

## **A Disequilibrium Model of the Korean Credit Crunch\***

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Using a disequilibrium model, we try to identify the periods of the Korean credit crunch. There appears no severe credit crunch in the first half of 1990s. However, four credit crunches have been identified after 1995, which is 1995:2-1995:3, 1996:11-1996:12, 2004:6-2004:8 and 2004:12-2005:3. The main cause of the recent credit crunch might come from the real economy as well as loan market itself. While estimation of a disequilibrium model obviously sheds light on some aspects of the causes of the Korean credit crunches, there is a certain limitation to understanding the fundamental causes behind them. Investigation of changes in the economic system and institutional factors will supplement the lack of proper explanation of the credit crunches.

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## 1. INTRODUCTION

The East Asian financial crisis of 1997 caused a reduction in the credit supply in many of the region's economies. The monetary authorities implemented a variety of monetary policies to smooth the flow of credit when the credit supply was greatly reduced during the crisis. They expanded the supply of money at the outset of the crisis and decreased interest rates later. In spite of such efforts, private credit in real terms did not bounce back right away. It took a while for real credit supply to recover to pre-crisis level in the crisis-hit countries.<sup>1)</sup> Korea also experienced such a similar credit shortage problem right at the beginning of the crisis. While much work has been done about the causes and predictability of the financial crisis itself, there has not been much research about the credit crunch. In this study we identify the periods of the Korean credit crunch using an econometric model.

According to the Council of Economic Advisors (1991), a credit crunch is defined as a situation in which an unusually sharp decline in the supply of credit generates an unsatisfied excess demand for credit at the prevailing interest rates. Similarly Bernanke and Lown (1991) define a bank credit crunch as a significant leftward shift in the supply curve for bank loans, holding constant both the safe real interest rate and the quality of potential borrowers. In our study we define a situation as a credit crunch if the supply of real credit declines and there exists excess demand for real credit in the loan market.<sup>2)</sup> Whereas the concept of credit crunch is straightforward, it is not always easy to identify the existence of a credit crunch simply from studying the loan market.

To evaluate the monetary policy stance, it is enough to examine the evolution of key macroeconomic variables in normal time. But it becomes complicated during the crisis, because the relationship between monetary

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<sup>1)</sup> It took 20 months for the real credit to recover to the pre-crisis level.

<sup>2)</sup> Hahm and Jung (2000) formally define concepts of credit rationing, credit differentiation, capital crunch and credit contraction separately.

policy instruments and nominal income changes drastically. We will review this relationship later. Ding *et al.* (1999) propose an interesting hypothesis to identify a credit crunch based on the literature in this field. In a situation of credit crunch, the external finance premium is likely to increase, thus increasing the cost of borrowing. This increase in the cost of borrowing is the effect of two channels, the balance sheet channel and the bank lending channel.

The balance sheet channel emphasizes the potentially depressing impact of credit tightness on borrowers' assets and profits, including variables such as borrowers' net worth, cash flow and liquid assets. In a credit crunch situation, the risk premium is increased. Increasing the risk premium reduces both business profits and the value of assets that firms have posted as collateral. This will increase the wedge between the interest rates at which corporations can borrow and the yields on risk-free assets.

The bank lending channel focuses more on the retrenchment in the supply of loans. The monetary squeeze raises the interest rates even for government bonds, which may be considered to be risk-free. Banks cannot increase deposit rates by as much since they have to build required reserves. This means that banks suffer a deposit drain as investors reshuffle their portfolios towards higher interest bearing assets. As a result of the deposit drain, banks have to adjust their portfolios. If banks differentiate between making loans and holding government bonds, they will be unwilling to deplete their holdings of government bonds below a certain level. Therefore the deposit drain will probably lead banks to restrict their loan supply. Since the majority of firms do not issue corporate bonds on the market in reality, bank lending rates will increase. Through the bank lending channel, we expect that the wedge between bank lending rates and yields on corporate bonds will increase.

