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The Risk-Taking Channel of Monetary Policy in Korea*

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This paper evaluates the impact on the bank risk of some control variables and the specific characteristics of five domestic banks in Korea by using data from the fourth quarter of 2005 to the fourth quarter of 2013 in order to test the risk-taking channel of monetary policy. Bank risk is measured by credit default swap (CDS) premium. In particular, this study focuses on the relationship between bank risk and the nominal short-term interest rate that reflects monetary policy. As the period of low interest rates becomes longer, banks are willing to take greater risks. This study confirmed that the risk-taking channel exists. This means that monetary policy has a direct impact on financial stability.

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1. INTRODUCTION

The U.S.A. experienced a recession until the middle of 2009 because of the 2007 global financial crisis. Korea is still experiencing the aftermath of that global financial crisis with the movement of macroeconomic variables remaining unstable. In addition, since 2000, the long-term interest rates (e.g., 3-year government bond yields), and base rates in Korea have fallen steadily with the decline of potential growth.[1)]

In case of a recession phase, such as that caused by the 2007 global financial crisis, monetary policy authorities tend to keep interest rates low to prevent an economic slump. The Bank of Korea has recently lowered the base rate to 2% in order to provide support for economic recovery and stabilization of the financial markets because of uncertainty in internal and external economic conditions. As such, the central bank provided liquidity to the market through an expansionary monetary policy in order to reduce the possibility of a recession.

The profitability of the banks, which relies mainly on interest income, has been reduced along with the decline in interest rates since 2000. Although there has been an effort to expand their non-interest income,[2)] these have yet to be effective.

The risk-taking channel is a transmission mechanism of monetary policy in which an expansionary monetary policy (i.e., low interest rates over an extended period) affects the risk appetite and the soundness of banks (Adrian *et al*., 2010; Borio and Zhu, 2008; Gambacorta, 2009; Dell'Aricciaa *et al*., 2014). There are different ways in which an expansionary monetary policy may affect bank risk.

First, there is the process of changes in bank balance sheets. In case short-term nominal interest rates are cut, there may be alterations in

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1) An estimate of the potential growth rate of Korea (Lee and Lee, 2011) shows an average of 6.3% in 1991-2000, 4.4% in 2001-2005, 4.9% in 2006-2010, and 4.3% in 2011-2020.

2) According to Annual Financial Statistics in the Financial Statistics Information System (FISIS), non-interest income of national banks in Korea reached 7.2 trillion won in 2007 and fell sharply to 3.4 trillion won in 2008.

valuations and income depending upon capital market conditions, and this may lead to changes in the risk exposure of the banks. Changes in risk perception can lead to changes in the balance sheet.

Second, there is the risk that an expansionary monetary policy may lead investors to seek higher returns through pursuing higher yielding alternative assets (Rajan, 2005). For example, if the risk-free bond yields decline, banks are likely to take on relatively greater risk to achieve their target return.

This study uses credit default swap (CDS[3)]) premiums as the risk indicators of Korean banks and as the factors affecting bank risk in order to identify the risk-taking channel of monetary policy. One of the major issues in determining the risk taking channel of monetary policy is how to separate it from other existing routes and appropriate control variables should be contained in the model.

The following question should be considered: Will low interest rates make banks take greater risks? This study is to evaluate empirically whether monetary policy affects the risk taking of Korean banks. While controlling the existing transmission mechanisms[4)] of monetary policy, this study seeks to determine the existence of the risk-taking channel. At times when financial stability stands out as one of the goals of monetary policy operations, the recognition of the risk-taking channel will provide monetary policy authorities with a new perspective in decision-making.

The second chapter of this paper examines existing research on monetary policy and bank risk. The third chapter describes data used in this study and identifies strategies used to set up an econometric model. Chapter four presents the results of the empirical analysis. Finally, the main conclusions are described.

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3) Default risk of credit default swaps will be transferred to the seller of a credit default swap from the holders of the debt securities. In the event of insolvency of debt securities, Credit default swap holders who regularly pay a fee will receive compensation for the face value of the debt securities from the seller.

4) This refers to the process by which the short-term nominal interest rate affects a real economic variable (e.g., national income, unemployment, inflation, etc.).

2. LITERATURE REVIEW

The risk-taking channel of monetary policy is associated with how changes in the policy interest rate (e.g., in Korea the base rate) affect the risk perception and risk tolerance level of financial intermediaries (e.g., banks) (Dell'Aricciaa *et al*., 2014; Adrian and Shin, 2009; Borio and Zhu, 2008). There are various ways for interest rate fluctuations to affect the risk seeking behavior of banks.

First, there is a yield search path, (Rajan, 2005; Buch *et al*., 2011). The longer the interest rates remain low, the greater is the risk that investors are willing to take. To achieve higher profits, investors may prefer to take a greater risk using various financial instruments.

Second, in case low-interest rates are prevalent, banks are able to take more risk with their valuation, earnings, and cash flow. The decline in interest rates increases the value of the assets and collateral, which can affect estimates of the probability of default and volatility. For example, a rise in stock prices can reduce corporate leverage and volatility; therefore, the banks have room to pursue greater risk (Bernanke and Kuttner, 2005). Also, changes in bank default risk lead to financial leverage through balance sheet conditions (Adrian and Shin, 2009).

Similar to the theoretical studies, the existing empirical analysis of the risk-taking channel can be split into two categories, micro-economic and macro-economic, according to the characteristics of the data used. Several studies (Gaggl and Valderrama, 2010; Ioannidou *et al*., 2009) show that bank default risk increases during periods in which interest rates are low, while one study shows conflicting results (Jiménez *et al.*, 2014).

