflow Reversals: Purgatory . . . Not Paradise,” *Journal of International Money and Finance*, 55(C), 88–110.
- Merrouche, O., and E. Nier (2017). “Capital Inflows, Monetary policy, and Financial Imbalances,” *Journal of International Money and Finance*, 77, 117–142.
- Mian, A., A. Sufi, and E. Verner (2017). “Household Debt and Business Cycles Worldwide,” *The Quarterly Journal of Economics*, 132(4), 1755–1817.
- Montecino, J.A. (2018). “Capital Controls and the Real Exchange Rate: Do Controls Promote Disequilibria?,” *Journal of International Economics*, 114, 80–95.
- Morais, B., J.-L. Peydró, J. Roldán-Peña and C. Ruiz-Ortega (2019). “The International Bank Lending Channel of Monetary Policy Rates and QE: Credit Supply, Reach-for-Yield, and Real Effects,” *The Journal of Finance*, 74, 55–90.
- Nier, E.W., T.T. Olafsson, and Y.G. Rollinson (2020). “Exchange Rates and Domestic Credit—Can Macroprudential Policy Reduce the Link?,” *IMF Working Paper*, 187.
- Pasricha, G.K. (2020). “Estimated Policy Rules for Capital Controls,” *IMF Working Paper*, 80.
- Rangvid, J., P. Santa-Clara, and M. Schmeling (2016). “Capital Market Integration and Consumption Risk Sharing over the Long Run,” *Journal of International Economics*, 103, 27–43.
- Reinhardt, D., L.A. Ricci, and T. Tressel (2013). “International Capital Flows and Development: Financial Openness Matters,” *Journal of International Economics*, 91, 235–251.
- Reinhart, C.M., and M.B. Sbrancia (2015). “The Liquidation of Government Debt,” *Economic Policy*, 30(82), 291–333.

Rey, H. (2013). “Dilemma not Trilemma: The Global Financial Cycle and Monetary Policy Independence,” *Proceedings - Economic Policy Symposium - Jackson Hole, Federal Reserve of Kansas City Economic Symposium*, 285–333.

Ryu, S.C. and J.J. Park (2008). “Analysis on the Efficiency and Stability of Korean Exchange and Swap Market,” *Survey Statistics Monthly Bulletin*, Bank of Korea.

Varela, L. (2018). “Reallocation, Competition, and Productivity: Evidence from a Financial Liberalization Episode,” *Review of Economic Studies*, 85, 1279–1313.

Yopez, J.F. (2021). “Unintended Consequences of U. S. Monetary Policy Shocks: Dutch Disease and Capital Flow Measures in Emerging Markets and Developing Economies,” *IMF Working Paper*, 209.