A credit crunch usually entails another phenomenon, as well as the risk premium increase, called flight to quality. Banks not only restrain the supply of credit but also adopt more restrictive lending policies. When a deposit drain squeezes their resources and credit risk heightens, banks try to

screen their loan applicants. They prefer credit worthy applicants to ones with a bad credit rating. Another form of flight to quality is a reallocation of bank assets away from lending to the corporate sector and toward government bonds.

The above description explains a typical framework to examine the existence of a credit crunch. Ding *et al.* (1999) apply this framework to investigate whether and to what extent East Asian countries have been suffering from a credit crunch in the aftermath of the recent crisis. They found some evidence supporting the existence of a credit crunch in Korea: (i) the risk premium on corporate bonds and the spread between the overdraft lending rate and the yield on corporate bonds increased greatly; (ii) bank holdings of government bonds also increased.

In this study we apply a more quantitative model to identifying the existence of a credit crunch and understanding the underlying structure causing the credit crunch to occur in the aftermath of the Korean crisis. In this paper a disequilibrium model of the Korean credit market is constructed to identify the periods of the credit crunch. Monthly banking data such as total loans and deposits of deposit money banks (DMBs) are used.

From the estimation of the model we realize that excess demand for real loans was widespread before the financial crisis. However, such a situation is not considered a credit crunch since the supply of real loan increased. But the loan market condition became very tight right after the outbreak of the crisis, so that the supply of real loans began to decline. The excess demand for real loans disappeared in the second half of 1998. However it emerged again in November 1999 under a different condition from the previous one. At that time the business cycle was in the boom stage. Since then commercial banks had to restrict their private loan to maintain the capital-to-asset ratio above the minimum requirement level. Such a regulation possibly created a decrease of real loans from December 2000 to March 2001. This period should not be regarded as a credit crunch, since there is excess supply of real credit during the period.

This paper is organized as follows. Section 2 examines time series

properties of the bank deposits and loans using techniques of unit root test and cyclical component extraction. These analyses help our understanding about the fundamental properties of the given time series. Section 3 explains the structure of our disequilibrium model and reports the estimation results. Main conclusions are in section 4.

## 2. UNIT ROOT TESTS AND CYCLICAL COMPONENTS

We analyze the time series properties of loans and deposits by DMBs.<sup>3)</sup> Time series data used in this chapter were obtained from the Bank of Korea (BOK) on a monthly basis. To analyze the credit situation, we could use loan data of the MCT account. However, we restrict our analysis to the bank account, since it provides longer time series data. To avoid fluctuations by price changes, all variables are transformed into the real ones by dividing by the consumer price index.<sup>4)</sup>

Real loans and deposits in figure 1 were jolted at the beginning of the financial crisis. While real deposits declined between January 1998 and March 1998 except February, real loans decreased from December 1997 until October 1998 except a few months. We can easily recognize that the real loans show more fluctuation than the real deposit. In other words, the financial crisis affected bank lending behavior more than deposit behavior. We take a close look at these series and examine time series properties. Both series seem to have positive trends, but it is not clear whether they are deterministic or stochastic. Identification of trends is important in understanding the properties of the shocks that occur in the series. We discuss this issue further in detail.

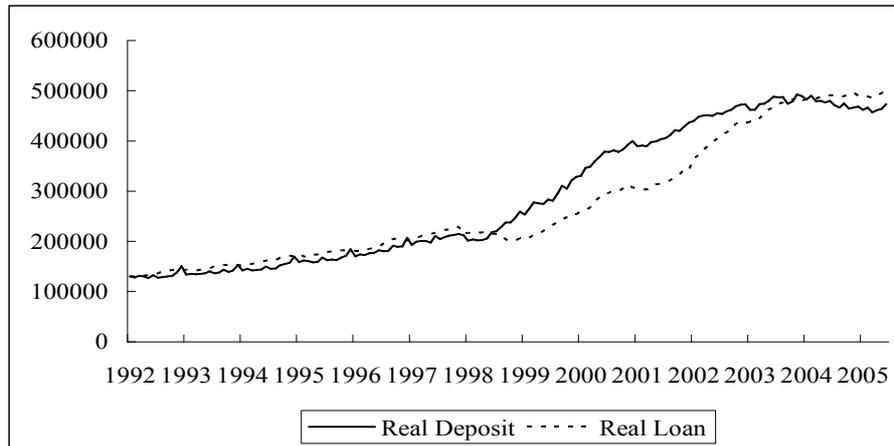
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<sup>3)</sup> DMB consists of commercial banks and specialized banks in Korea.