Also some studies depend on publicly available data and use variables that reflect both macro-economic conditions and bank characteristics. These studies show that, in case interest rates remain low for an extended period, the risk taking of banks increases (Gambacorta, 2009; Altunbas *et al*., 2012) and the data types used in them are similar to those used in this paper; however, this methodology has not been used with the data of Korean banks.

Several different studies have attempted to pursue the existence of risk-taking channels in Korea. In one study, the risk-taking channel of domestic banks in Korea was shown to focus on the evolution of risk over non-core liabilities (Yun, 2012) with, for example, an increase in non-core liabilities causing an expansion of bank leverage and adding to the risk in the financial system. Also, it was shown that in a case where banks have too much foreign debt in non-core liabilities, this can cause sudden capital outflows in the de-leveraging process (Shin and Shin, 2011). In addition, another study (Lee, 2011) points out that the leverage of banks has been expanding since 2005 through increases in foreign borrowing and wholesale funding.

3. DATA

It is difficult to measure bank risk, and there is a need to use proxy variables. In this study, CDS was used as the proxy variable and the data source was Bloomberg Data, which is only available for five[5)] domestic banks.

The trends of CDS for the five banks were obtained from the fourth quarter of 2005 to the fourth quarter of 2013 (figure 1). Although there are subtle differences in the five indices, they show a similar movement over time. The indices began to rise[6)] during the third quarter of 2008 and reached a local peak in the first quarter of 2009 before declining soon after.

One feature that can be inferred from the CDS premium data by bank is that the premium per bank becomes more differentiated at times when the risk to the banks increases. On the other hand, the difference of the CDS premium per bank is insignificant at times when the banks face less risk. This study uses panel data analysis of bank risk considering the temporal aspects of cross sections.

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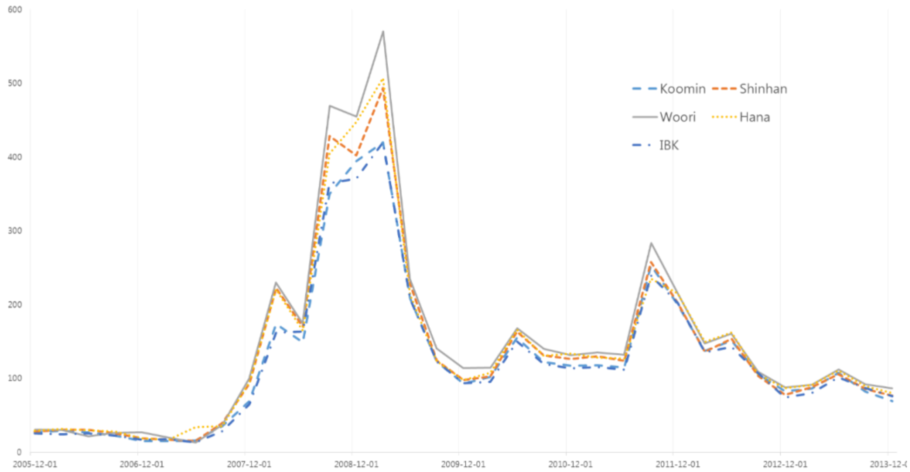
5) Kookmin Bank, Shinhan Bank, Woori Bank, Hana Bank, Industrial Bank of Korea and the like.

6) For CDS premium to rise, the likelihood of default of the underlying assets increases.

Figure 1 Credit Default Swap (CDS) Premium by Banks



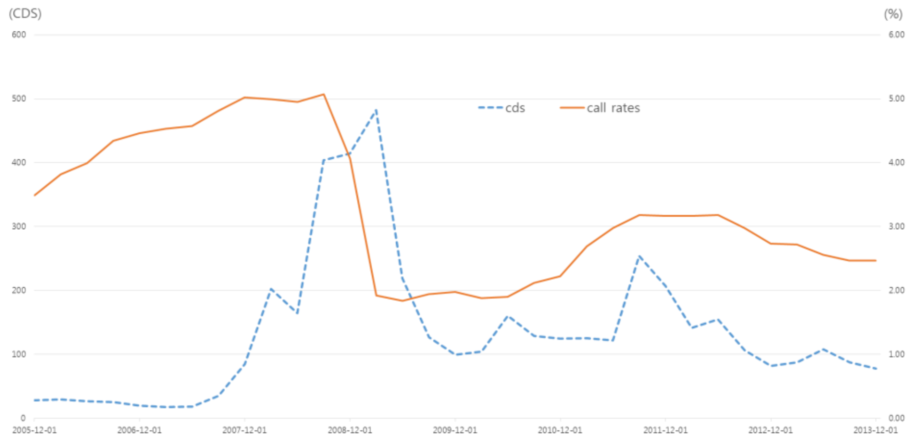
Source: Bloomberg.

In terms of the length and scope, the variables on the right-hand side of the econometric model are harmonized with the CDS premium. The control variables (the nominal short-term interest rate, nominal GDP growth rate, inflation rate, exchange rates, asset prices, slope of the yield curve, etc.) are extracted from the Bank of Korea Economic Statistics System. The bank-specific variables (asset size, liquid ratio, capital adequacy ratio, and credit growth rate, etc.) are provided by the financial statistical information system of the Financial Supervisory Service (FSS).

