Leading Behavior of Interest Rate Term Spreads and Credit Risk Spreads in Korea

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Abstract

Interest rate term spreads and credit spreads have been well known to have a predictive power for future fluctuations of output in many developed countries. This study examines leading behaviors of interest rate term spreads and credit risk spreads in Korea in two ways. First, we apply various empirical methods for finding leading behavior of interest rate term spreads and credit risk spreads in business fluctuations over the period after the financial crisis in 1998 when the monetary policy changed its operating target from monetary aggregates to short-term interest rates, call rates. Second, using structural VAR models, we decompose the sources of fluctuations of output and interest rate spreads into two sorts, permanent real shocks and temporary financial shocks and examine the impulse response of each variable to the shocks focusing on the leading behavior of the spreads over the business cycle. We establish successfully the leading behavior of the term spread and the credit risk spread in Korea that the term spread tends to increase and the credit risk spread tends to shrink about 6 months before an expansion. We also find that much of the output fluctuations are attributed to real shocks while fluctuations in the interest rate spreads come from temporary financial shocks.

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Keywords: Term spread; Credit risk spreads; Forecast-error variance decomposition

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1 Introduction

Information plays a very important role in financial markets because informational advantage such as inside information may easily create an excess return. Thus, financial market participants try to use all available information and sometimes want to know the future in advance. Some financial variables have been known to move in advance before real economy shows any direction. The index of leading indicator is composed of those variables. Among them interest rate term spreads and credit risk spreads have showed a predictive power for fluctuations in output in the future. With this observation much attention has been put on many financial variables and substantial amount of study is accumulated since Stock and Watson (1989).

The term spread defined as a difference between a long-term risk-free government bond yield rate and a short-term risk-free rate extends when a boom is expected and shrinks when a recession is expected. That is, a steep slope of the yield curve has been used as a signal for economic recovery and a flat or sometimes downward sloping yield curve indicates an impending economic recession. Lee (2007) finds that the case that short-term interest rates are higher than long-term rates for more than a month has been observed in the U.S. ten times over the period between 1960 and 2001 and in most of the cases a recession followed within a year and concludes that the term spread has a predictive power for future fluctuations of output. A private economic research institute, the Conference Board in the U.S. include the term spread as a component of the index of the leading indicators since 1996. In Korea, the Statistics Korea also added the term spread between 3 year government yield rates and call rates to the leading indicator variables.

Credit risk spreads have also been paid much attention as a leading variable over the business cycle. Bernanke (1990) and Friedman and Kuttner (1991) showed that the spread between 3 month commercial paper rates and 3 month T-bill rates are closely related to the future business cycle. Recently Gertler and Lown (2000) and Mody and Taylor (2003) focus on more credit risk related spreads by using the spread between high yield bond (junk bond) rates and risk-free interest rates based on the financial accelerator theory.

The purpose of this study is to examine a leading behavior of term spreads and credit risk spreads in Korea in two ways. First, we apply various empirical methods for finding leading behavior of interest rate term spreads and credit risk spreads in business fluctuations over the period after the financial crisis in 1998 when the monetary policy changed its operating target from monetary aggregates to short-term interest rates, call rates. Second, using structural VAR models, we decompose the sources of fluctuations of output and interest rate spreads into two sorts, permanent real shocks and temporary financial shocks and examine the impulse response of each variable to the shocks focusing on the leading behavior of the spreads over the business cycle. We establish successfully the leading behavior of the term spread and the credit risk spread in Korea that the term spread tends to increase and the credit risk spread tends to shrink about 6 months before an expansion. We also find that much of the output fluctuations are attributed to real shocks while fluctuations in the interest rate spreads come from temporary financial shocks.

The rest of the paper is organized as follows. In Section 2, the theoretical background for the leading behavior of the term spread and the credit risk spread is discussed. In Section 3, the data used in the empirical analysis are explained and descriptive statistics and long horizon analysis are provided. In Section 4 a structural VAR model is constructed and with some identifying restriction real shocks and financial shocks are identified to examine the leading behavior of the term spread or the credit risk spread. In Section 5, we summarize our main result and conclude.

2 Theoretical Background

2.1 Term Spreads and Future Business Activities

Following Plosser et al. (1994) or Mody and Taylor (2003), the slope of the yield curve depends on the expected real interest rate, the present and future inflation, risks, and the term premium. Therefore, the theoretical investigation regarding the relationship between the term spread and the future economic activities starts with a link between real interest rates and macroeconomic fluctuations. Consider a simple Euler equation derived from the first order conditions of a representative agent's optimization problem.[1]

$$u'(c_t) = (1 + r_t^{(1)})\beta \mathrm{E}_t[u'(c_{t+1})], \tag{1}$$

$$u'(c_t) = (1 + r_t^{(2)})\beta^2 \mathrm{E}_t[u'(c_{t+2})], \tag{2}$$

where u is the momentary utility function, c_t is consumption, $r_t^{(1)}$ and $r_t^{(2)}$ are one-period and two-period interest rates at time t, β is the discount factor, and E_t is the conditional expectation operator based on all information available at time t. The above equations are typical intertemporal first order conditions. From the above equations it is straightforward to get

$$r_t^{(2)} - r_t^{(1)} = \frac{1}{\beta}\frac{\mathrm{E}_t[u'(c_{t+1})]}{\mathrm{E}_t[u'(c_{t+2})} - 1. \tag{3}$$

[1]This part follows Ashoka and Taylor (2003)'s discussion.