<sup>4)</sup> Base year of the consumer price index is 2000.

**Figure 1 Real Loans and Real Deposits by DMBs**

(unit: billion won)



### 2.1. Unit Root Test<sup>5)</sup>

To test for the existence of unit root in the real loans and deposits, we applied the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.<sup>6)</sup> The test results are reported in table 1. From table 1 it is clear that each series has one unit root. Whereas the levels of both series are non-stationary, their first differences are all stationary. Since they are shown to have stochastic trends each shock has a permanent effect on each

<sup>5)</sup> One referee pointed out that the unit root of the real loan and the real deposit is not directly associated with the estimation of disequilibrium market model in the next chapter. However the unit root test is related to the next chapter in the following sense. We learned that the two series, real loan and real deposit, are non-stationary from the unit root test. It implies that some form of cointegration framework would be needed in a regression model. From additional unit root tests for the explanatory variables in the disequilibrium model, unit root was found in required ratio of reserves and industrial production series. Moreover cointegration evidence was also found between the four variables – real loan, real deposit, required ratio of reserves, industrial production and interest rate spread between the loan rate and the corporate bond rate. Similarly another cointegration evidence was found between the three variables – real loan, industrial production, interest rate spread between the loan rate and the CD rate. Therefore these tests justify the disequilibrium setup in section 3.

<sup>6)</sup> Variables are log transformed for unit root tests.

**Table 1 Unit Root Tests**

	ADF		PP	
	Loan	Deposit	Loan	Deposit
Level	$\tau_{\mu} : -0.16$ $\tau_{\tau} : -2.04$	$\tau_{\mu} : -0.93$ $\tau_{\tau} : -0.80$	$\tau_{\mu} : 0.04$ $\tau_{\tau} : -1.64$	$\tau_{\mu} : -0.68$ $\tau_{\tau} : -1.11$
Difference	$\tau_{\mu} : -4.71^{**}$ $\tau_{\tau} : -4.70^{*}$	$\tau_{\mu} : -6.34^{**}$ $\tau_{\tau} : -6.37^{**}$	$\tau_{\mu} : -10.75^{**}$ $\tau_{\tau} : -10.73^{**}$	$\tau_{\mu} : -17.54^{**}$ $\tau_{\tau} : -17.54^{**}$

Note:  $\tau_{\mu}$  is a test with drift,  $\tau_{\tau}$  is a test with drift and trend. 4 lagged variables were included in both the ADF and the PP tests. \*\* and \* mean significant at 1% and 5%.

series. The Korean financial market was exposed to dramatic changes such as financial liberalization, capital market opening, and the introduction of the deposit insurance system etc. during the 1990s. We presume that the rapid changes in the financial market generated those permanent shocks.

## 2.2. Cyclical Component Extraction

We think of the data as being the sum of components that have different frequencies of oscillations, for instance, the business cycle component lasting two to eight years. The spectral analysis of time series means that the data can be viewed as the sum of periodic functions. Based on the spectral theory, Baxter and King (1999) designed and implemented a specific band-pass filter, which isolates business cycle fluctuations in a macroeconomic time series with deterministic or stochastic trends. Their filter was designed to isolate fluctuations in the data, which persist for periods of two through eight years. We apply this Baxter-King (BK) band-pass filter to the real loans and deposits to extract their cyclical components.<sup>7)</sup>

The cyclical component is stationary. It remains after the log of original

<sup>7)</sup> Explanation of the BK filter cites Murray (2001).