The relationship between the quarterly average value of the CDS premiums of the five banks and interbank call rates (figure 2) show that, for a given time period, the two variables are negatively correlated; however, at a time when financial instability is heightened, as the interbank call rates are falling, bank risk generally seems prone to decline.[7)]

[7)] The inter-bank call rate from the fourth quarter of 2008 to the second quarter of 2009 was respectively 4.06%, 1.92%, and 1.84% on a quarterly basis. During the same period, credit default swap (CDS) values were 414.3, 482.4, and 218.7. CDS values rose when the call rate was declining sharply during the first two quarters. In the subsequent quarter, the call rate fell slightly; whereas the CDS values decreased significantly.

Figure 2 The Average Value of CDS Premium and Short-term Nominal Interest Rate



Source: Bloomberg, Bank of Korea.

A summary statistics table of the data based on quarterly observations of the five banks from the fourth quarter of 2005 to the fourth quarter of 2013 is shown in table 1 along with the data source. The data used in this study relates to four commercial banks (Kookmin, Shinhan, Woori, and Hana) and one specialized bank (IBK). The summary statistics table is based on variables consisting of the long panel. The big differences between the minimum and maximum of the selected variables help to identify the relevance of bank risk and those variables. In particular, the short-term nominal interest rate has shown a large variation from 1.88% to 5.13%, while the CDS premium ranges from 2.57 to 6.35. Table 2 shows the correlation between the measure of bank risk and the other variables.

Quarterly data are used in this study, although some variables exist on a daily basis, such as interest rates. The CDS premiums and most bank-specific data are available on a quarterly basis, and also macroeconomic variables such as output growth are mainly available as quarterly data. The unit root test results of the variables selected in this study are presented in the summary statistics table.

Table 1 Summary Statistics[1] (2005Q4-2013Q4)

Variables	Obs	Mean	Std.Dev	Min	Max	Unit Root[2]	Sources
lncds	165	4.550	0.912	2.565	6.347	0.0001	Bloomberg
call	165	3.336	1.058	1.880	5.130	0.0312	BOK
bel_nr	165	16.52	4.370	11	24	0.0000[3]	Author's Calculation
ngdpg	165	5.694	2.468	1.711	10.716	0.0002	BOK
cpi	165	2.823	1.085	1.068	5.541	0.0231	BOK
sm	165	–0.079	3.318	–9.490	6.164	0.0000	BOK
hp	165	–0.044	0.472	–0.725	2.089	0.0218	KOSIS
fx_dol	165	0.170	4.985	–7.473	13.830	0.0000	BOK
slope	165	0.759	0.720	–0.120	2.340	0.0201	BOK
size	165	19.005	0.294	18.142	19.408	0.0000	FSS
liq	165	0.002	0.074	–0.161	0.298	0.0000	FSS
cap	165	0.007	0.049	–0.164	0.190	0.0000	FSS
bis	165	0.005	0.057	–0.242	0.299	0.0000	FSS
overlend	165	0.108	6.193	–6.190	75.44	0.0000	Author's Calculation

lncds = Credit Default Swap (CDS) Premium (Log Value)
call = Call Rate
bel_nr = Number of Consecutive Quarters with Short-term Interest Rate below the Natural Rate since the First Quarter of 2000
ngdpg = Nominal GDP Growth
sm = Quarterly Change in Stock Market Returns
hp = Quarterly Change in the Housing Price Index (Seasonally Adjusted), 2013.3=100
cpi = Inflation Rate
slope = Government Bond Yield (3-year) – The Base Rate
fx_dol = Won/U.S.dollar Exchange Rate
size = Log of Total Assets (Million Won)
liq = Liquid Debt to Liquid Assets *100 (Log Difference)
cap = Capital to Assets * 100 (Log Difference)
bis = BIS Capital Adequacy Ratio (Log Difference)
overlend = Excessive Credit Expansion (Demeaned)

Notes: 1) The summary table uses quarterly observations of five domestic banks. 2) The panel data unit root test results are provided. Here an LLC (Levin-Lin-Chu) test is implemented. It is appropriate to perform the unit root test when the panel data is balanced and *T* goes to infinity. This test assumes the null hypothesis that all panels have unit roots. In this column, the *p*-values are shown. If the *p*-value is less than the significance level (e.g., 0.05), reject the null hypothesis. If that is the case, it turns out that the panel is stationary. 3) A linear trend is removed.

Table 2 Correlation Matrix

	lncds	*ngdpg*	*cpi*	*size*	*overlend*	*fx_dol*	*hp*	*sm*	*cap*	*bis*	*call*	*liq*	*slope*	*bel_nr*
lncds	1.00													
ngdpg	–0.16	1.00												
cpi	0.59	0.22	1.00											
size	0.45	–0.14	0.05	1.00										
overlend	–0.10	–0.02	–0.02	–0.05	1.00									
fx_dol	0.45	0.05	0.57	0.07	0.00	1.00								
hp	–0.42	0.17	0.04	–0.26	0.07	–0.12	1.00							
sm	–0.42	0.15	–0.42	–0.10	–0.06	–0.64	0.03	1.00						
cap	–0.09	–0.10	–0.12	0.01	–0.07	–0.43	0.04	0.28	1.00					
bis	0.12	–0.33	–0.02	0.09	–0.17	–0.10	–0.25	–0.09	0.33	1.00				
call	–0.34	0.15	0.32	–0.35	0.10	0.35	0.35	–0.28	–0.29	–0.16	1.00			
liq	0.07	0.00	0.07	0.05	–0.03	0.05	0.00	–0.05	0.00	0.10	–0.06	1.00		
slope	0.23	0.24	0.11	–0.02	–0.02	–0.15	–0.19	0.18	0.28	0.26	–0.51	0.12	1.00	
bel_nr	0.30	–0.21	–0.28	0.49	–0.13	–0.20	–0.02	–0.26	0.10	–0.03	–0.62	–0.03	–0.25	1.00

The panel data type is different from a usual long panel format because the number of the panel (*N*) is smaller than the number of the time variable (*T*). If the time length is long, the unit root test should be carried out by the variables included in the model. Of the specific unit root tests for the panel data, the LLC (Levin-Lin-Chu) method is used. This method is used because the panel data is balanced and, as the dataset has a small number of panels and a large number of time periods, *N* approaches to infinity at a slower rate than *T*. The null hypothesis of this test is that the panel has a unit root. The unit root test results show that the selected variables are stationary.