Thus, the interest rate term spread is related to the ratio of the expected marginal utility of consumption at time $t+1$ to the expected marginal utility of consumption at time $t+2$. In other words, when the consumption at time $t+2$ is expected to increase relative to the consumption at time $t+1$, the term spread between the two-period interest rate and the one-period interest rate widens. If the expected inflation rate is constant, this relationship can be applied to the the spread between nominal interest rates with different maturity. Extending the above argument to the spread between the long-term interest rate and the short term interest rate, when the consumption level is expected to rise in the future relative to the next period consumption, the term spread tends to increase. That is, the term spread increases before output rises, which is the leading behavior of the term spread for business fluctuations observed in the data.

Harvey (1994) shows that the term spread is related to the movement of consumption using the intertemporal CAPM instead of a representative agent model. His argument starts with consumption smoothing behavior that when people expect a recession in the future, they increase saving by purchasing a long-term bond to prevent a decrease in the future consumption for the purpose of consumption smoothing. This behavior increases the demand for long-term bonds and thus, the price of long-term bonds increases and the long-term interest rates fall, which makes the yield curve flat or even downward sloping when a depression is expected in the future. However, as Deaton (1992) and Taylor (1999) point out, the above argument holds at a marginal relationship and many empirical studies documents that the relationship between the current term spread and the future movement in consumption is very weak. Some studies such as Chirinko (1993) and Taylor (1999) try to find a channel through investment but they find that the current term spread is weakly related to the future movements in investment.

Bernard and Gerlach (1996) emphasize the effect of monetary policy and expected inflation in the relationship between the term spread and future economic activities. The monetary policy argument views a leading behavior of the term spread as a result of a change in monetary policy. When monetary contractionary policy raises short-term interest rates, people expect this tight monetary policy temporary which results in a relatively small increase in the future short-term interest rate and a decline in the term spread. The contractionary monetary policy affects real economic activities with a lag, which means the decline in the term spread is associated with the future economic recession.

The expected inflation argument focuses on people's expectation for the future economy. When an expectation of a recession in the future prevails, expected inflation rate falls and thus long-term interest rates fall. If people's expectation is correct on average, the fall in the term spread or the flat yield curve is related to future economic recession.[2]

2.2 Credit Risk Spreads and Future Business Activities

Credit risk spreads are defined as a difference between interest rates on risky bonds and risk-free interest rates with the same maturity. Most studies finding the leading behavior of the credit risk spread use the spread between three-month commercial paper (CP) rates and three-month Treasury bill rates. Since only recognized firms can issue commercial papers, the default risk in commercial papers does not appear to be existent. However, commercial papers are ex ante not risk-free. Friedman and Kuttner (1991) find that the wider credit risk spread predicts an economic recession and the smaller credit risk spread predicts an expansion. They explains this leading behavior of the credit risk spread in three channels. First, expectations of recession in the future raise the default risk of corporate bonds. Second, when monetary policy becomes contractionary and it affects economic activity with a lag, banks reduces loans to firms, which makes firms to issue commercial paper and raises the interest rate of commercial papers. Thus, a wider credit spread between the commercial paper rate and risk-free Treasury bill rates is associated with a recession in the future. Third, when an economic recession is near, firms have a trouble in cash flows and try to have liquidity, which makes firms issue new commercial paper. Due to the above three channels, an increase in the spread between the commercial paper rate and Treasury bill rates predicts a recession in the future.

The leading behavior of the credit risk spread defined as a difference between the three-month commercial paper rates and the three-month Treasury bill rates has appeared to be weaker since 1980 due to an increase in the substitutability across financial assets coming from globalization and liberalization in financial markets (Gertler and Mown, 2000). As an alternative explanation many studies focus on high yield bond spreads based on the financial accelerator theory suggested by Bernanke et al. (1999). Gertler (1999) and Mody and Taylor (2003) define high yield bond spreads as a difference between junk bond yields and AAA-rated corporate bonds yields or T-bill rates and show that the junk bond yield spreads are closely related with the future business fluctuations.

[2] Haubrich and Dombrosky (1996) find that the term spread between the 10-year treasury bond yields and the three month T-bill rates predicts the GDP growth rate in four quarters later but its predictive power changes over time and becomes significantly lower since 1980.

3 Data and Long Horizon Analysis

3.1 Data and Descriptive Analysis

Even though the size of the Korean bond market is substantial and the history is long, the Korean bond markets were not much developed until recently. The trading volume in the Korean bond markets was not heavy and regulated by the government. After the financial crisis in Korea in 1998 the Bank of Korea changed its monetary policy target from monetary aggregates such as M2 to a short-term interest rate in the call market which is an overnight loan between commercial banks with the purpose of managing bank reserves.[3] With liberalization and deregulation of the financial markets after the financial crisis the Korean bond markets have developed significantly in a qualitative aspect as well as in a quantitative aspect.

This study covers the period after the financial crisis in Korea spanning January 1998 through December 2008.[4] The frequency of the data is monthly. We use several financial data and real output data for the VAR analysis. To calculate the term spread we use 3 year government bond yield rates ($gb3$) and 5 year government bond yield rates for long-term interest rates and call rates (overnight loans between commercial banks for reserves; $call$), CD (certificate of deposit, cd) rates, and one-year monetary stabilization bond rates for the short-term interest rates ($ms1$).[5] Since the empirical results for the terms spread with 5 year government bond yield rates are very similar to those with 3 year government bond yield rates, only the empirical results with 3 year government bond yield rates are reported. The certificate of deposit market has been grown significantly since the financial crisis in Korea and the CD rates have been a benchmark interest rate for collateralized mortgage loans. The term spread used in the index of economic leading indicator in the U.S. is defined as a difference between the 10 year Treasury bond yields and the federal funds rate. However, the 10 year bond market started to be traded only recently in 2007. Thus, we use 3 year government bond yield rates. The term spread defined as a difference between 3 year government bond yield rates and call rates is currently one of 10 components composing the leading economic indicator in Korea. For the credit risk spread, we use 3 year government bond yields for risk-free rates and 3 year AA- rated corporate bond yields for risky rates.

