

The Monetary Stabilization Bond Spread as a Signal for Financial Crisis

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Abstract

This paper explores the potential signaling role of the Monetary Stabilization Bond (MSB) spread together with several financial variables in Korea. The MSB spread widened and became more volatile during the crisis period after the variance change point at the end of 2007. At that point, the causality relationships among the key variables became apparent. The results of the impulse responses and variance decompositions, as well as the Granger causality, illustrate that the foreign exchange rate shock is likely to have a significant impact on domestic markets in the case where the shock has a sizable negative impact on national foreign reserve holdings. However, since the information on foreign reserves is available on a monthly basis, the daily observable MSB spread is a timelier signal for a financial crisis. The empirical results show that the signaling role of the MSB spread comes from one of its primary functions, as a monetary policy instrument for foreign exchange reserve management.

Keywords: Monetary Stabilization Bond spread, signaling role, Granger causality test, foreign exchange reserves.

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1. Introduction

The Monetary Stabilization Bond (MSB) is a unique policy tool devised by the Korean government to control excess liquidity to manage export-driven economic growth. It is a fine-tuning instrument in the face of the impossible or unholy trinity.¹ MSBs were originally issued in 1961 by the Bank of Korea (BOK) as one of the major instruments in the central bank's open market operations, especially with respect to external factors that affect domestic liquidity. Typically, if there is a steady increase in market liquidity generated by current account surpluses or foreign capital inflows, the BOK issues MSBs to sterilize the excess liquidity. On the other hand, when there is a lack of liquidity as a result of current account deficits or capital outflows, the central bank increases the monetary supply in the economy by redeeming MSBs.

Given Korea's heavily export-driven economic structure and the significance of foreign investors in its financial markets, overseas factors such as current accounts or foreign capital flows, tend to drive fluctuations in market liquidity. Accordingly, MSBs represent an important foreign exchange policy tool, as well as an instrument of monetary policy. The use of MSBs as a foreign currency reserve management tool became critical after the 1997 Asian financial crisis. Since the end of the crisis, the Korean government has accumulated large amounts of foreign reserves by exchanging United States (U.S.) dollars from its current account surplus and foreign capital inflows into Korean won; the resulting excess liquidity is primarily absorbed through the issuance of MSBs. While the outstanding MSB balance was around 25 trillion Korean won prior to the Asian financial crisis, the amount continued to grow dramatically after 1998, reaching 166 trillion Korean won by the middle of 2009.

Since MSBs are issued on BOK credit, they bear a credit risk comparable to that of the Korean Treasury Bond (KTB), which is guaranteed by the Korean government. The new issuance of one-year KTBS has not occurred at all in Korea, so the yield on the 364-day MSB is often used as the on-the-run one-year benchmark rate. While the issuing institutions, procedures and market liquidity are not exactly identical between MSB and KTB, the value of the 364-day MSB is not expected to significantly differ from the value of the one-year KTB,² because MSBs and KTBS with the same maturity should bear comparable exposure to duration and credit risks. The yields on the two securities are reliably similar, at least until the third quarter of

¹ The impossible trinity implies that three ideal conditions, monetary independence, free capital flow and the freely floating exchange rate, cannot be achieved simultaneously.

² The rate on the one-year KTB is the average, excluding the maximum and minimum, of yields on KTBS with remaining maturity from ten months to one year, as reported by 15 reporting companies to the Korea Financial Investment Association.

2007, when the yield on the MSB began to rise significantly over that of the KTB. The spread between the two yields illustrated an unprecedented level of volatility beginning in the fourth quarter of 2007. These observations are especially interesting, since the timing of the MSB spread movement coincides with the global financial crisis. As the yield of the MSB increases, the yield on KTB should rise, as the two instruments are supposedly identical in credit risk. It is a puzzle that there is a significant widening of the MSB spread around the beginning of a period of financial turmoil. The widening MSB spread appears to be an abnormal movement, possibly related to market conditions.

A global financial crisis raises significant risk factors, such as diminishing export demand leading to trade account deficits or capital outflows triggered by a lack of risk appetite, for countries with small, open economies. Since such risk factors can result in a shortage of liquidity, the redemption of the MSB to provide liquidity would be expected from the viewpoint of standard open market operations. This paper investigates whether movement in the MSB spread includes information regarding the transmission of an overseas shock to the domestic financial markets. This paper is believed to be the first to rigorously analyze the transmission mechanism from external shocks to domestic credit markets.

Consistent with our conjecture, the econometric analysis using the Granger causality, variance decomposition, and impulse response function, supports the role of MSB as a uniquely important signal in the transmission of foreign shocks into the Korean domestic financial market. The MSB spread widened and became more volatile during the crisis period after the variance change point at the end of 2007. At that point, the causality relationships among the key variables became apparent. To control for the signaling function of other potential financial variables, we perform vector autoregressions (VARs). The results of the impulse responses and variance decompositions, as well as the Granger causality, demonstrate that the foreign exchange rate shock is likely to have a significant impact on domestic markets in the case where the shock has a sizable negative impact on the national foreign reserve holdings. In addition, we find that the impact of the short-term portfolio investment of the balance of payments becomes conspicuous on the foreign exchange (FX) rate and foreign reserves as we enter the crisis period, which, in turn, has a significant impact on the MSB spread. However, since the information on foreign reserves is available on a monthly basis, the daily observable MSB spread is a timelier signal for a financial crisis.

This paper proceeds as follows. Section 2 describes the observations that motivate the investigation of the patterns in the MSB spread's co-movement with the other financial variables. Section 3 considers a possible regime shift in terms of a change of variance in the MSB spread. This is the case, since a particular type of relationship may hold in one regime, such as a crisis period, but not in another regime, such as a non-crisis period. Section 4 applies

the Granger causality test (Granger, 1969; Sims, 1972) to the variables to statistically investigate the existence of lead and lag relationships and, accordingly, the potential order of signaling. This section also performs VARs by employing a set of macroeconomic variables to provide an economic rationale that underlies the signaling relationships. Section 5 concludes the paper.

2. Empirical Observation

Dooley and Hutchison (2009) pointed out that the transmission of the U.S. subprime crisis to emerging markets became apparent beginning in the fall of 2008, although emerging markets seemed to be somewhat insulated until the summer of 2008. With this time frame in mind, it is likely that the MSB spread begins its movement prior to the transmission of a crisis to emerging markets. Many financial variables tend to move closely with one another, especially when there is a significant credit event or economic shock. While it is common to observe simultaneous movements, the identification of a potential lead and lag relationship among a group of key financial market variables is useful, because leading variables perform, to a certain degree, as a signaling function for the lagging variables. Therefore, this relationship would help clarify the transmission mechanism by which a global financial crisis is spread to domestic financial markets. This paper investigates the transmission of outside economic shocks on Korean domestic fixed-income market sectors.

Figure 1 illustrates the historical movements of the MSB spread and other major variables of the Korean fixed-income markets during the sample period from March 4, 2002 to December 30, 2009, on a daily basis. The top left panel shows that the MSB spread, calculated by the yield difference between the 364-day MSB and the one-year KTB, is stable around zero, at least until the third quarter of 2007. At that point, the MSB spread begins to demonstrate a quite different pattern of movement, widening roughly by 10 basis points by the end of 2007, followed by a widening of as much as 60 basis points through the second half of 2008.

<Figure 1>

The other panels of Figure 1 illustrate the patterns of co-movement in the MSB spread with a group of variables that represent the Korean fixed-income markets. These variables include the one-day call rate, a target rate for the monetary policy; the yield on the three-year KTB, the benchmark government bond with the highest liquidity; and the credit spread, calculated by the yield difference between the three-year AA-minus-rated and BBB-minus-rated corporate bonds as credit market benchmarks. Also included are the Korean won to the U.S. dollar (won/dollar)

FX rate and the 5-year Korean sovereign credit default swap (CDS)³ spread denominated in U.S. dollars. These latter two measures are key indicators of the economic and financial status of the Korean financial market from a global perspective. The time-series data on the 364-day MSB yields, the three-year KTB yields, the one-day call rate, and the won/dollar FX rate are taken from the Economic Statistics System of the BOK. Yields on the one-year KTB, AA-minus-rated and BBB-minus-rated corporate bonds are from the Korea Financial Investment Association. The 5-year Korean sovereign CDS spread data are from Bloomberg.