4. ECONOMTRIC MODEL

4.1. Quantitative Model

The quantitative model is designed to determine the factors affecting bank risk and describes the behavior of bank risk perception. The CDS premiums[8)] is used as an indicator of bank risk. There may be a number of indicators that can be used to represent bank risk, and the CDS premium was used in this study. Additionally, the estimated stock price volatility and the risk premium[9)] of the selected banks were utilized for robustness testing.

The elements to explain bank risk are composed of the control variables to describe the overall condition of the economy as well as the variables shown on the balance sheet of the bank. Thus, it is possible to identify the risk-taking channel and examine the effect of monetary policy on bank risk.

In this study, a model based on dynamic balance panel data is used to describe the risk behavior of domestic banks:

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8) The only five banks for which CDS premiums can be obtained from the Bloomberg Terminal are Kookmin, Shinhan, Woori, Hana, and IBK.

9) Risk premiums are the average additional returns required by an investor as compensation for investing in equities rather than a risk-free instrument.

$$y_{it} = \gamma y_{it-1} + X'_{it}\beta + \sum_{j=1}^{3} q_j + u_{it}, \ i = 1, \ \ldots, N, \ t = 1, \ \ldots, T, \qquad (1)$$

where the dependent variable, y_{it}, is a risk measure faced by the banks, γ is a parameter, and X'_{it} is $1 \times K$ vector of explanatory variables which consist of the control variables and the bank-specific characteristics. β is $K \times 1$ vector of coefficients to be estimated and q_j is a quarter-dummy variable. u_{it} follows $u_{it} = \alpha_i + \mu_{it}$, where α_i is the unobserved panel-level effects which may be correlated with X_{it}, and μ_{it} are independent and identically distributed (i.i.d.) with σ^2_μ.

Of variables that describe bank risk, liquid ratio ratio, capital adequacy ratio, and the excess credit ratio may be correlated with the error terms. Those observed bank-specific variables are set to endogenous variables. In addition, the nominal GDP growth, nominal short-term interest rates, the won/dollar exchange rate, inflation rate, the slope of the yield curve, stock price index rate, housing price percentage change, seasonal dummy[10] variables, etc. are considered as exogenous variables.

In equation (1), the risk of a bank at a specific point in time and the logarithm values of the CDS premium are affected by many variables that are listed on the right side of the equal sign. The short-term nominal interest rate represents a change in monetary policy (i.e., inter-bank call rates). Control variables, such as nominal GDP growth rate, the slope of the yield curve, inflation rate, capital adequacy ratio, exchange rate, and seasonal dummy variables are included in order to represent the macro-economic conditions. Also, there are bank-specific variables representing bank attributes, such as asset size, capital-to-asset ratio, liquid ratio, and excess credit growth.

Nominal interest rate cuts in the short term (i.e., expansionary monetary policy) increase the collateral value of the borrower, thereby raising the value of the bank's existing total loans. As a result, the risk indicators of the banks decline and the estimated coefficient is expected to have a positive

[10] A quarter is excluded in order to avoid multiple collinearity issues.

sign. Also, the sign of the coefficient for the number of consecutive quarters (*bel_nr*) in which short-term interest rates are below the natural interest rate is expected to be positive. As the value of *bel_nr* increases, the expansionary monetary policy is operating. This means that bank risk becomes greater as the period of low interest rates increases.

The sign on the parameter estimates of economic growth is expected to be negative. In case the economy is good, the number of business projects is expected to increase and lead to bank profits; therefore, it has the effect of reducing the credit risk of the bank (Kashyap *et al*., 1993). The inflation rate is included in the model to block a path where events that occurred in the banking sector affect monetary policy. In order to maintain financial stability, the central bank's priority is price stability (Bernanke and Woodford, 2005). In case the value of the assets increases owing to inflation, bank risk is reduced. In the opposite case, bank risk increases.

The parametric estimate for the slope of the yield curve is expected to have a negative sign. The steeper the slope of the yield curve, the greater are the bank profits (Viale *et al*., 2009). For example, if the slope of the yield curve declines, profitability will fall owing to the nature of the transformation in bank assets, and this will naturally reduce bank lending. Thus, an economic downturn happens because of a reduction of credit supply to the real sector (Adrian *et al*., 2010).

Those variables that capture the bank-specific characteristics include asset size, liquid ratio, capital-to-asset ratio, and excess credit growth. Bank assets do not have a clear effect on bank risk. If the expansion of bank assets increased leverage, then bank risk would increase (Demsetz and Strahan, 1997). While the liquid ratio and capital-to-asset ratio change, the other variables remain fixed. In the case where liquid assets are in abundance or bank capital is sufficiently maintained, bank risk will be relatively low. Excess credit[11)] growth of individual banks may be negligible irrespective of the size of the estimate. A study (Shin, 2009)

[11)] The gross credit of individual banks consists of total loans, commercial paper (CP), acceptances and guarantees, and repurchase agreements.

demonstrates that there is no significant relation between traditional bank lending and a bank's risk level. In the case of Malaysia, the increase in gross domestic credit lowers the credit risk of the bank (AlizadehJanvisloo and Muhammad, 2013).