Figure 1 shows the fluctuations of the term spreads calculated with 3 year government bond yields for the long-term rate over the sample period. The shaded areas

[3] The call market corresponds to the federal funds market in the U.S.

[4] The end date will be extended to the present in the future.

[5] The monetary stabilization bonds are issed by the Bank of Korea for the purpose of monetary policy. The total outstanding of the monetary stabilization bonds at the end of year 2011 is about 165 trillion wons.

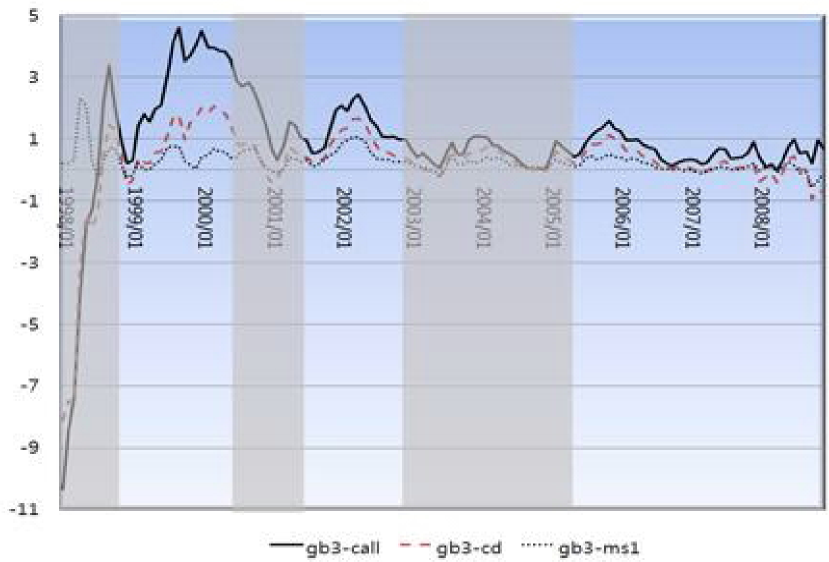

Figure 1: Term Spreads over Business Cycle, Jan. 1998-Dec. 2008

indicate recessions. The term spreads were negative in 1998 due to the credit crunch in a financial crisis in Korea. It confirms the conventional observation that the yield curve becomes flat or downward sloping during economic recessions. The spreads became quickly reversed to the positive territory when the economy started to recover in the second half of the year of 1998. The figure shows that the term spreads tend to reach a peak several months in advance of a peak of a business cycle. Since the starting point of a shaded area indicates a peak of a business cycle, the term spread tends to increase several months before the peak of the business cycle. The term spread also tends to decrease several months before a trough of a business cycle since the end point of a shaded area implies a trough of a business cycle. Therefore, the figure shows a leading behavior of the term spread over the business cycle.[6]

To investigate the statistical property of the term spreads with the industrial production index, Figure 2 plots correlograms for each of the three term spreads. Each of the graphs indicates the correlation coefficient between each of the term spread at time t and the industrial production index at time $t + x$ where x is the number at the horizontal axis. The correlation coefficients are calculated after all the series are detrended with the Hodrick-Prescott filter to remove trends. When the correlation coefficients are high in absolute term in the left side of the origin, the term spread moves in advance of the fluctuations in the industrial production index. The highest correlation

[6]However, the leading behavior of the term spread over the business cycle seems to be weak for the case of one year monetary stabilization bond yield rates.

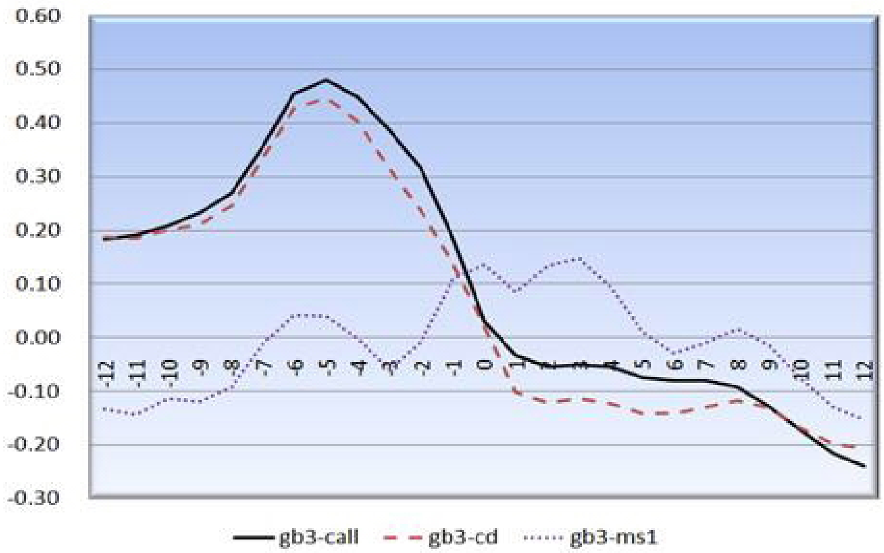

Figure 2: Correlogram between Term Spreads and Industrial Production Index

coefficients for the two cases of the spreads, $gb3 - call$ and $gb3 - cd$ are about 0.45 for the correlation between the term spread at time t and the industrial production index at time $t - 5$, which means there is a tendency that the term spread moves 5 months ahead of the movement in the industrial production index. However, the term spread between 3 year government bond yield rates and one year monetary stabilization bond yield rates does not show clearly the leading behavior over the business cycle.