time series is passed through an ideal band-pass filter. This definition relies on frequency components of the data. Since the Korean business cycle shows periods from 3 to 6 years, we use the 3 to 6 years frequency band in our study. The ideal BK filter has the following two-sided infinite moving average representation where symmetry is imposed so that the filter does not induce a phase shift.

$$a(L) = \sum_{k=-\infty}^{\infty} a_k L^k. \quad (1)$$

The transfer function of a filter determines the extent to which periodic components of the filtered series are related to periodic components of the underlying series. The BK filter is designed to pass through the stationary component of the given series whose periodicity ranges from 3 to 6 years per cycle. For stationary time series, the transfer function of this ideal filter takes the form

$$a(\varpi) = 1 \quad \text{if} \quad \begin{cases} \pi/36 \leq |\varpi| \leq \pi/18 \\ 0 \quad \text{otherwise} \end{cases}. \quad (2)$$

This ideal filter is not feasible since it requires an infinite amount of data. Baxter and King employ the following truncated version of the ideal filter, which is the optimal approximation

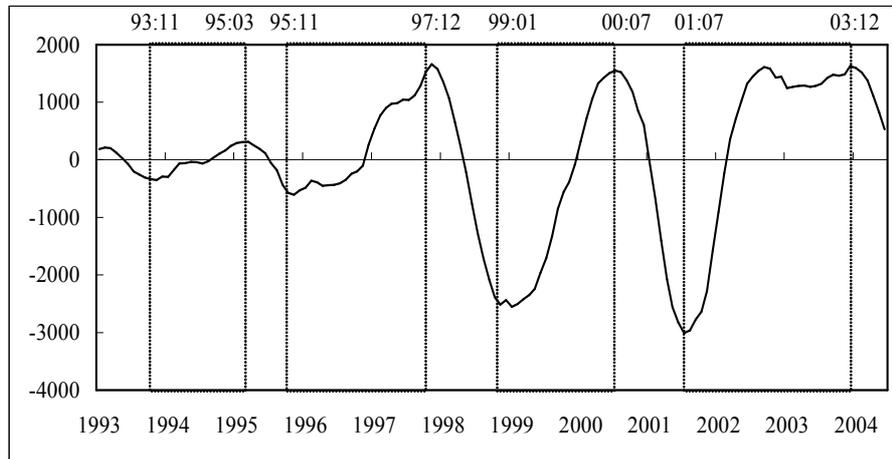
$$a_K(L) = \sum_{k=-K}^K a_k L^k. \quad (3)$$

This approximate band-pass filter, with corresponding transfer function  $\alpha_K(\omega)$  sacrifices  $2K$  data points.

Figure 2 and 3 show the cyclical components of the real loans and deposits between January 1993 and June 2004.<sup>8)</sup> The cyclical component of the loans

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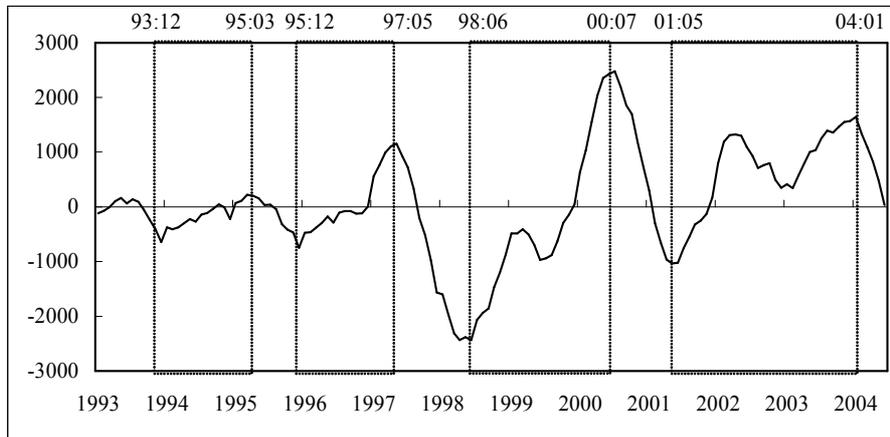
<sup>8)</sup> We used  $K=12$  in both series.