For the purpose of controlling the level of bank regulation, this study uses the BIS capital ratio[12)] under Basel II as a proxy variable. A rise in the capital adequacy ratio, which is enhanced regulation effect, is expected to reduce bank risk. As in the case of the U.S.A., if commercial banks are involved heavily in investment banking services, such activities can be used to measure changes in the regulatory level. A previous study (Stiroh, 2006) claims that in case banks provide a wider range of services than traditional banking services as a result of deregulation, the risk facing the banks is reduced owing to risk diversification. In Korea, the involvement of domestic banks in investment banking services is very limited; therefore, this study uses the capital adequacy ratio to represent regulatory levels.

4.2. Identification Strategy of the Risk-taking Channel

This study attempts to analyze the risk-taking channel of monetary policy, which is distinguished from conventional financial accelerator path (Bernanke and Gertler, 1989) such as the financial accelerator mechanism, bank-lending channel, and the exchange rate channel.

The financial accelerator mechanism refers to a path in which monetary policy is transmitted through the net worth of the borrower (i.e., corporations and households). For example, in case monetary policy is tightened, the collateral value of the borrower will be lowered, thereby reducing the overall credit limit; aggregate demand shrinks and production is reduced. This causes the net assets of businesses and households to decrease. This path results in bank loans and investments being reduced further. In this case, banks would enhance the screening of borrowers and this position is likely to

12) BIS capital ratio = (owner capital based on BIS/risk weighted assets)*100, owner capital based on BIS = core capital + tier 2 – exemptions.

reduce the loan amounts of borrowers. While monetary policy is focusing on the impact on the balance sheet of the borrower in the financial accelerator mechanism, an analysis of the risk-taking channel is also needed to determine the impact of monetary policy on bank risk levels.

For an analysis of the risk-taking channel, this study set control variables that affect the value of net worth and collateral. Stock price change and housing price change are used as control variables of the financial accelerator mechanism. The corresponding parameters of these variables are used to measure the impact of changes in the asset prices on bank risk, given the risk attitude of the bank, through changes in the borrower's collateral value. A rise in asset prices enhances the collateral value and lowers the overall credit risk.

The risk-taking channel is also distinguished from the bank-lending channel. In accordance with the bank-lending channel, a fall in the short-term nominal interest rate enables the amount of funds available to be expanded and, thereby, aggregate demand rises as the amount of loans rises.

Variables that describe bank-specific attributes (i.e., asset size, liquid ratio, capital adequacy ratio, etc.) controlling the bank-lending channel are included in the explanatory variables in this study. The bank-lending channel is based on the view that the bank-specific attributes affect the supply of bank loans. A previous study (Kang and Kim, 2010) shows a generally negative correlation between total bank loans and bank risk. The bank-specific variables are specified as endogenous ones in order to avoid endogeneity problems in the process of estimating a system Generalized Method of Moment (GMM).

In addition, the risk-taking channel is differentiated from the exchange rate channel. In accordance with the exchange rate channel, expansionary monetary policy leads to a fall in relative yields of domestic assets and then a decline in domestic asset prices; therefore, the domestic currency declines in value. However, in a small open economy such as that of Korea, the exchange rate tends to be highly dependent on foreign economic conditions. In cases such as that of Korea, if the expansionary monetary policy results in an influx of foreign investment, there is also the possibility of a rise in the value of the domestic currency because of price rises and increased demand for the domestic currency.

In order to control the exchange rate mechanism, the won/dollar exchange rate is included in the model. The effect of exchange rate fluctuations is expected to appear differently depending on the value of foreign-currency-denominated assets and liabilities of the bank. For example, in the case where foreign-currency-denominated assets are greater than foreign-currency denominated debts, a decline in the value of the domestic currency would have the effect of improving financial conditions, while in the opposing case it would worsen the financial conditions (Bank of Korea, 2012).

4.3. Constraints of the Identifying Strategies

One constraint that might appear in the identification strategy adopted in this study is that the situation in the banking sector may be associated with monetary policy decisions. Although a primary objective of monetary policy is price stability, the Bank of Korea should take into account financial stability in order to achieve sustainable growth of the national economy. Monetary policy authorities should consider policy stability in their policy efforts,[13] and this will affect monetary policy decisions. For example, when the monetary authorities take measures to ensure financial stability such a move is included in the error term and influences the dependent variable of bank risk indicators.

This situation can cause endogeneity problems. In other words, the lagged short-term nominal interest rate chosen as one of the key variables can be correlated with the error term, making the standard estimators inconsistent. Also, it is easy to increase improperly the size of the estimated

[13] The Bank of Korea Act Article 1 paragraph 1 prescribes the purposes of the Act as, “establish Bank of Korea and the establishment and enforcement of effective monetary credit policy by maintaining price stability and contribute to the sound development of the national economy”. In addition, Article 1 paragraph 2 of the Act states that, “the Bank of Korea in carrying out monetary credit policy should note financial stability”.

value of the parameter in the quantitative model. In this paper, a system GMM panel analysis is used in order to mitigate these endogeneity problems. A system estimator uses moment conditions in which lagged differences are used as instruments for the level equation in addition to the moment conditions of lagged levels as instruments for the differenced equation.