While all of these variables are characterized by their own historical movements, the patterns of the co-movements among the variables are not distinguishable prior to the second half of 2007. For example, the one-day call rate, which is the monetary policy target, decreases until the first half of 2005, then begins to rise in the second half of the year as a result of the tight monetary policy related to the outlook for economic recovery and inflation. Simultaneously, the KTB yield moves in accordance with the target interest rate. The credit spread illustrates a strong upside movement in the first half of 2003, during the bankruptcy of the U.S. trading arm of the SK Group, one of the largest conglomerates in Korea, but returns to a decreasing trend until 2007. The value of the Korean won against the U.S. dollar continues to appreciate over this period. The sovereign spread stays at low and stable levels, except for a period in early 2003, consistent with the credit spread.

However, all variables begin to show quite large changes in their movements starting in the second half of 2007. The variables seem to have simultaneous co-movements, as well as lead-and-lag relationships. In particular, the starting point of these movement patterns appears to be matched with the starting point of the widening of the MSB spread. Following the widening MSB spread, increasing trends in the call rate and the KTB yield reverse to significant drops, and the credit spread, the FX rate, and the CDS spread all begin to rise dramatically. If the widening point coincides with the timing of the transmission of a foreign shock to domestic markets, and if a type of lead-and-lag relationship can be found in the process of transmission, then the order of lead and lag across market sectors may provide a clue to the transmission channel through which overseas shocks affect sectors of the domestic financial market.

In the following discussions, we will demonstrate that the widening of the MSB spread precedes movements in other domestic markets. We will also demonstrate that the MSB spread performs a signaling role in the transmission of external shocks to domestic financial markets.

3. Change of Variance Test

³ The five-year CDS is considered a benchmark. The CDS is the most actively traded, with the most completed data points. Those with other maturities are very closely correlated with the five-year spread.

The current research is motivated by the recent abnormal movement in the MSB spread and by the potential to verify the lead and lag, or signaling, relationships of the MSB spread with other major financial variables, such as the one-day call rate, the three-year KTB yield, the domestic credit spread benchmark, the won/dollar FX rate, and the five-year sovereign CDS spread. These variables may not be stationary in our sample, which would prevent appropriate econometric testing. Therefore, we first determine a stationary transformation for each variable. For the MSB spread, call rate, KTB yield, and credit and CDS spreads, we use the daily changes in their levels. For the won/dollar FX rate, we use the log difference to capture the daily return from the FX change. We apply the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979, 1981) to test both the level and the (log) difference for each variable by determining the autoregressive order of each series by the Akaike information criterion. Once the autoregressive order $rlag$ is determined for each series r_t , we perform the ADF test for the following regression

$$\Delta r_t = \alpha + \beta t + \gamma r_{t-1} + \delta_1 \Delta r_{t-1} + \dots + \delta_{rlag} \Delta r_{t-rlag} + \varepsilon_t, \quad (1)$$

with the test statistics calculated as

$$ADF = \frac{\hat{\gamma}}{se(\hat{\gamma})}, \quad (2)$$

where $se(\hat{\gamma})$ denotes the standard error of the estimated coefficients $\hat{\gamma}$. The results of the ADF tests, presented in Table 1, illustrate that the null hypothesis that the series has no unit root is rejected at the 5% significance level for all series. In addition, all transformed series with a (log) difference are rejected, suggesting that these transformed variables are all stationary.

<Table 1>

When we apply an econometric test to these transformed variables to verify the lead-lag relationships, we allow for the possibility that certain types of relationships may hold in one regime, such as a crisis period, but not in another, such as in a non-crisis or normal period. As is evident from the left panel of Figure 2, there seems to be a structural break in the volatility of the MSB spread's daily change approximately prior to and following the second half of 2007. Thus, it is reasonable to test whether a regime shift occurs in terms of the variance of the MSB spread and to investigate which type of relationship can be found for each regime. We apply the centered cumulative sums of squares (Brown et al., 1975; Inclán and Tiao, 1994) approach to detect the variance change point in the series.

<Figure 2>

Let $C_k = \sum_{t=1}^k r_t^2$ be the cumulative sum of squares in a series of uncorrelated random

variables $\{r_t\}$ with a mean zero and variance σ_t^2 , $t=1, \dots, T$. The centered cumulative sums of squares D_k can then be calculated by:

$$D_k = \frac{C_k}{C_T} - \frac{k}{T}, \quad k=1, \dots, T. \quad (3)$$

If there is homogeneous variance for the entire sample period, the plot of D_k against k will remain close to zero, while, if there is a significant change in the variance, the value of D_k will deviate from zero outside of some specified boundaries. With this property, we can detect a change point in the variance by $\max |D_k|$, since the D_k plot is likely to reach a peak at a point of variance change. Suppose k^* is the value of k at which $\max |D_k|$ is achieved. If the maximized value exceeds a pre-specified boundary, we may take k^* as an estimate of the variance change point.

While the average daily change in the MSB spread in the sample is not significantly different from zero, with the t -statistic value at 0.08, we nevertheless apply the demeaned series of the MSB spread to calculate D_k . The right panel of Figure 2 presents the plot of D_k against k with the demeaned MSB spread, which indicates that the $\max |D_k|$ was attained on December 24, 2007. Inclán and Tiao (1994) empirically estimated the asymptotic critical value of $\sqrt{T/2}D_k$ under variance homogeneity. While the critical value at the 1% significance level is 1.63, the maximized value of $\sqrt{T/2}D_k$ using the MSB spread is 16.82, far beyond the critical value. Therefore, it is reasonable to estimate the date of December 24, 2007 as the break point for the variance of the MSB spread, and divide the entire sample into the period preceding and the period following the break point. This is conducted to apply an econometric test that will verify lead-and-lag relationships among the variables for each period separately. The period preceding December 24, 2007 is called the “normal period” and the sample period thereafter is referred to as the “crisis period.”

Table 2 provides descriptive statistics for the financial variables under our consideration, such as the MSB spread, the one-day call rate, the three-year KTB yield, the domestic credit spread benchmark, the won/dollar FX rate, and the five-year sovereign CDS spread, in their stationary forms for the normal and crisis period. While the mean and the median for each variable are relatively stable across the normal and crisis periods, there seems to be a significant increase in the standard deviation. The standard deviation of the MSB spread increases by more than three times, and those of all other variables, except KTB, show increases of more than double. While there are a couple of cases to show increases, the correlation measures do not

seem to fully explain the observed patterns of co-movements among the variables, which suggests the possibility of lead and lag relationships.

<Table 2>

4. Empirical Results

4.1. Causality Test

In this section, we apply the Granger causality test (Granger, 1969; Sims, 1972) to investigate potential lead-and-lag relationships between the MSB spread and several important Korean financial market variables.⁴ The bivariate Granger causality test using the autoregressive specification with a lag length of p is performed using the following regressions

$$x_t = \alpha_1 + \sum_{l=1}^p \rho_{1l} x_{t-l} + \sum_{l=1}^p \beta_{1l} y_{t-l} + \varepsilon_{1t}, \quad (4)$$

$$y_t = \alpha_2 + \sum_{l=1}^p \rho_{2l} y_{t-l} + \sum_{l=1}^p \beta_{2l} x_{t-l} + \varepsilon_{2t}, \quad (5)$$

to perform an F – test under the null hypothesis

$$H_0 : \beta_{i1} = \dots = \beta_{ip} = 0, \quad (6)$$

for each variable $i = 1, 2$. To choose the lag length p , the autoregressive order of the lag for each variable is first determined by the Akaike information criterion, then p is determined to be the larger between the optimal lags of x and y . By this choice we provide a chance for each variable to be fully explained by its autoregressive structure and evaluate the marginal effect of the other. The results from the Granger causality test for each regime prior to and following the variance change point of the MSB spread are summarized in Table 3. The order of the lag chosen for each pair of variables in this table ranges from 9 to 12.