The same exercises are done for the credit risk spreads. Figure 3 shows the fluctuations of the credit risk spreads calculated with a 3 year government bond yield rate (aa) for a risk-free rate and a 3 year AA- rated corporate bond yield rate for a risky rate. The credit risk spread extended significantly at the beginning of the financial crisis in 1998. There is also a tendency that a peak of the credit risk spread appears several months ahead of a trough of the business cycle identified as the end point of the shaded area. An increase in the credit rate spread seems to be associated with a depression in the future over the business cycle. The most recent sharp increase in the credit risk spread reflects the global financial crisis starting in September 2008.[7]

The correlogram for the industrial production index and the credit risk spread is drawn in Figure 4. As before, the credit risk spread and the industrial production index are detrended with HP-filter to get rid of any existing trend. The figure shows that

[7] However, the leading behavior of the credit risk spread over the business cycle seems to be weaker than that of the term spread. Thus, currently the term spread is included as a component in the index of the leading indicator while the credit risk spread is not.

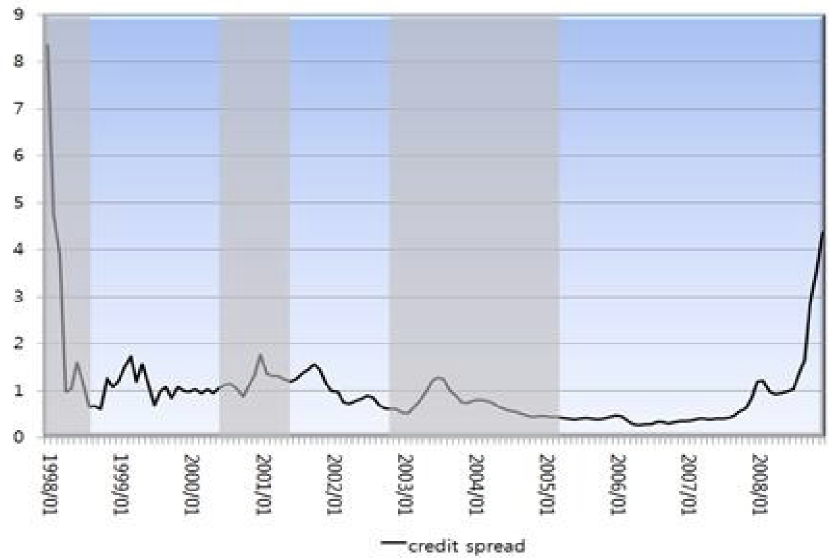

Figure 3: Credit Risk Spread over Business Cycle, Jan. 1998-Dec. 2008

the correlation coefficient between the credit risk spread ($aa - gb3$) and the industrial production index becomes the largest in absolute term (-0.29) for the correlation between the credit risk spread at time t and the industrial production index at time $t-6$, which implies that a decline in the credit risk spread is associated with an increase in the industrial production index five months later. Thus, the credit risk spread leads the business cycle.

3.2 Long Horizon Analysis

A more serious testing method showing a leading behavior of a variable over the business cycle, named the long horizon analysis, is suggested by Estrellar and Hardouvelis (1991). The estimation equation used in the long horizon analysis is as follows.

$$(\frac{1200}{k})(\log IP_{t+k} - \log IP_t) = \alpha_0 + \alpha_1 SPREAD_t + e_t, \tag{4}$$

where IP_t and $SPREAD_t$ are the industrial production index and term spread (or credit risk spread) at time t, respectively, and k is the forecasting horizon. The estimation regression basically examines the predictability of the spreads for real activity. The first term, $(\frac{1200}{k})$ is for converting the coefficient into annual percentage effect. Table 1 reports the estimated coefficient on the term spread defined as the difference between 3 year government bond yield rates and call rates, CD rates, or one year monetary stabilization bond yield rates. The numbers in parentheses indicate Newey and West (1987)

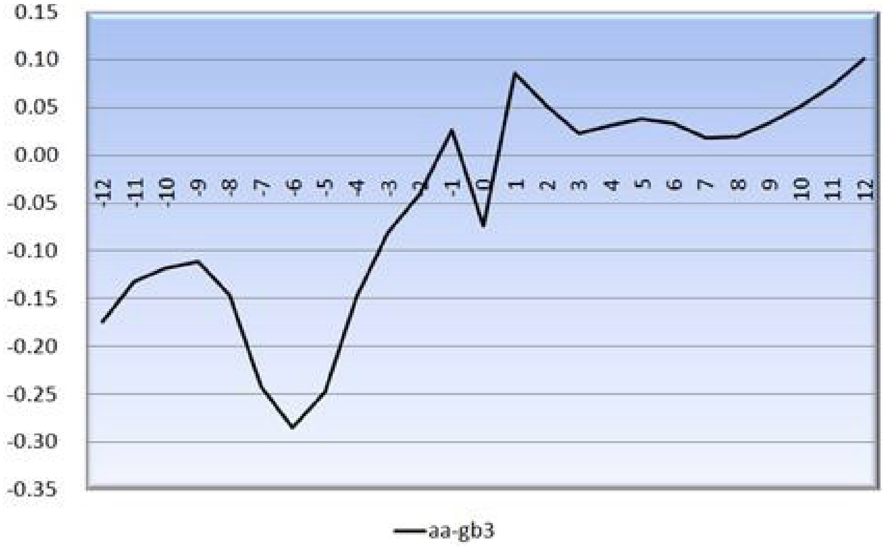

Figure 4: Correlogram between Credit Risk Spread and Industrial Production Index

heteroskedasticity and autocorrelation consistent standard errors corrected with twelve lags.[8] It shows that the term spread helps predict the growth of industrial production index up to five months ahead. A one percent point increase in the term spread with call rates as a short-term rate is associated with 1.29~2.88 percent cumulative increase in annual term in the industrial production index over the following 5 months periods. For the term spread with CD rates as a short-term rate a one percent point increase in the term spread is related with 1.41~4.21 percent cumulative increase in annual term in the industrial production index over the next 5 months periods. The sign of the coefficient on the term spread turns to negative for 12 to 24 months forecast horizon. This behavior may reflect a mean-reverting behavior of business cycles[9] or monetary and fiscal policy responses facing business fluctuations.[10] However, the result with one year monetary stabilization bond yield rates is different from the other two. The term

[8] When Newey and West (1987) heteroskedasticity and autocorrelation consistent errors are computed, we chose 2 to 12 lags but the results were not qualitatively different. We fix the lag to 12 following Hamilton and Kim (2002).