4.4. Estimation Method

In case the number of the panel is relatively smaller than the number of the time period, asymptotic distribution[14)] and standard errors of the sample applied to a conventional panel analysis can be used (Stock and Watson, 2012). In case the length of the time variable is large, additional assumptions of normality and the same variance of the error term are not required for using *t*-distribution to obtain the standard error of the panel data sample.

If one is using a dynamic panel model, the lagged-dependent variables of the bank risk are on the right hand side of the equation (1). This means that there is correlation between the lagged-dependent variables and error terms. In such cases, the two-stage least-squares first-differenced estimator (Anderson and Hsiao, 1981) has been proposed to overcome the endogeneity problems generated between the lagged-dependent variables and the error terms. The estimation method satisfies consistency (not efficiency) of the parameter estimates in case the length of the time variables is limited.

One of the characteristics of the dynamic panel data estimation proposed by Arellano and Bond (1991) is that, unlike the estimation based on Anderson and Hsiao (1981), it attempts to use all the information available from the samples. That means that the number of instrumental variables produced by the variables listed on the right side of the quantitative model

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[14)] In case N is small and T is large, we still use t-statistics and F-statistics. These distributions are valid under assumptions as follows: first, the error term has conditional mean zero; second, the explanatory variables and the error terms are i.i.d. from their joint distribution; third, the explanatory variables and the error terms have nonzero finite fourth moments; fourth, there is no perfect multicollinearity.

increases. In the estimation process, the endogenous variables are instrumented with GMM-style instruments, i.e., lagged values of the variables in levels. The included exogenous variables use first differences as their own instruments. In this case, the number of instrumental variables increases significantly. This usually increases efficiency.

In case the number of the panel is relatively smaller than that of the time periods, whether to bring the panel data into the conventional dynamic model or not should be checked beforehand. A Monte Carlo simulation study[15)] (Judson and Owen, 1999) was carried out on the basis of a dynamic panel data model. According to the results, first, as the length of the time variable increases, estimates based on Anderson and Hsiao (1981) work well. Second, computational efficiency is improved by the parameter estimates based on the GMM that use a subset of the lagged values as instruments.

The weakness of the Arellano and Bond estimation is that the lagged levels of endogenous variables included in the model do not work well as instruments for the first-differenced variables on the right hand side of the equation (1). In particular, it occurs that the level of endogenous variables or the lagged dependent variables follow a random walk. The estimation method used in this study is a system GMM proposed by Arellano and Bover (1995) and Blundell and Bover (1998). The method improves the properties of the finite sample, as well as the accuracy of the parameter estimates, compared with the Arellano and Bond (1991) method.

When applying GMM for dynamic panel data, attention should be paid to whether the second-order autocorrelation exists. Only when estimated parameters are free from second-order autocorrelation, they maintain efficiency and consistency.

4.5. Estimation Results

The purpose of this study is to find out whether the risk-taking channel of

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15) Criterion for evaluating various estimation techniques is unbiased of the parameter estimates. In other words, less bias is considered to be a more accurate estimate.

monetary policy exists and to verify whether or not individual banks take more risks for time periods when interest rates are kept low. The main results of the quantitative model analysis are shown in table 3. According to the results estimated using the one-step system GMM, a Sargan test suggests that the overidentifying instruments are valid. An autocorrelation test does not present a correlation between the error terms. That is, the output does not present evidence that the model is misspecified.

The analysis confirms the presence of the risk-taking channel of monetary policy. In case the other variables remain constant, the estimate for the major variable, *bel_nr*, turns out to be a positive and significant. This confirms that a risk-taking channel exists. As the period of low interest rates becomes longer, banks are willing to take greater risks. These results are consistent with previous studies (Jiménez *et al*., 2014; Gambacorta, 2009; Ioannidou *et al*., 2009).

This study considers the nominal GDP growth (*ngdpg*) and inflation rate (*cpi*) in order to control the domestic macroeconomic conditions. Nominal GDP growth has a negative impact on the bank risk. Economic growth means that the economy is in good shape; there will be improvement in the future returns on investment. This reduces the credit risk of a bank. According to the analysis results, a 1 percent rise in the nominal GDP growth rate leads to about a 4.5 percent reduction of the CDS premium. Also, note that the parameter estimates of the first and second lagged-variables are significant at the 1 percent level. The overall effect on bank risk of nominal GDP growth is negative on the basis of the sum of the estimates of the lagged variables.

While inflation rate (*cpi*) is positively associated with bank risk, the first-lagged variable of the inflation rate has a negative impact on bank risk. All parameter estimates are found significant at the 5 percent level. Contemporaneously the increase in inflation rate results in higher bank risk. On the other hand, change in the first lagged variable of the inflation rate causes bank risk to be reduced.