<Table 3>

The top panel indicates no evidence that the MSB spread Granger causes the other variables before the variance change point or the normal period. The null hypothesis that the MSB spread change does not Granger cause the other variables under consideration is not rejected at the 1% significance level. One possible explanation for this is that the MSB spread

⁴ As Hamilton (1994) pointed out, the Granger causality test should be interpreted carefully. When one Granger causes the other, it does not necessarily mean that one is a fundamental reason for the change in the other. It is better to interpret causality relationships such that one is helpful in forecasting the other via an observed lead-and-lag relationship.

does not illustrate enough movement to indicate any subsequent change in another variable. Among the variables, a feedback relationship, rather than a unidirectional causality, can be found between the daily FX return and the CDS spread change. A CDS is a derivative contract wherein a buyer makes periodic payments to a seller and receives a payoff if there is a credit event, such as a default, by the underlying financial instrument. The Korean sovereign CDS, a contract using the Foreign Exchange Stabilization Bond (FXSB) as the underlying instrument, is considered a measure of Korean sovereign default risk because the FXSB is issued under the authority of the Ministry of Strategy and Finance. If the CDS spread rises, it reflects the situation such that the sovereign default risk rises, or at least the global market perceives that the financial soundness of the Korean government has deteriorated. A rise in the CDS spread, accordingly, is directly related to the (un)covered interest arbitrage condition between the U.S. dollar and Korean won, requiring a higher interest premium on the Korean won bond and, as a result, the Korean won depreciates.

However, the causality tests applied to the periods following the variance change point illustrate quite different results from those prior to the change period. The pairwise combination of the MSB spread with any other variable shows a particular type of causality relationship. The null hypotheses that the MSB spread change does not Granger cause the daily changes of the one-day call rate, the three-year KTB yield, and the credit spread are all rejected at the 1% significance level. It is also determined that the call rate and the KTB yield Granger cause the credit spread. This finding indicates that, once there is a signal from a sudden widening of the MSB spread, there will first be an impact on the call and Treasury markets, followed by an impact on the domestic credit and corporate sectors with longer lags.

The direction of causality reverses for the MSB spread with the FX return and the sovereign CDS spread tests. Daily changes in both the won/dollar FX rate and the Korean CDS spread were found to Granger cause changes in the MSB spread at the 1% significance level, while the null hypotheses that the MSB spread does not Granger cause the FX return and the CDS spread are not rejected. At the same time, changes in the FX rate and the CDS spread continue to demonstrate a strong mutual feedback effect after the variance change point.

4.2. Interpretation of Granger Causality

How can we interpret these causality relationships, especially during the crisis period of high variance in the MSB spread? During the period of volatile MSB spread, changes in the CDS spread and the won/dollar FX rate were found to Granger cause changes in the MSB spread. In turn, this Granger causes changes in the domestic interest rates, such as the call rate, the KTB yield, and the credit spread. It is widely known that the recent global financial crisis was triggered in the U.S. subprime sector prior to spreading worldwide because of the

connectedness and interdependence of the international financial markets. The empirical results of this paper suggest a characteristic pattern of transmission of overseas financial shocks to domestic markets.

When an enhanced risk in a foreign financial market emerges, the first channels through which the shock is recognized are naturally the sovereign credit and foreign exchange markets, both directly influenced by foreign participation. As the shock spreads, increased risk and the corresponding risk aversion worldwide creates challenges for countries with export-driven economic structures and financial systems that are highly open to foreign investors. These challenges are transmitted through such channels as worsening balance of payments, currency depreciation, and increased pressure to manage foreign debt. As the shock from the foreign markets is transmitted to the domestic financial sectors, the domestic market response is likely to begin in the liquid money and bond market sectors, such as the call and KTB markets. These markets serve as indicators for domestic funding and interest rates, leading to a response of a less liquid credit market in the form of an increased default risk. The widening MSB spread, as the first and most important policy reactions and responses to foreign shocks, serves as a signaling role in the transmission of shocks from foreign sectors to those of domestic sectors, indicating that an overseas financial shock will impact the domestic money and bond markets in the near future.

A comparison of causality results prior to, and during, the crisis periods, is presented in Table 3. Table 3 also illustrates why the MSB spread holds importance as a signal. The MSB spread, as a key signal, should indicate whether an overseas shock will have a significant impact on the domestic markets. This conjecture is confirmed by an empirical analysis. While the CDS spread and the FX return are likely to precede the MSB spread in recognizing the shock, the responses of the CDS spread and the FX return are observed not only during, but also prior to, the crisis period, which means that the feedback relationship between the CDS spread and the FX return can be observed even when there is no overseas shock transmitted to the domestic markets. However, the crisis period is distinguished by significant causality relationships from the CDS spread and the FX return to the MSB spread, with subsequent impacts on domestic interest rates and credit spreads. Accordingly, the MSB spread can be regarded as a signal of impending crisis, indicating that particular shocks occurring in foreign markets are likely to be transmitted to domestic markets with significant impacts only when the CDS spread and FX return Grange cause the MSB spread.

4.3. Vector Autoregressions

What underlies the role of the MSB spread as a signaling instrument of overseas shocks to domestic markets? Why does the MSB spread increase correspond to a specific shock that

indicates the transmission of such a shock to the domestic money and bond markets? To answer these questions, it is necessary to again consider the primary functions of the MSB. In principle, the MSB is usually issued to control excess liquidity. In reality, especially since the Asian financial crisis of 1997, liquidity control via the MSB has been directly connected with the governmental management of foreign exchange reserves. The Korean government accumulates U.S. dollar reserves by exchanging Korean won for U.S. dollars. The central bank then issues MSBs to absorb the excess domestic liquidity generated in this dollar-accumulation process. Accordingly, an overseas shock is expected to increase the MSB spread if the shock has a direct impact on foreign reserves, since the shock is expected to trigger additional efforts by the government to accumulate more dollars in exchange for domestic currency, which leads to an excess supply of the MSB.

The literature has indicated that the role of the MSB is tightly related to the macroeconomic function of the monetary authority. Therefore, in this section, we perform VARs (Sims, 1980) with the MSB spread, the foreign exchange reserves (FXV), and other variables that may potentially affect the status of foreign reserves or the issuance of MSBs. The VARs are conducted to pursue a more economic interpretation about the signal that the MSB is likely to deliver. Those variables include two major components of the capital account in the balance of payments, the foreign direct investment (FDI) to represent a long-term capital investment and the portfolio investment (PI) as a short-term investment calculated as the sum of securities and derivatives investment. We include changes in the won/dollar FX rate (FXR) again in this VAR, because the amount of foreign reserves can be purely be modified by the change in the FX rate. The monetary supply M2 is also included to determine whether the MSB spread moves in response to the domestic monetary supply.

While the bond price and FX data are available daily, data on the foreign reserves and capital accounts are only available monthly from the Economic Statistics System of the BOK. To utilize all data, the VAR estimations are performed in a monthly frequency. We divided the full sample periods, from March 2002 to December 2009, into two subsamples, with the latter subsample beginning in January 2007. With the variance change point of the MSB spread estimated as the end of 2007 by the daily series, we include full three-year's recent periods for the later subsample and investigate whether we can determine any fundamental reason to explain the movements of the MSB spread distinguished from those of the earlier sample. We apply a one-month lag as the order of the lags in the VARs. This order is determined as the lesser of the lengths by the Akaike information criterion and the Schwarz information criterion (Chordia et al., 2005). We present the results of the pairwise Granger causality tests among the six variables FDI, PI, FXR, FXV, M2, and MSB in Table 4.

<Table 4>

First, we find evidence of a strong unidirectional relationship, i.e., FXV Granger causes MSB at the 5% significance level in the crisis period, while a bidirectional relationship between FXV and MSB is observed at the 10% significance level in the normal period. These results confirm that the movement of the MSB spread is closely related to the foreign exchange reserves. In particular, the sudden increase in the MSB spread observed in recent years is strongly affected by the slowdown of the growth of foreign reserve holdings observed since the fourth quarter of 2007, as can be seen in the top panels of Figure 3.