**Figure 2** Cyclical Component of Real Loans

Note: Vertical lines denote the turning points.

in figure 2 contains valuable information regarding credit cycles, because trend is already filtered out. Two cycles are observed from the cyclical component before the financial crisis and two cycles after the crisis. The cyclical components of the two series have shorter periods than the average business cycle and their amplitudes become huge around the financial crisis.<sup>9)</sup> We observe that the credit cycle was in the boom stage just before the crisis. However, the cyclical component suddenly decreased after the financial crisis in December 1997 and it continued until the early 1999. Even though we extract the cyclical component out of the real loan data, it does not show the credit crunches. It only demonstrates the cyclical status of credit in the banking sector. Since a credit crunch situation is usually caused by the shortage of credit supply and the credit supply should also decrease for other reasons, figure 2 does not directly show the period of credit crunch.

<sup>9)</sup> The average period of business expansion is 33 months and the average period of business contraction is 21 months in Korea. According to the official reference date of the National Statistical Office, the first trough is March 1972 and the last trough is August 1998 in our sample. Only two official business cycles appeared after January 1993.

**Figure 3 Cyclical Component of Real Deposits**

Note: Vertical lines denote the turning points.

We can interpret the cyclical component of the deposits in a similar way. There is not much fluctuation of the cyclical component of the deposit series before the financial crisis just like the loan series. But there was a big fluctuation around the crisis. One of the different features of the deposit cyclical component from the loan component is that the peak in May 1997 and the trough of June 1998 lead the corresponding peak and trough in the loan series.

### 3. A DISEQUILIBRIUM MODEL FOR CREDIT CRUNCH

Even though we extracted cyclical components and investigated time series properties in the previous chapter, we still do not have any evidence of credit crunch in the financial market. We have to identify whether the credit contraction came from the demand side or supply side of the loan market. Bernanke and Gertler (1995) point out that it is often impossible to establish whether the usual decline in bank lending stems from a shift in demand or supply when the economy is hit by a negative shock. They give

one clue to identify the source of loan deceleration. If bank loans have shrunk but the spread between bank lending rates and rates on risk-free assets has widened, then demand for loans could not have declined more than loan supply.<sup>10)</sup>

Whereas Bernanke and Gertler (1995) use a descriptive method to determine the source of loan deceleration, some quantitative models were developed to identify the sources of credit crunch. One is based on a traditional disequilibrium model proposed by Maddala and Nelson (1974), and the other is a two-step approach proposed by Agénor *et al.* (2000). Agénor *et al.* (2000) apply their model to assess the extent to which the fall in credit in Thailand is a supply-induced or a demand-induced phenomenon. Their first step is based on the estimation of a demand function for excess liquid assets by commercial banks. The second step consists in establishing dynamic projections for the periods following the crisis and assessing whether or not residuals are large enough to be viewed as indicators of involuntary accumulation of excess reserves. They concluded that the contraction in bank lending during the crisis was the result of supply factors. The framework of a disequilibrium model has already been applied to the Finnish credit fall in the early 1990s. Pazarbasioglu (1996) estimates a disequilibrium model of credit supply and demand to evaluate whether there was a credit crunch in Finland following the banking crisis of 1991-1992. The author concluded that the marked reduction in bank lending was mainly in reaction to a cyclical decline in credit demand. Other applications are made by Ghosh and Ghosh (1999) and Beng and Ying (2001). Ghosh and Ghosh (1999) apply it to analyze the East Asian credit crunch during 1997-1998. They found little evidence of quantity rationing at the aggregate level although individual firms might have lost access to credit. And Beng and Ying (2001) use the disequilibrium framework to determine the extent to which the sharp decline in loans and advances in the Malaysian banking system during the currency crisis can be attributed to a credit crunch. They identify the credit crunch period as the period from July 1997 to March

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<sup>10)</sup> Recently Ding *et al.* (1999) adopted this identification method.

1998.