Table 3 Determinants of Bank Risk

Classification	Variable Names	Coefficients	Std. Errors
Dependent Variable	$lncds_t$		
	$lncds_{t-1}$	0.818***	0.050
	$call_t$	0.183***	0.050
A Major Explanatory Variable	bel_nr	0.021***	0.004
Macroeconomic Variables	$ngdpg_t$	–0.045***	0.010
	$ngdpg_{t-1}$	0.067***	0.010
	$ngdpg_{t-2}$	–0.049***	0.012
	$slope_t$	–0.109	0.071
	$slope_{t-1}$	0.310***	0.102
	fx_dol_t	0.040***	0.004
	fx_dol_{t-1}	–0.001	0.003
	sm_t	–0.013***	0.004
	hp_t	–0.210***	0.044
	cpi_t	0.163***	0.044
	cpi_{t-1}	–0.101***	0.029
	bis_t	–0.353	0.523
	bis_{t-1}	0.614	0.505
Bank-specific Variables	$size_t$	0.160	0.391
	$size_{t-1}$	–1.054**	0.428
	$size_{t-2}$	1.035**	0.484
	cap_t	–0.398	0.501
	cap_{t-1}	0.641*	0.369
	cap_{t-2}	0.209	0.312
	liq_t	–0.462***	0.144
	liq_{t-1}	–0.444**	0.211
	liq_{t-2}	–0.362	0.257
	$overlend_t$	–0.003	0.004
	$overlend_{t-1}$	0.004	0.004
	$overlend_{t-2}$	–0.001***	0.000
Constant	*const*	–2.946	2.078

Number of Banks: 5

Number of Observations: 155

Sargan Test (*p*-value): 0.6237

AR(1) *p*-value, AR(2) *p*-value: 0.0528, 0.1037

Notes: All variables range between the fourth quarter 2005 and the fourth quarter 2013. *, **, and *** indicate significance levels of 10%, 5%, and 1% respectively.

The slope of the yield curve (*slope*) has a negative impact on bank risk. A relatively steep yield curve implies a rise in long-term interest rates. A steeper yield curve increases the revenue of the bank and lowers bank risk because of the nature of long-term loans, which are based on funds financed by short-term deposits. However, the sign of the estimate for the first-lagged variable is positive and a steeper yield curve appears to increase bank risk in the subsequent period.

To distinguish the risk-taking channel from the financial-accelerator channel, it is necessary to control the net worth and the collateral value of the borrower. The quantitative model in this study includes stock price change (*sm*) and house price change (*hp*). The parameter estimates of those variables are all negative and are significant at the 5 percent level. The result is consistent with theoretical predictions. The rise in asset prices increases the collateral value and results in increased net assets for the borrower and thereby reduces the credit risk of the bank.

According to the analysis results, changes in house prices have a greater impact on bank risk than stock price change. A 1 percent rise in house prices causes a reduction in the CDS premium of about 21 percent, whereas a 1 percent rise in stock prices leads to a 1.3 percent reduction of the CDS premium. In an earlier study (Altunbas *et al*., 2012), a rise in house prices has an inverse relationship with bank risk in countries where a housing price bubble has not materialized. In the case of Korea, there is no boom and bust of the real estate market during the period analyzed in this study so that the relationship between the two variables in Korea can be expected to be negative.

The won/dollar exchange rate (*fx_dot*) is chosen as one of the control variables for the purpose of controlling the exchange rate mechanism. An exchange rate depreciation will increase bank risk and the associated parameter estimate is significant at the 5 percent level. If the exchange rate depreciates and there is a net outflow of foreign investment at the same time, then bank risk may also increase owing to a decline in asset value. The decline in asset value seems to have a real explanatory power. On the other hand, for the first-lagged variable, exchange rate depreciation reduces the future bank risk, but the relevant parameter estimate is not statistically significant at the 5 percent level.

To distinguish the risk-taking channel from the bank-lending channel, this study uses bank characteristic variables such as excess credit growth (*overlend*), asset size (*size*), liquid ratio (*liq*), and capital-to- asset ratio (*cap*), etc. When the excess credit growth of individual banks rises, the bank risk contemporaneously appears to decrease. More specifically, in the case of a 1 percent increase in excess credit growth, the CDS premium is reduced by approximately 0.3 percent. The corresponding parameter estimate is not statistically significant. On the other hand, the parameter estimates of the first and second-lagged variables are significant at the 5 percent level.

The bank-specific variables, such as asset size, liquid ratio, and capital-to-asset ratio, included as the endogenous variables in the model form inverse relationships with bank risk. An increase in both liquid ratio and capital-to-asset ratio appears to decrease bank risk. The coefficient of the capital-to-asset ratio is not statistically significant at any level and the coefficient of the liquid ratio is statistically significant in both the level and the first-lagged variable at the 5 percent level. A rise in bank asset size is found to increase bank risk; however, the estimated parameter, contemporaneously, is not statistically significant at the 5 percent level.

Finally, although the estimated parameter of the capital adequacy ratio (*bis*), which is used as a proxy variable of the regulatory level, is not statistically significant, it shows a negative sign. However, the effect of the first-lagged regulatory level on the bank risk turns into a positive sign and is statistically significant at any level.

4.6. Robustness Tests

Robustness tests that either examine specific sub-samples or take two different bank risk measures are reported in table 4.