[9] This idea may be assured by the fact that following the official turning point date announced by the Statistics Korea, the business cycle expansion from a trough to the following peak lasts around one to two years.

[10] Boudoukh, et al. (2005) argue that the long horizon analysis may include other effects as the forecast horizon is longer. They alert that we must be cautious in interpreting the relationship between the term spread and output fluctuation since the empirical result with long horizon is a mixture of many factors the effects of which we need to decompose.

spread between the 3 year government bond yield rates and the one year monetary stabilization bond yield does not show any predictive power for future fluctuations in the industrial production index. The coefficients on the spread in the estimation equations are not significant over all the horizons considered. This result is consistent with the correlogram in Figure 2 in which the term spread with one year monetary stabilization bond yield rates does not show any leading behavior for the future industrial production index. We suspect that the one year monetary stabilization bond is not really considered as a short-term bond in the financial market or the maturity difference between the 3 year government bond yield rate and the one year monetary stabilization bond yield rate is too short and thus the term spread does not reflect a change in inflation expectations properly.[11] This empirical result is different from the previous studies by Park and Kim (2008) and Ji and Park (2002) which found a predictive power of the term spread with one year monetary stabilization bond yield rates for future output fluctuations. The long horizon analysis for the credit risk spread is reported in Table 2. The credit risk spread is calculated as a difference between 3 year AA- rated corporate bond yield rates and 3 year government bond yield rates. An increase in the credit risk spread is associated with a decline in output two to five months later. A one percent point increase in the credit risk spread implies that the industrial production index tends to decrease in two to five months by -2.27~-6.55 percent in annual percentage term. Therefore, we can observe a leading behavior of the credit risk spread over fluctuations in the industrial production index by the long horizon analysis.[12]

[11] When we used all available data from May 1995 through December 2008 rather than the data after the financial crisis in 1998, we found that the term spread between 3 year government bond yield rates and one year monetary stabilization bond yield rates shows a predictive power (even though weak) for a medium horizon of 4 months or longer. This may suggest that the change in the monetary policy after the financial crisis in Korea is responsible for any possible change in the structure of the relationship between the term spread with one year stabilization bond yield rates and output fluctuations.

[12] The reversal of the sign of the coefficient at 10 to 24 months horizon is similar to the results of the term spread.

TABLE 1. Long Horizon Analysis for Leading Behavior of Term Spread

Forecast Horizon	$gb3 - call$		$gb3 - cd$		$gb3 - ms1$	
k	α_1	R^2	α_1	R^2	α_1	R^2
1	2.84***	0.03	4.21**	0.04	8.65	0.01
	(3.55)		(2.54)		(0.65)	
2	2.88***	0.07	3.66***	0.06	2.79	0.00
	(4.29)		(3.30)		(0.24)	
3	2.14***	0.06	2.41***	0.04	1.53	0.00
	(3.78)		(4.74)		(0.25)	
4	1.70***	0.06	1.97***	0.04	0.96	0.00
	(3.17)		(4.1)		(0.25)	
5	1.29**	0.04	1.41**	0.03	1.47	0.00
	(2.34)		(2.52)		(0.59)	
6	0.85	0.02	0.80	0.01	1.86	0.00
	(1.51)		(1.38)		(0.71)	
7	0.30	0.00	0.07	0.00	1.99	0.00
	(0.55)		(0.12)		(0.66)	
8	-0.12	0.00	-0.54	0.01	1.13	0.00
	(-0.23)		(-1.14)		(0.37)	
9	-0.35	0.01	−0.86**	0.02	0.49	0.00
	(-0.74)		(-2.15)		(0.18)	
10	-0.50	0.01	−0.99**	0.03	0.87	0.00
	(-1.14)		(-2.58)		(0.31)	
11	-0.64	0.03	−1.14***	0.04	0.49	0.00
	(-1.59)		(-2.94)		(0.18)	
12	−0.72*	0.04	−1.26***	0.06	0.32	0.00
	(-1.87)		(-3.09)		(0.12)	
15	−0.96***	0.08	−1.56***	0.12	0.47	0.00
	(-3.10)		(-3.89)		(0.16)	
18	−1.10***	0.14	−1.69***	0.18	1.30	0.01
	(-4.83)		(-5.06)		(0.50)	
21	−1.11***	0.19	−1.65***	0.23	2.73	0.04
	(-5.38)		(-6.91)		(1.32)	
24	−1.04***	0.22	−1.57***	0.26	2.51	0.04
	(-5.38)		(-8.54)		(1.63)	

Note: In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected with twelve lags. All estimation equations have a constant term which is abstracted from the table.