Kim (1999) adopts a disequilibrium framework to examine the Korean crisis. He finds convincing evidence of the practical importance of the credit channel in the aftermath of the Korean financial crisis. Furthermore he presents strong evidence that a marked decline in loans is essentially driven by a sharp decline in loan supply largely attributable to pervasive and stringent bank capital regulation rather than by a weak demand for loans. There is no consensus about the source of the credit crunch during the recent crisis period. We make an effort to construct a refined disequilibrium model using recently updated data in the paper.

A disequilibrium model by Maddala and Nelson (1974) is applied to aggregate Korean data to find whether credit contraction is due to a reduction of the loan supply by banks or a decrease in loan demand by the private sector.<sup>11)</sup> The model consists of the supply equation, the demand equation, and the transactions equation below

$$L_t^s = \alpha' x_{1t} + u_t^s, \quad (\text{supply function}) \quad (4)$$

$$L_t^d = \beta' x_{2t} + u_t^d, \quad (\text{demand function}) \quad (5)$$

$$L_t = \text{Min}(L_t^s, L_t^d). \quad (\text{transactions equation}) \quad (6)$$

The variables  $L_t^s$  and  $L_t^d$  are loan supply and loan demand, the vectors  $x_{1t}$  and  $x_{2t}$  contain exogenous variables and normally include the price variable, which is also exogenous in this model.<sup>12)</sup> The error terms  $u_t^s$  and  $u_t^d$  are distributed with mean 0 and covariance matrix  $\Sigma$ . Ordinarily they are assumed to be jointly normal and independent over time.  $L_t^s$  and  $L_t^d$

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<sup>11)</sup> Maddala and Nelson (1974) classified disequilibrium models into 4 different categories. Among them Model A is used in this paper.

<sup>12)</sup> Even if the price variable is exogenous, it does not mean rigidity. Prices are adjusted by the given state, but they do not resolve the disequilibrium state as fast as in the equilibrium model. The classification of Maddala and Nelson (1974) may be regarded as a method by price adjustment.

are not observed by the econometrician, only  $L_t$  is observed. This model makes the assumption of voluntary transaction, so that in the presence of excess demand, lenders cannot be forced to supply more than they wish to supply. And in the presence of excess supply, customers cannot be made to borrow more than they wish to borrow. In other words, excess demand implies  $L_t^d > L_t^s$ , therefore the observation  $L_t$  is always equal to the amount lenders wish to lend,  $L_t = L_t^s$ . On the contrary, excess supply means  $L_t^s > L_t^d$ , therefore the observation  $L_t$  is equal to the demand borrowers want to borrow,  $L_t = L_t^d$ .

### 3.1. Likelihood Function

No *a priori* knowledge is available about the price adjustment mechanism. The likelihood function of the disequilibrium model is shown in this chapter.<sup>13)</sup> Given the p.d.f. of error terms  $u_t^s$  and  $u_t^d$  it is easy to obtain the joint p.d.f.  $g(L_t^s, L_t^d)$  of the unobservable random variables  $L_t^s$  and  $L_t^d$ . The p.d.f. of  $L_t$ ,  $h(L_t)$ , can be written as

$$h(L_t) = f(L_t | L_t^d < L_t^s) \Pr(L_t^d < L_t^s) + f(L_t | L_t^d \geq L_t^s) \Pr(L_t^d \geq L_t^s). \quad (7)$$

The conditional density function  $f(L_t | L_t^d < L_t^s)$  is

$$\begin{aligned} f(L_t | L_t^d < L_t^s) &= \int_{L_t}^{\infty} g(L_t, L_t^s | L_t^d < L_t^s) dL_t^s \\ &= \int_{L_t}^{\infty} g(L_t, L_t^s) dL_t^s / \Pr(L_t^d < L_t^s), \end{aligned} \quad (8)$$

and for  $f(L_t | L_t^d \geq L_t^s)$  the conditional density function is calculated in a similar way. Substituting (8) and a corresponding expression for  $f(L_t | L_t^d \geq L_t^s)$  in (7) yields