The strong causality relationship from FXV to MSB is consistent with the post-sterilization function of the MSBs, such that the bonds are used to absorb liquidity after the Korean government attempts to purchase the U.S. dollar and sell the Korean won to maintain foreign reserves, especially after a sizable negative shock. MSB spread movements are expected to be followed by near-term responses from domestic market sectors. The post-sterilization function of the MSB can also be explained by the relationship between foreign reserves and the change in the outstanding balance of the MSB, equivalent to the net issuance (total issuance minus the amount of redemption). While the result is not presented here, it is shown that foreign reserves strongly Granger cause the outstanding balance of the MSB. This implies that the relative amount of both the issuance and redemption is adjusted following changes in the foreign reserves. This causality relationship, however, is observed both in the earlier and in the recent samples, implying that while the amount of outstanding balance has been adjusted for the purpose of subsequent liquidity control during the overall periods, the MSB spread, as the market price relative to the KTB, moves more significantly responding to the negative shock in the foreign reserves in the crisis period.

Second, whereas FXR and FXV do not show any visible relationship from the earlier sample period, these two variables show a significant bidirectional relationship at the 10% level during the recent three years. The bottom panels of Figure 3 show that the Korean won starts to show a depreciating trend around the fourth quarter of 2007, which matches the timing of the slowdown of the foreign reserve accumulation.

Third, the role of FDI is significant in the earlier period in the sense that it Granger causes MSB and becomes insignificant in the recent sample. On the other hand, while the role of PI is insignificant in the earlier sample, it becomes significant to Granger cause FXV and to have a feedback relationship with FXR during the crisis period. If we again think of the foreign direct investment and the portfolio investment as long-term and short-term capital investments, then the results indicate that, while the impact of the short-term investment is not clearly seen during the normal period prior to the current financial crisis, it becomes conspicuous on the FX rate and foreign reserves as we enter the crisis period. This, in turn, has a significant impact on the MSB spread.

<Figure 3>

To further investigate the dynamic relationships among the variables, we also compute the impulse response functions and variance decompositions by considering a VAR with four variables considered to be closely linked during the crisis period: PI, FXR, FXV, and MSB. As the results of the impulse responses and variance decompositions are sensitive to the ordering of the variables, we choose the ordering by combining the results of the Granger causality with the economic interpretation. Based on the post-sterilization function of the MSB, as well as the results of the causality, we put FXV before MSB. In addition, as PI has been demonstrated to Granger cause FXV, PI takes priority to FXV. Foreign reserves are considered to be controlled by the monetary policy, which is again responding to situations of capital flow. Therefore, this ordering seems to be reasonable. While PI and FXR illustrate bidirectional causality to each other, we notice that PI seems to cause FXR more strongly at the 5% level and that FXR demonstrates a feedback effect with FXV, which is strongly caused by PI. Hence, we put PI before FXR.⁵

The ordering between FXR and FXV is not clear in the sense that both directions can provide good economic interpretation, even though FXV Granger causes FXR more strongly at the 5% level. Depreciation of the domestic currency leads to a larger pressure of dollar-denominated foreign debt and inflationary pressure from the imported goods, so the monetary authority tries to bolster the currency value by providing dollars to the currency markets out of the reserve holdings under the managed floating system. This leads FXV to decrease. On the other hand, once there occurs a negative shock on the foreign reserves, the authority begins to purchase dollars from the market with the intention of maintaining reserves at the exchange of domestic monetary supply. This is likely to trigger the depreciation of the domestic currency and the policy action to increase the issuance of MSB for the purpose of sterilization.

Accordingly, we consider both the PI-FXR-FXV-MSB and PI-FXV-FXR-MSB orderings. We report the results of the impulse responses and variance decompositions from the VAR estimations considering these two cases. Figure 4 presents the impulse responses of the FXV and MSB in response to innovations of PI, FXR, FXV, and MSB (from left to right) for a ten-month period, estimated from the recent sample of the crisis period. When FXR is set prior to FXV, it is observed that FXV drops by 1.5% and MSB widens by about 24 basis points in response to one standard deviation innovations of FXR. The innovation of FXR by one standard deviation means that the Korean won suddenly becomes depreciated, which is followed by an outflow from the foreign exchange reserves. It can be also noticed that MSB illustrates a

⁵ The results, including the relationships between FXR and FXV, or the impacts of FXR and FXV, turned out to be robust in relation to the ordering between PI and FXR.

tightening response by 22 basis points to an innovation of FXV, indicating that a negative shock to foreign reserves will be followed by the MSB spread widening. If we look at the case of FXV prior to FXR, the impact of FXR to FXV becomes insignificant by the ordering, i.e., FXR shows a depreciating response by about 3% (the plot not included in Figure 4), and an innovation to FXV is the primary source to make a significant impact on MSB.

<Figure 4>

Table 5 reports the results of the forecast error variance decompositions for both of the earlier and recent sample periods with the forecasting horizons of five months, where the results of the decompositions are stabilized from the fifth months on. We observe several differences in the decomposition results between, prior to, and during the crisis period. First, PI can explain 17% of the error variance in forecasting FXR for the five-month forecasting horizon in the crisis period, compared with 1.5% before the crisis. Second, with the ordering of FXR prior to FXV, the fractions of the FXV and MSB forecasting error variances explained by the FXR innovation, as well as the contribution of FXV to explain the error variance of MSB, show quite different and sizable magnitude in the crisis period in comparison with those from the earlier period. Almost 50% of the FXV five-month forecasting error variance can be explained by FXR. Then, by combining the contributions of FXR and FXV variances, over a quarter of the MSB variance can be explained for the crisis period. These contributions of FXR and FXV are reversed by setting the order of FXV before FXR. While the fraction of FXR becomes very small in explaining the variances of FXV and MSB, even in the crisis period, the contribution of FXV jumps up to over one third of the FXR variance. This explains over 25% of the MSB variance alone.

<Table 5>

4.4. Interpretations of the Vector Autoregressions

The empirical analyses, with respect to the widening of the MSB spread, lead to an interesting point regarding the source of risk incorporated in the valuation of the MSB, especially in comparison with the standard Treasury bonds with the same remaining maturities. The 364-day MSB is comparable to the one-year KTB in terms of the major risk exposures, such as duration and credit risk, because the maturities are the same and there is no systematic difference in the credit risk of their issuers, the government and the central bank. However, there is an important difference in their source of risk. More specifically, the foreign exchange and foreign reserve risk is related to the primary functions of the instruments. While the KTB is a regular type of Treasury bond used to manage government debt, the MSB carries the special policy purpose of controlling the amount of liquidity arising from U.S. dollar holdings, especially in the process of managing foreign reserve holdings.

In normal times, there is no imminent concern about the maintenance of foreign reserves. Consequently, the MSB tends to follow a regular issuance procedure and is valued based on the standard risk exposures of regular government bonds. However, in a period such as the global financial crisis, as pressures on foreign debt or foreign currency funding become significant, the risk regarding the foreign reserve management policy begins to be strongly incorporated into the market valuation of the MSB. As such, the price begins to significantly diverge from that of the KTB with comparable maturity. Hence, even if the MSB is a class of security that is newly issued with a specific fixed maturity and is expected to be a monetary policy tool in liquidity management, this specific type of risk arising from the institutional mechanism that the MSB behaves more responsively than the KTB because of its policy purpose causes the MSB spread to widen substantially.

Because of the timing of the availability of information on foreign currency reserves, the MSB spread is a timelier market signal for a financial crisis. If a shock on foreign reserves is considered the source of risk to affect the MSB spread followed by domestic financial sectors, then the change in foreign reserves itself could deliver a market signal, since foreign reserves cause the MSB spread. However, the level of foreign reserves is announced monthly by the BOK, in accordance with the Special Data Dissemination Standards of the International Monetary Fund. The timing is typically some date early in the following month. As a result, information on the status of foreign reserves for the current month becomes publicly available with a time lag. On the contrary, the MSB spread is a market variable observable with, at most, a one-day lag, so a signal on the impact of a shock on the reserve management at any particular point can be delivered in more timely manner to the public before the foreign reserves data are available. In this sense, the MSB spread can be considered a proper market signal in the transmission of a financial crisis to domestic sectors.