***, **, and * denote statistically significant at the 1%, 5%, and 10% level in a two-tailed test, respectively.

TABLE 2. Long Horizon Analysis for Leading Behavior of Credit Risk Spread

3 year AA- rated Corporate Bond Yield−3 year Government Bond Yield

Forecast Horizon, k	α_1	R^2
1	-8.16	0.06
	(-1.35)	
2	-6.55^{**}	0.07
	(-1.98)	
3	-3.38^{***}	0.03
	(-2.89)	
4	-2.49^{***}	0.02
	(-2.59)	
5	-2.27^{**}	0.02
	(-2.18)	
6	-1.60	0.02
	(-1.48)	
7	-0.52	0.00
	(-0.58)	
8	0.53	0.00
	(0.67)	
9	0.90	0.01
	(1.35)	
10	0.98^{*}	0.01
	(1.70)	
11	1.13^{**}	0.02
	(2.09)	
12	1.20^{*}	0.02
	(1.95)	
15	1.58^{***}	0.05
	(2.81)	
18	1.77^{***}	0.07
	(4.02)	
21	1.85^{***}	0.10
	(5.40)	
24	1.88^{***}	0.14
	(6.63)	

Note: In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors corrected with twelve lags. All estimation equations have a constant term which is abstracted from the table.

***, **, and * denote statistically significant at the 1%, 5%, and 10% level in a two-tailed test, respectively.

4 Structural VAR Analysis

From the descriptive analysis and the long horizon analysis we can find a leading behavior of the term spread and the credit risk spread over the business cycle. In this section, we attempt to step up a little further to see how the industrial production index and the term spread (or the credit spread) respond to shocks identified by a set of identifying restrictions. From this exercise we can also look for the leading behavior of the spreads over the business cycle, the size of the responses of the variables to each of the shocks, and the relative importance of the shocks in explaining fluctuations of the variables.

4.1 A Structural VAR Model and Identification

Consider a simple bivariate unrestricted vector autoregressive model as follows:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} \mu_x \\ \mu_y \end{bmatrix} + \begin{bmatrix} a_1 & b_1 \\ c_1 & d_1 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \cdots + \begin{bmatrix} a_p & b_p \\ c_p & d_p \end{bmatrix} \begin{bmatrix} x_{t-p} \\ y_{t-p} \end{bmatrix} + \begin{bmatrix} \epsilon_t^x \\ \epsilon_t^y \end{bmatrix}. \tag{5}$$

A structural VAR model starts an unrestricted VAR model estimation and converts the estimated model into a structural model linked to structural shocks with a set of identifying restrictions. To convert the two estimated residuals into structural shocks requires an identifying restriction.[13] We use the industrial production index and term spreads (or credit risk spreads) in the bivariate VAR model. First, we test an existence of unit root for each of the variables as in Table3. Table 3 reports unit root test statistics for the industrial production index and various spreads. Both the ADF test statistics and the Phillips-Perron test statistics suggest that the industrial production index has a unit root and the spreads considered are stationary. With this test, we can identify a permanent shock and a temporary shock from the unrestricted VAR estimation. We call a permanent shock as a real shock and a temporary shock as a financial shock. An identifying restriction we adopt is that "a financial shock does not have a long-run (permanent) effect on real output."[14] This identifying restriction can be expressed as $\sum_{j=1}^{\infty} \phi_{12}^j = 0$ in the following model:

$$\begin{bmatrix} \Delta \log IP_t \\ SPREAD_t \end{bmatrix} = \sum_{j=1}^{\infty} L^j \begin{bmatrix} \phi_{11}^j & \phi_{12}^j \\ \phi_{21}^j & \phi_{22}^j \end{bmatrix} \begin{bmatrix} \nu_{1t} \\ \nu_{2t} \end{bmatrix}, \tag{6}$$

[13] For a detailed discussion on the methodology of structural VAR models, refer to Kwark (2004).

[14] This identifying restrictions are similar to the ones used by Blanchard and Quah (1989) in identifying supply shocks and demand shocks in the bivariate VAR model composed of GDP and unemployment. They assume that a demand shock does not have a permanent effect on real output.

where ν_1 is a real shock which has a permanent effect on the industrial production index and ν_2 is a financial shock which has only a temporary effect on the industrial production index. We examined a bivariate structural model for term spreads with various measures and found very similar results. Thus, the following discussion of the empirical results will focus on the term spread between 3 year government bond yield rates and call rates ($gb3 - call$).

TABLE 3. Unit Root Test

	ADF Statistics	Phillips-Perron Statistics
$\log IP$	-2.36	-2.19
$gb3 - call$	-5.72^{***}	-6.62^{***}
$gb3 - cd$	-7.43^{***}	-7.32^{***}
$gb3 - ms1$	-6.74^{***}	-4.94^{***}
$aa - gb3$	-2.99^{**}	-8.16^{***}

Note: The lag length is chosen by the SIC and a constant term is included.
*** and ** denote a rejection of the null hypothesis of unit root at the 1% and 5% significance level, respectively.

4.2 Impulse Response and Variance Decomposition

The purpose of this section is to examine quantitatively a leading behavior of the spread over the business cycle and the relative importance of structural shocks in explaining fluctuations of the variables concerned by a structural VAR model analysis. Figures 5 shows impulse responses of the industrial production index and the term spread ($gb3 - call$) to a one percent standard deviation innovation increase in a real shock. The impulse response of the industrial production index to a real shock is hump-shaped reaching a highest point of about 6 percent increase (left vertical axis scale) 20 months after a one percent standard deviation increase in real shock is realized while the response of the term spread reach a peak of 0.4 percent point increase (right vertical axis scale) 11 months after the real shock. The real shock has a permanent effect on the industrial production index by about 5 percent increase while it has only a temporary effect on the term spread since the spread is stationary. From this impulse response analysis we may conclude that the term spread tends to move 9 months earlier than the industrial production index, which is approximately consistent with the previous studies (e.g., Lee, 2000, and Ji and Park, 2002) finding the leading behavior of the term spread over the business cycle by three to nine months.