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<sup>13)</sup> For further discussion of the model, refer to Quant (1988).

$$h(L_t) = \int_{L_t}^{\infty} g(L_t, L_t^s) dL_t^s + \int_{L_t}^{\infty} g(L_t^d, L_t) dL_t^d. \quad (9)$$

The likelihood function is then

$$L_F = \prod_{t=1}^T h(L_t). \quad (10)$$

The customary assumptions are  $(u_t^s, u_t^d)$  are jointly normally distributed with mean 0, covariance  $\Sigma$ , and that  $(u_t^s, u_t^d)$  are temporally uncorrelated. In our case we assume  $\sigma_{sd} = 0$ , then (9) becomes

$$\begin{aligned} h(L_t) = & \frac{1}{\sqrt{2\pi}\sigma_s} \text{Exp} \left\{ -\frac{1}{2} \frac{(L_t - \alpha' x_{1t})^2}{\sigma_s^2} \right\} \left\{ 1 - \Phi \left( \frac{L_t - \beta' x_{2t}}{\sigma_d} \right) \right\} \\ & + \frac{1}{\sqrt{2\pi}\sigma_d} \text{Exp} \left\{ -\frac{1}{2} \frac{(L_t - \beta' x_{2t})^2}{\sigma_d^2} \right\} \left\{ 1 - \Phi \left( \frac{L_t - \alpha' x_{1t}}{\sigma_s} \right) \right\}. \end{aligned} \quad (11)$$

The maximum likelihood estimate of (10) is proved to show strong consistency under standard conditions. Equation (10) and (11) are used to estimate the parameters  $\alpha$  and  $\beta$ .

### 3.2. Specification

The Korean loan market is characterized as follows

$$\begin{aligned} L_t^s = & \alpha_1 + \alpha_2 L_{t-1} + \alpha_3 (R_t^l - R_t^{ycb}) + \alpha_4 D_{t-1} + \alpha_5 RR_t \\ & + \alpha_6 Y_t + \alpha_7 P_t + \alpha_8 D_{t-1} P_t + \alpha_9 RR_t P_t + u_t^s, \end{aligned} \quad (12)$$

$$L_t^d = \beta_1 + \beta_2 L_{t-1} + \beta_3 (R_t^l - R_t^{cd}) + \beta_4 Y_t + u_t^d. \quad (13)$$

Credit variable,  $L_t$ , is the real loans of commercial banks.<sup>14)</sup> Loan rates are not assumed to adjust in each period to clear the loan market. Explanatory variables of the loan supply function ( $L_t^s$ ) are loans of the previous period ( $L_{t-1}$ ), differential between the loan rate and the yield on corporate bonds ( $R_t^l - R_t^{ycb}$ ), total deposits of the previous period ( $D_{t-1}$ ), required ratio of reserves ( $RR_t$ ) and industrial production ( $Y_t$ ).<sup>15)</sup> We assume that some variables such as  $D_{t-1}$  and  $RR_t$  have different effects on the credit supply after the financial crisis. And constant term adjustment after the crisis is also assumed. To specify this idea, a period dummy variable  $P_t$  is introduced in equation (12). It takes value 1 from December 1997 until the end of the sample period. Next, the loan demand function ( $L_t^d$ ) is specified as lagged value of loans ( $L_{t-1}$ ), differential between the loan rate and the yield on CD ( $R_t^l - R_t^{cd}$ ) and industrial production ( $Y_t$ ). All variables in these functions are deflated by the consumer price index. In addition loans, deposits and the industrial production index are log-transformed.

Loan supply is basically determined by deposit, the required reserve ratio and the lending interest rate. The coefficients of deposits and the required reserve ratio are positive and negative respectively before the crisis. Interestingly the coefficient of the required reserve ratio becomes positive after the crisis. It is partly due to stabilizing the required reserve ratio around 3% by the Bank of Korea (BOK) since March 1997. We should be cautious when taking into account the lending interest rate. The Korean lending interest rate was rigid for a while until the lending rate liberalization in the second half of 1996. Before the liberalization the lending rate sometimes did not move for several months regardless of the loan market situation. Because of this problem, we use the differential between the lending interest rate and the yield on corporate bonds rather than the lending interest rate itself.