Some of the results appear to suggest that the foreign exchange rate could be a good signal in that it responds to an overseas shock prior to the MSB spread. It is true that the FX market is very sensitive to information from the international capital market and moves very responsively to it. However, our focus is on the detection of the transmission of overseas shocks to domestic markets. Hence, certain types of shocks can be digested within the capacity of the FX market without any significant impact on domestic markets. The shock is likely to be seriously transmitted into domestic markets in the case where the shock is big enough to have a sizable negative impact on the national foreign reserve holdings. In this case, the MSB spread works as a signal by demonstrating the extraordinary widening movement corresponding to it. Also, the results show that the changes of foreign reserves consistently have an impact on, or a contribution to, the change in the MSB spread movement while the foreign exchange reserves in some cases do not. The consistent and reasonable interpretation of previous results supports the

hypothesis that the MSB spread is a good signal for a financial crisis.

4.5. Discussion of the Empirical Results

The widening spread between the MSB and KTB during the crisis and the results that the exchange rate and foreign currency reserves are significant factors in explaining the spread indicate that: 1) MSB is an effective tool in providing and absorbing liquidity originated from short-term foreign capital flows, and 2) MSB is a better signal for domestic interest rate and credit markets. The empirical results give us a clue as to how and why there is a widening spread between the MSB and KTB during crisis periods. It can be explained by the distinct nature of the MSB as a policy tool to manage the economy-wide liquidity, and the differences of maturity structure and asset liquidity in the MSB and KTB market, when the source of the liquidity change is the change in foreign currency reserves.

KTBs are issued based on the Government Bond Law. They are issued in tenors of 3, 5, and 10 years. The BOK issues MSBs within the maximum issuance limit set at 50% of M2. MSBs are issued either as discount bonds up to 1.5 years or as 2-year coupon bonds (quarterly). Traditionally, the central bank used MSBs to absorb excess liquidity generated by current account surpluses. There are several possibilities that the spread of the MSB and KTB for the same 365-day maturity can be different. First, MSBs are short-term bonds, while KTBs are medium and long-term bonds. The market liquidity is different between these two markets, and investors would rely on the primary new-issue market, since the secondary market for government bonds is not as liquid as it is for other financial assets. While the averages of the monthly total transactions for the overall KTB and MSB markets in our sample are 116 trillion vs. 74 trillion Korean won, respectively, those of the securities with remaining maturities from 9 months to 1 year are 0.8 trillion (KTB) and 7.8 trillion (MSB). Consequently, the transaction amounts of MSBs with these specific maturities account for over 10% of total transactions, while those of KTBs with similar-maturities only take less than 1%.⁶

Second, it is likely that two markets would have their own clientele for liquidity and term-structure considerations. For example, the transaction data also illustrate that foreign investors made total transactions in the KTB and MSB markets with similar amounts of approximately 2.3 trillion Korean won, on average. However, the average ratios of their transactions for securities with maturities from 9 months to 1 year out of the total transactions were almost 19% for the MSB against 2.5% for the KTB. This may indicate that, in the case where there occurs a difficulty in foreign funding triggered by an overseas shock, subsequent responses of foreign investors in the form of shrinking demand are likely to have bigger impact

⁶ The transaction data are from the CHECK expert, a financial information terminal maintained by Koscom, established in 1977 by the Ministry of Finance and the Korean Stock Exchange.

on the MSB than on the KTB markets with similar short-term maturities.

Third, the supply, i.e., government auction for KTB, is planned and scheduled up to one-year in advance. The auction of MSB is temporary and intermittent. BOK uses MSB as a policy tool in controlling excess foreign currency reserves. Its auction is likely to be cleared at the lower price, especially when there is a sudden surge of foreign currency reserves in a crisis. During the 1997 Asian financial crisis, BOK stepped up the issuance of MSBs to absorb liquidity because of the surging foreign exchange reserves. The amount of MSB issuance increased from 0.4 trillion in August 1997 to 60 trillion in June 1998. Fourteen-day MSBs were frequently used at that time.

Financial statistics demonstrate that at the start of the crisis period, net short-term foreign credit began to decline drastically. Quarterly data of Korean external debt/assets from the BOK illustrate that the size of the overall net short-term assets was 126 billion dollars at the third quarter of 2008, compared to 177 billion dollars at the third quarter of 2007, with a decrease of about 30% during a year. Furthermore, banking institutions, in particular, foreign banking institutions, are a major source of the decline in short-term capital. Between the third quarter of 2007 and the same quarter of 2008, net short-term foreign assets of banking institutions diminished by 25 billion dollars, explaining 50% of the overall decreases. Foreign banking institutions took 22 billion dollars out of it.

Interestingly, long-term credit held by banking institutions and foreign banks did not change noticeably. During the one-year period, net long-term foreign assets held by the banking institutions diminished by 3 billion dollars, and those of foreign banking institutions increased by about 2 billion dollars. The same trend is observable during the 1997 Asian crisis period. Between the third quarters of 1996 and 1997, the overall net short-term foreign assets decreased from 11.5 billion to 4 billion dollars, approximately 60%. In addition, the size of the diminishment of net short-term foreign assets explained by foreign banking institutions was over 4 billion dollars, over 50% of the overall decrease during those periods. Our empirical analysis illustrates that MSBs are an effective tool in foreign currency reserve management. In the face of the impossible trinity in obtaining monetary independence, free capital flows and fixed exchange rates, simultaneously, policy makers will compromise an autonomous monetary policy and free capital flow to preserve the managed or fixed exchange rate, or any excess reserve arising from free capital flows that has to be sterilized. In Korea, MSBs are used as a targeted tool to neutralize a shock from free capital flows. To the extent that MSBs can be used as a standalone tool, and that foreign shocks are limited to short-term capital flows, economic policy makers would have a certain degree of freedom from the impossible trinity.

5. Conclusion

This paper is motivated by the recent abnormal movement of the MSB spread over the KTB and its pattern of co-movements with a group of financial variables. These variables are the key elements in better understanding Korean fixed-income markets. Since the restructuring of the Korean financial systems following the 1997 Asian financial crisis, the one-year MSB spread has been stable at approximately zero, because the two constituent bonds share identical terms and credit risks under the authorities of the Korean government (KTB) and the central bank (MSB).

The MSB spread began to demonstrate an unprecedented widening at the end of 2007, when the global financial crisis triggered by the U.S. subprime mortgage sector materialized and spread worldwide. Through these periods of financial turmoil, several financial market variables had lead-and-lag relationships with the widening MSB spread. To investigate the sudden widening of the spread for the seemingly identical bonds, we conducted an econometric analysis of potential causality or signaling relationships, in an effort to provide information regarding a signaling channel from one market to another when an overseas shock is transmitted to domestic markets.

We divide the sample period into normal and crisis periods, beginning with the fourth quarter of 2007. We find no causality relationship between the MSB spread and the other variables under consideration before the estimated date of the variance change. We also find that the MSB spread remains stable and close to zero during these periods. However, as the MSB spread widens and becomes more volatile after the variance change point, causality relationships among key variables become apparent. The daily changes in the Korean won to the U.S. dollar exchange rate and the Korean sovereign CDS spread Granger cause daily changes in the MSB spread. The MSB spread in turn Granger causes daily changes in the domestic interest rate variables, such as the one-day call rate, the three-year KTB yield, and the credit spread. In addition, the call rate and the KTB yield are shown to Granger cause the credit spread. These findings imply that the MSB spread signals the transmission of an external shock to the domestic financial markets with economy-wide implications. The more liquid sectors, such as the money markets and government-bond markets, are first affected by the shock, followed closely by the less liquid sectors.