Figure 6 shows impulse responses of the industrial production index and the term spread to a one percent standard deviation increase in financial shock. Since we assume financial shocks to be temporary, the long-run effect of a financial shock converges to

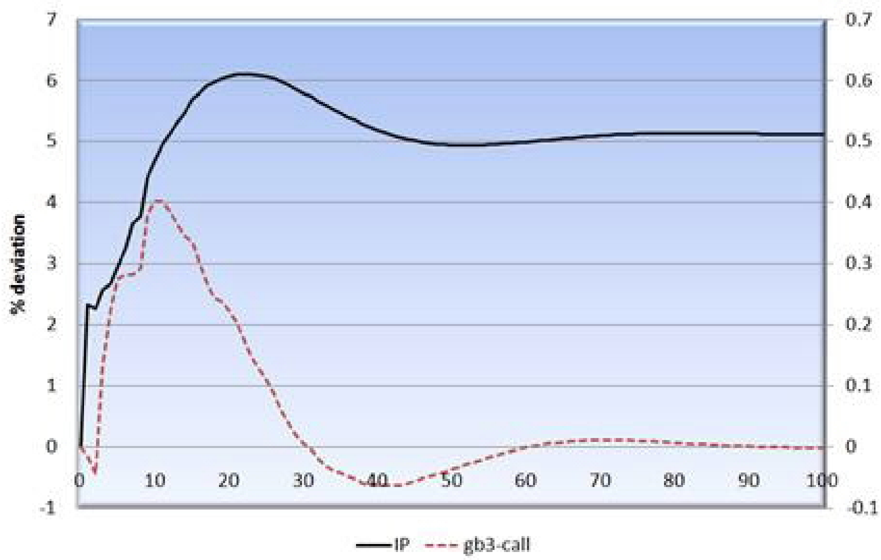

Figure 5: Impulse Responses to a Real Shock

zero. A one percent standard deviation increase in the financial shock increases the industrial production index reaching a maximum point of 1.4 percent 8 months after the shock is realized. The term spread shows a peak response of 0.6 percent point increase in two months. The impulse responses clearly give a leading behavior of the term spread over the industrial production index by about 6 months.

The forecast-error variance decomposition is provided in Table 4. The number in the table implies a relative importance of contribution of each of the shock in explaining unexpected fluctuations k-period later. As expected from the impulse response analysis, most of the fluctuation in the industrial production index is explained by real shocks. Over the all horizon real shocks are responsible for over 90 percent of the fluctuation of the industrial production index. Financial shocks explain up to about 7 percent of the fluctuation of the industrial production index. On the contrary, the term spread is largely explained by financial shocks in the short-term and medium-term horizon. In the long-run the fluctuation of the term spread is attributed to real shocks and financial shocks almost evenly.

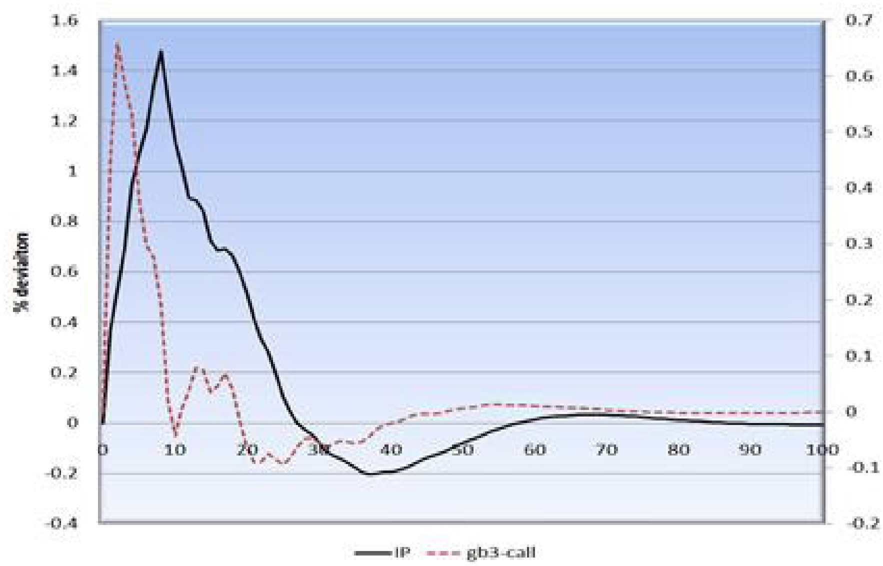

Figure 6: Impulse Responses to a Financial Shock

TABLE 4. k-Period Ahead Forecast-Error Variance Decomposition

	IP		$gb3 - call$	
k	real shock	financial shock	real shock	financial shock
1	97.6	2.4	0.1	99.9
2	97.1	2.9	0.3	99.7
3	96.7	3.3	2.0	98.0
4	95.7	4.3	5.3	94.7
5	95.5	4.5	9.4	90.6
6	95.4	4.6	13.1	86.9
8	94.8	5.2	19.5	80.5
10	94.2	5.8	30.2	69.8
20	93.7	6.3	50.9	49.1
60	93.2	6.8	52.3	47.7

The same exercise with a structural VAR model is applied to the credit spread. The results are drawn in Figures 7 and 8 and Table 5. The impulse responses in Figure 7 show that the industrial production index responds to a real shock reaching a maximum of about 4.2% 12 months later while the credit risk spread responds negatively to the real shock. The maximum response of the credit risk spread is 0.1 percent fall three months later. For a financial shock the industrial production index responds with an increase of 0.6 percent 8 months after the shock and the credit risk spread shows a quick negative response of -0.2 percent in a month. From the impulse response analysis the