Results using data from a particular sub-period, excluding three quarters

Table 4 Robustness Tests for Bank Risk

$lncds_t$ (or $lnvol_t$, $lnriskprem_t$)	Dynamic Panel ($lncds_t$) (except 08Q3-09Q1)		Volatility ($lnvol_t$) (2004Q1-2013Q4)		Risk Premium ($lnriskprem_t$) (2002Q2-2013Q4)	
$lncds_{t-1}$(or $lnvol_{t-1}$, $lnriskprem_{t-1}$)	0.607***	(0.055)	0.239***	(0.077)	0.553***	(0.052)
$call_t$	0.364***	(0.090)	0.140***	(0.025)	–0.064***	(0.022)
bel_nr	0.107***	(0.010)	0.005	(0.006)	0.011***	(0.004)
$ngdpg_t$	0.056***	(0.016)	–0.040*	(0.023)	0.046***	(0.012)
$ngdpg_{t-1}$	0.056***	(0.010)	0.024	(0.016)	–0.054***	(0.008)
$ngdpg_{t-2}$	–0.025	(0.017)	0.004	(0.013)	0.014**	(0.005)
$slope_t$	–0.126	(0.130)	0.419***	(0.029)	–0.005	(0.036)
$slope_{t-1}$	0.348***	(0.046)	–0.128***	(0.044)	–0.004	(0.047)
fx_dol_t	0.029***	(0.006)	0.021***	(0.004)	–0.001	(0.001)
fx_dol_{t-1}	0.020***	(0.004)	0.007**	(0.003)	–0.001	(0.002)
sm_t	–0.086***	(0.009)	–0.063	(0.039)	–0.008	(0.012)
hp_t	–0.479***	(0.110)	–0.002	(0.006)	–0.010***	(0.004)
cpi_t	0.084	(0.084)	–0.113***	(0.042)	–0.007	(0.021)
cpi_{t-1}	–0.092**	(0.039)	0.131**	(0.054)	0.086***	(0.013)
bis_t	–0.716	(0.584)	–0.417	(0.330)	0.032	(0.251)
bis_{t-1}	1.240*	(0.658)	0.091	(0.438)	0.504**	(0.211)
$size_t$	–1.234	(0.756)	0.336	(0.782)	–0.028	(0.253)
$size_{t-1}$	1.967***	(0.476)	0.251	(0.576)	0.197	(0.287)
$size_{t-2}$	–0.633	(0.907)	–0.532	(0.482)	–0.116	(0.371)
cap_t	–0.227	(0.583)	0.244	(0.218)	–0.102	(0.177)
cap_{t-1}	0.176	(0.344)	0.246	(0.234)	0.126	(0.170)
cap_{t-2}	–0.877**	(0.404)	0.101	(0.240)	0.065	(0.196)
liq_t	–0.084	(0.195)	–0.425**	(0.185)	–0.019	(0.064)
liq_{t-1}	–0.602*	(0.346)	–0.484**	(0.228)	–0.124	(0.089)
liq_{t-2}	0.066	(0.340)	–0.187	(0.180)	0.016	(0.081)
$overlend_t$	–0.001	(0.012)	–0.004	(0.008)	–0.000	(0.002)
$overlend_{t-1}$	–0.007*	(0.007)	–0.010*	(0.005)	–0.002	(0.003)
$overlend_{t-2}$	0.000	(0.001)	–0.003*	(0.002)	0.001	(0.002)
$const$	–4.016	(2.967)	0.850**	(0.336)	–0.239*	(0.139)
No. Obs	130		266		450	
No. Panels	5		7[1)]		10[2)]	
Sargan Test (p-value)	0.9993		0.2283		0.2504	
AR(1) (p-value)	0.0534		0.0286		0.0036	
AR(2) (p-value)	0.1449		0.2681		0.3145	

Notes: 1) Kookmin, Shinhan, Woori, Korea Exchange, Jeonbuk, Cheju and IBK banks are included. 2) Kookmin, Shinhan, Woori, Hana, Korea Exchange, Daegu, Busan, Jeonbuk, Cheju and IBK banks are included. *, **, and *** indicate significance levels of 10%, 5%, and 1% respectively. The coefficients for the quarter dummy variables are not reported. The numbers in parentheses are robust standard errors.

(2008Q3, 2008Q4, and 2009Q1) with the highest financial instability index as provided by the Bank of Korea, are shown in Column 2. The sign and the significance of the coefficients associated with the short-term interest rate (*call*) and the number of consecutive quarters with interest rates below the natural rate (*bel_nr*) are similar with those results for the benchmark shown in table 3.

The estimation results for the use of volatility as a dependent variable are reported in Column 3. This robustness test is aimed at checking whether the outcomes for dynamic panel analysis in table 3 hold or not in case a different bank risk measure is used. Data for the volatility measure are available from the second quarter of 2002 to the fourth quarter of 2013, thereby extending the number of observations in the sample. The effect of the risk-taking channel is detected. The coefficients of the short-term interest rate (*call*) are statistically significant and have a positive sign. Also, the estimated coefficient for the number of consecutive quarters with an interest rate below the natural rate (*bel_nr*) has a positive sign, but is not statistically significant.

A robustness test based on a different bank risk measure, the risk premiums of the banks, is shown in Column 4. According to the results, the estimated coefficient for the short-term interest rates (*call*) is negative and significant. On the other hand, the variable, *bel_nr*, has a positive and significant impact on bank risk.

5. CONCLUSIONS

To examine the hypothesis that expansionary monetary policy increases bank risk, this study takes advantage of the resources of five domestic banks in Korea. The results show that an expansionary monetary policy increases bank risk as measured by CDS premiums. This is commonly found in existing studies (Jiménez *et al*., 2014; Ioannidou *et al*., 2009; Gambacorta, 2009).

The estimated parameters of the endogenous variables, such as liquid ratio and capital-to-asset ratio, that reflect the bank-specific characteristics have various impacts on bank risk in a comparison with exogenous monetary policy shocks; however, of more significance is that, according to the robustness test results, a decrease in interest rates for considerable time periods increases bank risk.

The implications of this analysis are, first, in terms of individual banks, that banks can manage potential risks through distributing resources appropriately by recognizing the risk-taking channel of monetary policy. Second, in terms of the monetary policy maker or regulatory authorities, in addition to the traditional mechanism of monetary policy, it is necessary to pay particular attention to monetary policy adjustment because the risk-taking channel affects the financial stability of the overall economy through the risk of the banking system.

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