Considering the role of the MSB, tightly related to the macroeconomic function of the monetary authority, we perform VARs with the MSB spread, the foreign exchange reserves and the other variables. These variables potentially affect the status of foreign reserves or the issuance of MSBs, such as foreign direct investment and portfolio investment from the capital account, domestic monetary supply, and the won/dollar FX rate. By looking at the results of the impulse responses and variance decompositions, as well as the Granger causality, we can

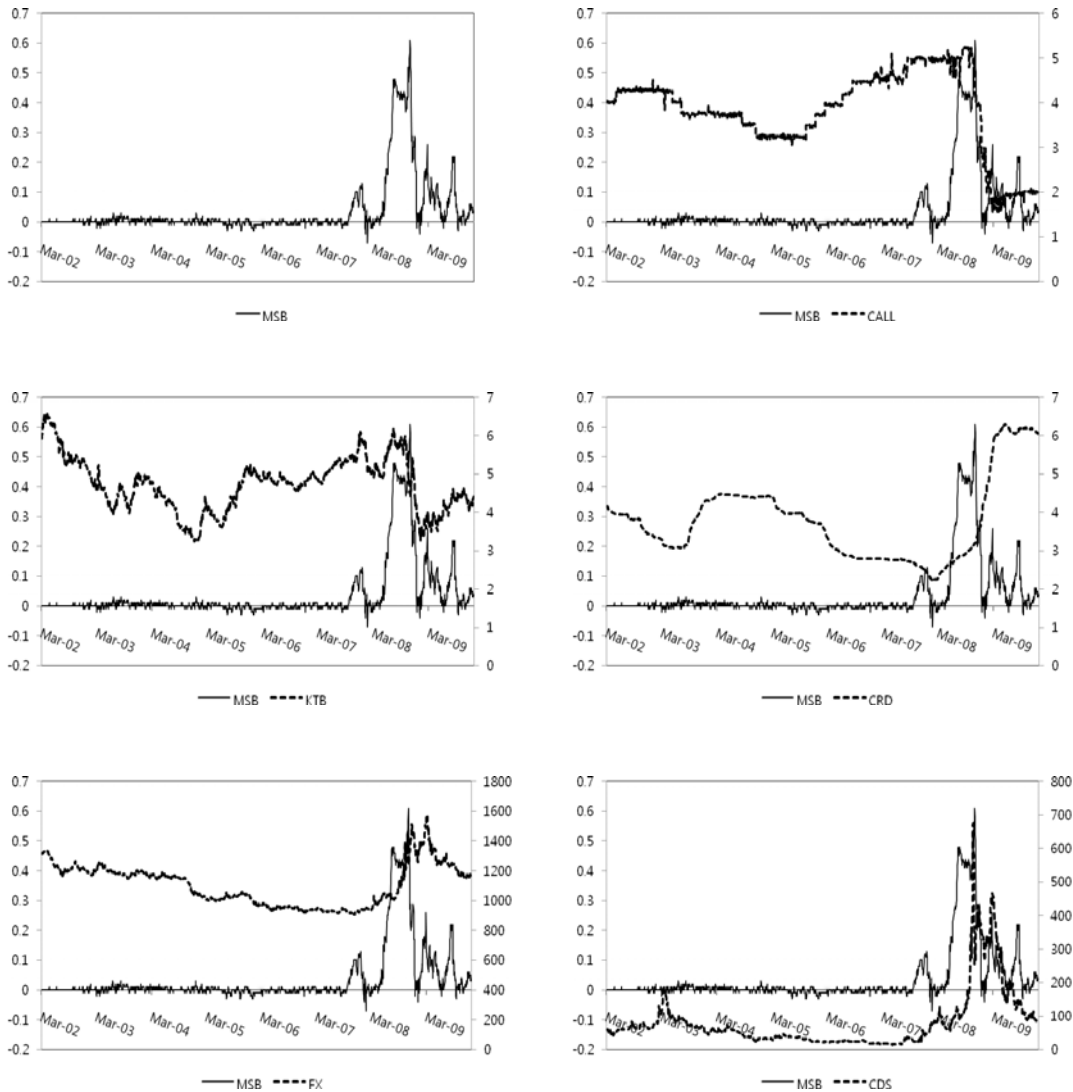
provide an economic interpretation for why the MSB spread plays a role in the transmission of overseas shocks to the domestic market.

It is demonstrated that the portfolio investment, as short-term international investment, as well as the foreign exchange rate, have certain impacts on foreign reserves. The foreign reserves were found to strongly Granger cause the MSB spread and explain a significant fraction of forecasting error volatility, especially during the crisis period. The negative impact on foreign reserves is a major risk in terms of the government's ability to meet short-term foreign debt payments, with respect to the nation's overall financial soundness. Since the Asian financial crisis of 1997, the shock is expected to be substantially transmitted to the domestic financial markets. The MSB, used as a major instrument in controlling liquidity, especially in the process of foreign reserve management, is found to have risk exposure that the KTB with the same maturity does not have. While the status of foreign reserves is a major channel for the transmission of a shock from overseas, the MSB spread is considered to be a timelier market signal for a financial crisis, because of the timing of the availability of information on foreign currency reserves. Foreign exchange rates can also be considered a good signal, as the FX rate is very responsive to a shock from the international capital market. However, the shock is likely to have a significant impact on domestic markets in the case where the shock has a sizable negative impact on the national foreign reserve holdings. In this case, the MSB spread works as a signal by showing an extraordinary widening movement, indicating that the MSB spread is a good signal for a financial crisis.

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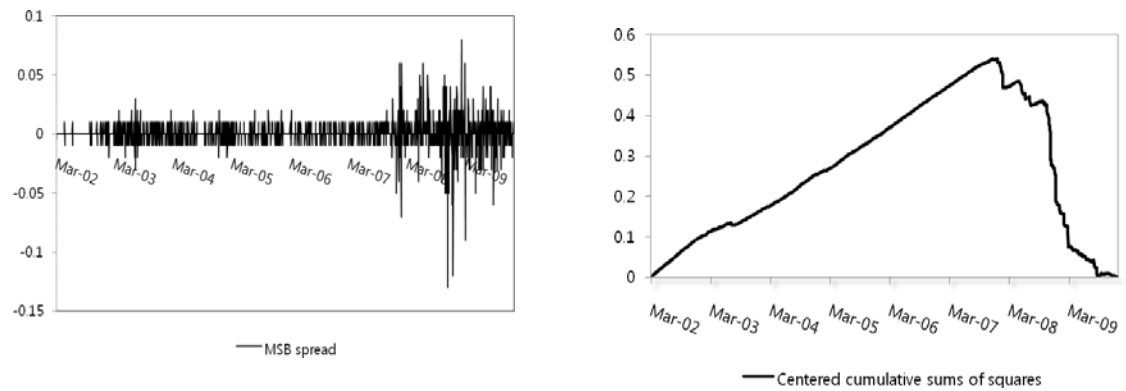
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Figure 1. The MSB Spread vs. Other Variables.