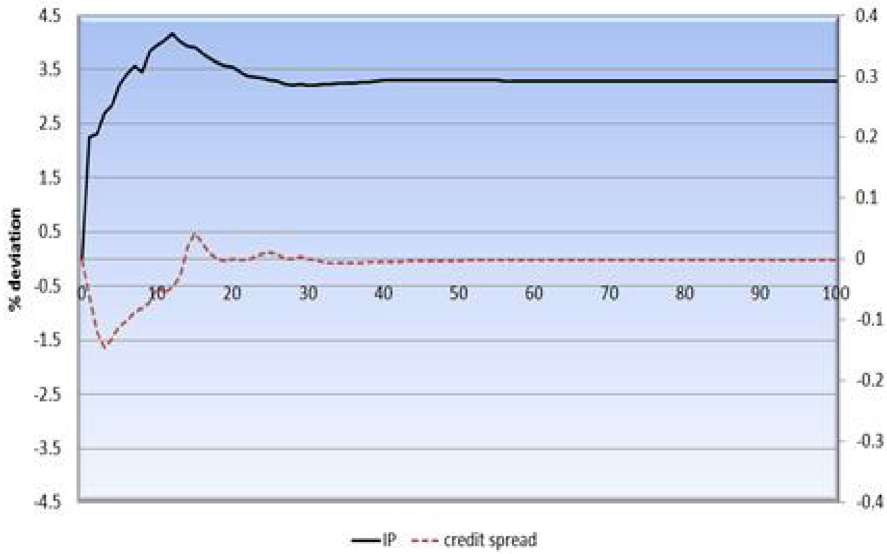

Figure 7: Impulse Responses to a Real Shock

credit risk spread shows a leading behavior of industrial production by about 7 months. The forecast-error variance decomposition for the credit risk spread is similar to that of the term spread. Over the all horizon most of the fluctuation in the industrial production is explained by real shocks and the contribution of financial shocks is small. The fluctuation of the credit spread in the short-term is largely explained by financial shocks but the contribution of real shocks increases as the horizon become longer.

TABLE 5. k-Period Ahead Forecast-Error Variance Decomposition

	IP		$aa-gb3$	
k	real shock	financial shock	real shock	financial shock
1	99.9	0.0	6.0	94.0
2	98.9	1.1	14.6	85.4
3	98.9	1.1	24.3	75.7
4	98.5	1.5	29.3	70.7
5	98.5	1.5	33.4	66.6
6	98.5	1.5	36.5	63.5
8	98.2	1.8	39.9	60.1
10	97.9	2.1	41.6	58.4
20	97.5	2.5	42.0	58.0
60	97.4	2.6	41.5	58.5

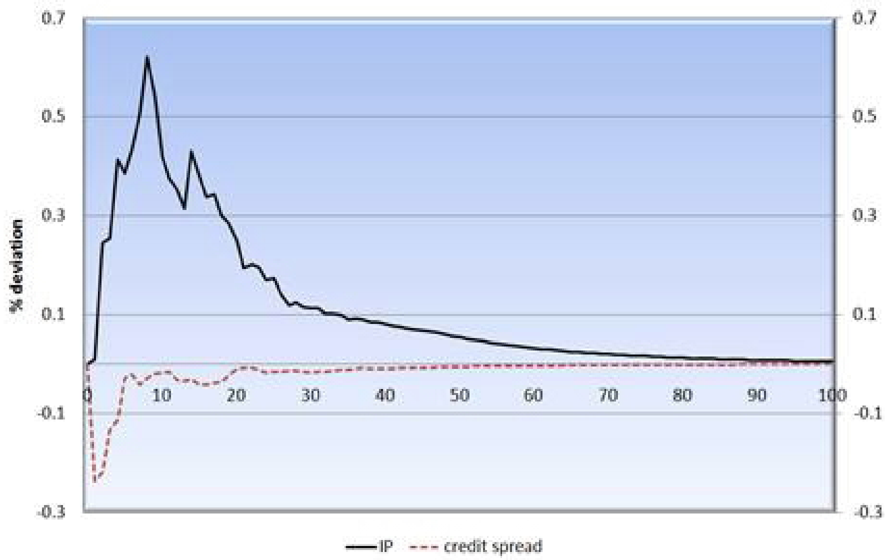

Figure 8: Impulse Responses to a Financial Shock

5 Concluding Remarks

The term spread may reflect a change in monetary policy and a change in expected inflation and the credit risk spread also incorporates expectations on default risk in the future. These links make the term spread or the credit risk spread a useful means of predicting future business cycles. The term spread has been used ad a component of a leading index in many developed countries, e.g. U.S. and was recently added to a leading indicator in Korea.

This study examined the leading behavior of the term spread and the credit risk spread in Korea in two ways. We first applied various empirical methods such as correlogram analysis and long horizon analysis to the term spread and the credit risk spread to find a leading behavior of the variables after the financial crisis in Korea in 1998 when the monetary policy changed its operating target from monetary aggregates to short-term interest rates, call rates. The term spread as well as the credit risk spread showed a predictive power for future fluctuations in industrial production. Second, using structural VAR models, we decompose the sources of fluctuations of output and interest rate spreads into two sorts, permanent real shocks and temporary financial shocks and examine the impulse response of each variable to the shocks focusing on the leading behavior of the spreads over the business cycle. From the impulse response analysis in the structural VAR model, we establish the leading behavior of the term spread and the credit risk spread successfully in Korea that the term spread tends to increase and the credit risk spread tends to shrink about 6 months before an expansion. We also find that much of the output fluctuations are attributed to real shocks while fluctuations in the interest rate spreads come from temporary financial shocks.

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