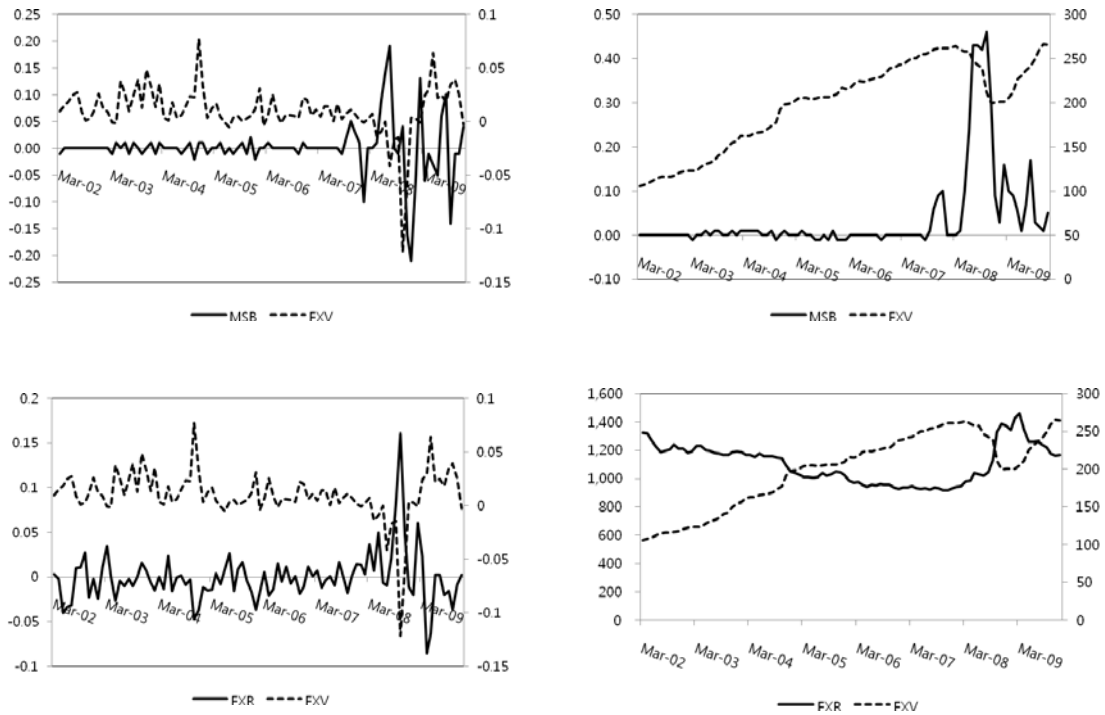
The top left panel plots the daily time-series of the MSB spread. The top right panel plots the one-day call rate against the MSB spread. The middle left panel plots the three-year KTB yield against the MSB spread. The middle right panel plots the credit spread calculated by the yield difference between the three-year AA-minus-rated and BBB-minus-rated corporate bonds against the MSB spread. The bottom left panel plots Korean won to U.S. dollar FX rate against the MSB spread. The bottom right panel plots the five-year Korean CDS spread against the MSB spread, from March 4, 2002 to December 30, 2009. Data source: The Bank of Korea, The Korea Financial Investment Association, and Bloomberg.

Figure 2. Change in MSB Spread Volatility.



The left panel plots the daily change in the MSB spread. The right panel presents the centered cumulative sums of squares calculated using the demeaned MSB spread to estimate the variance change point. Data was for the time period of March 4, 2002 to December 30, 2009.

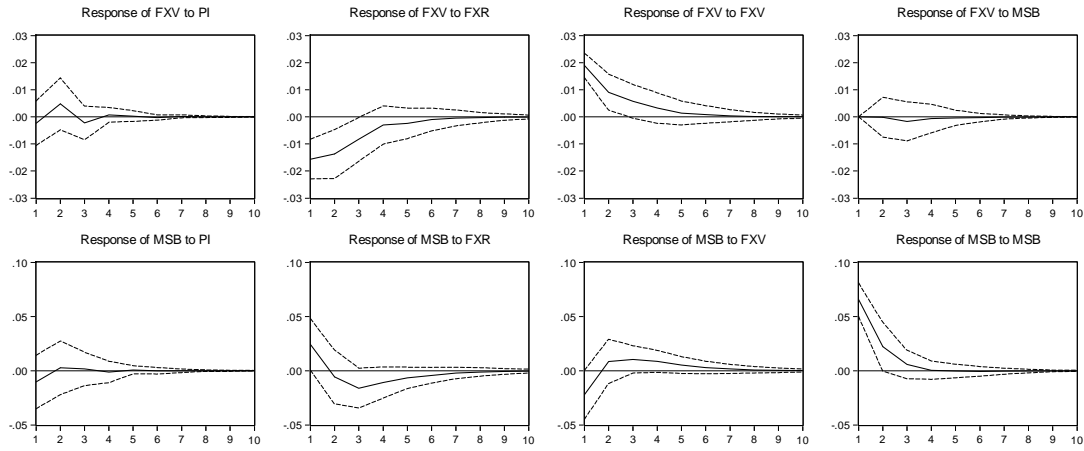
Figure 3. MSB Spread, FX Return, and Foreign Reserves



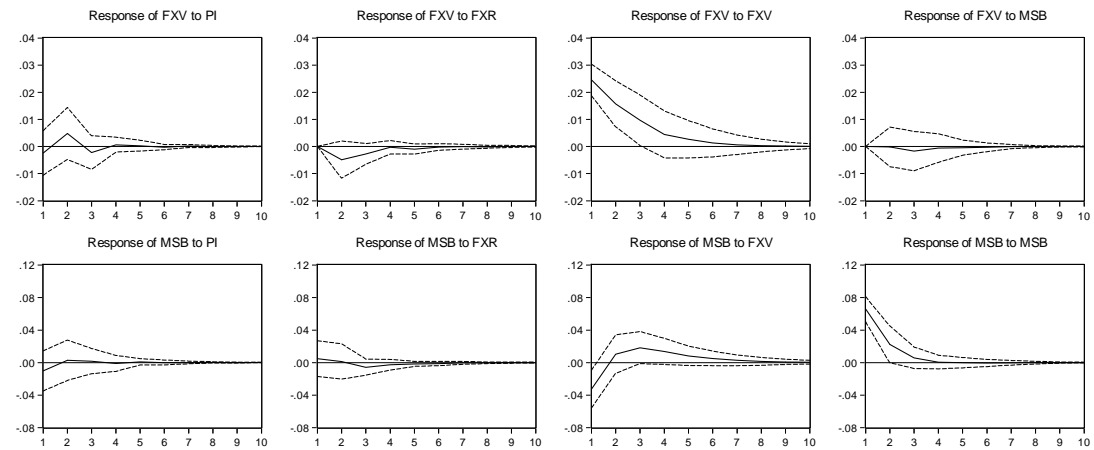
The plots on the left side are the monthly time-series of the MSB spread (MSB) (top) and the won/dollar FX rate (FXR) (bottom) against the foreign exchange reserves (FXV), in monthly changes. The plots on the right side are those of MSB (top) and FXR (bottom) against FXV in levels, from March 2002 to December 2009.

Figure 4. Impulse Responses of FXV and MSB

(a) Ordering: PI, FXR, FXV, MSB



(b) Ordering: PI, FXV, FXR, MSB



This figure illustrates the impulse responses of FXV and MSB from the VARs with two different orderings: (a) PI, FXR, FXV, and MSB (top), and (b) PI, FXR, FXV, and MSB (bottom), estimated with one lag using the recent sample of the crisis period from January 2007 to December 2009. The dotted lines represent two standard error bands. PI is the portfolio investment, FXR is the won/dollar FX rate, FXV is the amount of foreign exchange reserves, and MSB is the spread between the 364-day MSB and the one-year KTB yields.

Table 1. Augmented Dickey-Fuller Test.

This table presents the estimated number of optimal lags and the value of the test statistic from the Augmented Dickey-Fuller (ADF) test for each variable, before and after the stationary transformation. $rlag$ and $ADF(r)$ are the number of lags and ADF test statistics prior to the transformation, respectively. $\Delta rlag$ and $ADF(\Delta r)$ are those after the transformation. MSB is the spread between the 364-day MSB and the one-year KTB yields, CAL is the one-day call rate, KTB is the three-year KTB yield, CRD is the credit spread between the three-year BBB-minus-rated and AA-minus-rated corporate bond yields, FXR is the won/dollar FX rate, and CDS is the five-year Korean sovereign CDS spread. Bold letters indicate that the existence of a unit root is rejected at the 5% significance level.

	MSB	CAL	KTB	CRD	FXR	CDS
$rlag$	31	11	7	1	32	31
$ADF(r)$	-3.685	-0.533	-2.657	-0.117	-1.856	-2.309
$\Delta rlag$	29	32	6	27	32	30
$ADF(\Delta r)$	-7.114	-5.616	-15.88	-3.839	-6.904	-8.212

Table 2. Descriptive Statistics.

This table presents the mean, the standard deviation (SD), and the median (Med) of the variables in the first column for the normal and crisis period, in percentages. Correlations among the variables are also presented. MSB is the spread between the 364-day MSB and the one-year KTB yields, CAL is the one-day call rate, KTB is the three-year KTB yield, CRD is the credit spread between the three-year BBB-minus-rated and AA-minus-rated corporate bond yields, FXR is the won/dollar FX rate, and CDS is the five-year Korean sovereign CDS spread.

	Mean	SD	Med	Correlation					
				MSB	CAL	KTB	CRD	FXR	CDS
Normal period: Mar. 4, 2002 – Dec. 24, 2007									
MSB	0.000	0.006	0.000	1.000					
CAL	0.001	0.043	0.000	-0.002	1.000				
KTB	-0.000	0.051	0.000	-0.101	0.061	1.000			
CRD	-0.001	0.009	0.000	0.006	-0.011	-0.094	1.000		
FXR	-0.024	0.398	-0.032	-0.070	0.008	0.099	-0.010	1.000	
CDS	-0.001	0.025	0.000	-0.007	-0.015	0.056	-0.052	0.042	1.000
Crisis period: Dec. 26, 2007 – Dec. 30, 2009									
MSB	-0.000	0.019	0.000	1.000					
CAL	-0.006	0.095	0.000	-0.011	1.000				
KTB	-0.003	0.085	-0.010	-0.049	-0.058	1.000			
CRD	0.007	0.020	0.000	-0.117	-0.101	0.003	1.000		
FXR	0.043	1.444	0.029	-0.069	-0.038	0.078	0.000	1.000	
CDS	0.001	0.165	-0.001	-0.031	0.162	0.124	-0.031	0.102	1.000

Table 3. Granger Causality Test.

This table presents the results of the Granger causality test for each pair of variables. The F – value is the value of the F – test statistics under the null hypothesis of no causality. $x \rightarrow y$ denotes “ x Granger causes y .” MSB is the spread between the 364-day MSB and the one-year KTB yields, CAL is the one-day call rate, KTB is the three-year KTB yield, CRD is the credit spread between the three-year BBB-minus-rated and AA-minus-rated corporate bond yields, FXR is the won/dollar FX rate, and CDS is the five-year Korean sovereign CDS spread. Bold letters indicate that the null hypothesis of no causality is (marginally) rejected at the 1% significance level.

Normal period: Mar. 4, 2002 – Dec. 24, 2007					
<u>MSB vs. CAL</u>		<u>MSB vs. KTB</u>		<u>MSB vs. CRD</u>	
MSB→CAL	CAL→MSB	MSB→KTB	KTB→MSB	MSB→CRD	CRD→MSB
0.841	1.193	0.975	1.366	0.788	0.913
<u>MSB vs. FXR</u>		<u>MSB vs. CDS</u>		<u>FXR vs. CDS</u>	
MSB→FXR	FXR→MSB	MSB→CDS	CDS→MSB	FXR→CDS	CDS→FXR
1.117	0.405	1.393	0.462	2.392	4.477
<u>CAL vs. CRD</u>		<u>KTB vs. CRD</u>		<u>CAL vs. KTB</u>	
CAL→CRD	CRD→CAL	KTB→CRD	CRD→KTB	CAL→KTB	KTB→CAL
0.425	1.703	1.182	0.846	0.266	1.652
Crisis period: Dec. 26, 2007 – Dec. 30, 2009					
<u>MSB vs. CAL</u>		<u>MSB vs. KTB</u>		<u>MSB vs. CRD</u>	
MSB→CAL	CAL→MSB	MSB→KTB	KTB→MSB	MSB→CRD	CRD→MSB
2.697	1.040	2.636	1.036	2.265	0.705
<u>MSB vs. FXR</u>		<u>MSB vs. CDS</u>		<u>FXR vs. CDS</u>	
MSB→FXR	FXR→MSB	MSB→CDS	CDS→MSB	FXR→CDS	CDS→FXR
1.118	2.881	1.606	2.903	8.635	20.766
<u>CAL vs. CRD</u>		<u>KTB vs. CRD</u>		<u>CAL vs. KTB</u>	
CAL→CRD	CRD→CAL	KTB→CRD	CAL→CRD	CAL→KTB	KTB→CAL
4.204	1.339	2.289	0.967	2.015	2.358

Table 4. Granger Causality Test: Monthly.

This table presents the values of the F – test statistics under the null hypothesis that the row variable does not Granger cause the column variable, estimated with one lag. FDI is the foreign direct investment, PI is the portfolio investment, FXR is the won/dollar FX rate, FXV is the amount of foreign exchange reserves, MSB is the spread between the 364-day MSB and the one-year KTB yields, and M2 is the domestic monetary supply. All variables are in monthly changes. ** and * indicate that the null hypothesis of no causality is rejected at the 5% and 10% significance level, respectively.

	FDI	PI	FXR	FXV	MSB	M2
March 2002 – December 2006						
FDI		3.755*	0.430	1.094	3.431*	0.293
PI	1.230		1.013	0.039	1.710	0.793
FXR	0.031	0.323		1.240	0.371	0.628
FXV	0.039	0.034	0.297		3.814*	1.533
MSB	0.006	1.317	0.844	6.612**		1.751
M2	0.421	0.617	0.015	0.079	1.241	
January 2007 – December 2009						
FDI		0.184	0.062	0.006	0.100	2.194
PI	0.142		5.642**	3.029*	0.257	3.595*
FXR	0.125	3.219*		2.929*	0.995	0.231
FXV	1.169	0.017	4.899**		4.259**	0.058
MSB	0.171	2.071	0.070	0.334		0.002
M2	1.593	1.826	0.002	2.277	0.519	

Table 5. Variance Decompositions

This table presents the results of the variance decompositions in percentages of the variables in the first column from the VARs with two different orderings: (a) PI, FXR, FXV, and MSB (left), and (b) PI, FXV, FXR, and MSB (right), estimated with one lag. Hor. denotes the forecasting horizon and St. Er. denotes the standard error. PI is the portfolio investment, FXR is the won/dollar FX rate, FXV is the amount of foreign exchange reserves, and MSB is the spread between the 364-day MSB and the one-year KTB yields.

	Hor.	St.Er.	PI	FXR	FXV	MSB	PI	FXR	FXV	MSB
			(a) Ordering: PI, FXR, FXV, MSB				(b) Ordering: PI, FXV, FXR, MSB			
March 2002-December 2006										
PI	1	0.01	100	0.00	0.00	0.00	100	0.00	0.00	0.00
	5	0.02	95.64	0.84	0.16	3.36	95.64	0.94	0.06	3.36
FXR	1	0.02	0.01	99.99	0.00	0.00	0.01	78.56	21.43	0.00
	5	0.02	1.46	96.70	0.63	1.21	1.46	75.20	22.13	1.21
FXV	1	0.01	0.85	21.25	77.90	0.00	0.85	0.00	99.15	0.00
	5	0.01	0.82	25.60	66.07	7.51	0.82	2.65	89.02	7.51
MSB	1	2.47	0.10	0.47	0.65	98.78	0.10	0.06	1.06	98.78
	5	2.77	5.39	0.55	2.69	91.37	5.39	0.31	2.93	91.37
January 2007-December 2009										
PI	1	0.02	100	0.00	0.00	0.00	100	0.00	0.00	0.00
	5	0.03	87.44	9.84	0.41	2.31	87.44	7.49	2.76	2.31
FXR	1	0.05	0.06	99.94	0.00	0.00	0.06	59.56	40.38	0.00
	5	0.06	17.12	76.32	5.69	0.87	17.12	46.98	35.03	0.87
FXV	1	5.08	0.91	40.04	59.05	0.00	0.91	0.00	99.09	0.00
	5	5.84	3.31	49.59	46.77	0.33	3.32	3.08	93.27	0.33
MSB	1	0.07	1.93	10.83	8.88	78.35	1.93	0.42	19.30	78.35
	5	0.08	1.76	15.37	11.44	71.43	1.76	1.00	25.81	71.43