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<sup>14)</sup> CPI is used as a deflator for real loan. This variable is the same as the one in the previous chapter.

<sup>15)</sup> The loan rate before 1996 is the medium of the range of the loan rates and it becomes the weighted average of the loan rates since 1996.

If there is a lot of uncertainty in the loan market, the yield on corporate bonds normally increases. Under such circumstances, commercial banks want to reduce their loans and switch their high-risk assets to risk-free assets. As a result, we expect to see the interest rate differential and the loan supply move in the same direction. The industrial production index and previous period's loans are added to control the scale of the economy and persistence of the variable.<sup>16)</sup>

We take the differential between the loan rate and the yield on CDs as an important explanatory variable in the loan demand function. If the differential increases significantly, borrowers want to postpone their loan application or search for other ways to finance their investment. When it shrinks, they favor getting loans. Since the demand for loans has a close relationship with business cycles, the industrial production index is expected to play an important role. We include the industrial production index as a scale variable and the lagged loans to control the persistence of the series.<sup>17)</sup> This model is estimated from January 1992 to June 2005.

### 3.3. Estimation Results

The estimation results of (12) and (13) are shown in table 2. They indicate that coefficients in both the supply and demand functions have the expected signs. The  $z$ -values and  $p$ -values of the estimated coefficients indicate their statistical significance. The coefficients are generally significant except in a few cases. Reflecting the persistence of the loan variable, the lagged dependent variables appear with strong significance in both functions. Both of the residual variances also show strong significance.

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<sup>16)</sup> Lending rate, yields on CD, yields on government bonds, call rates, time deposit rate instead of yields on corporate bonds were used in the supply of loan function. However, we could not obtain good estimation results. Also, adding the stock price index, the total market value of stocks, the stock price index of the banking industry/total stock price index, the excess demand pressure index, and the inflation rate to explanatory variables did not produce any significant estimation results either.

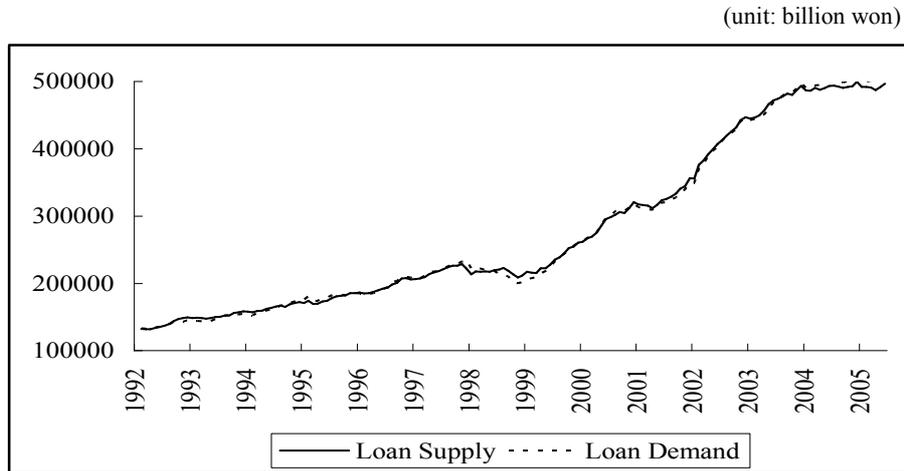
<sup>17)</sup> We estimated various types of demand functions other than that of table 2 using different interest rates, but the result was unsatisfactory.

**Table 2** Estimates of Supply and Demand Function of Loans

Variable	Loan Supply	Loan Demand
Constant	0.96 (24.50, 0.00)	0.21 (10.15, 0.00)
Constant $\times P_t$	-0.99(-5.72, 0.00)	
$L_{t-1}$	0.91 (63.84, 0.00)	0.94 (893.93, 0.00)
$R_t^l - R_t^{ycb}$	7.50E-3 (5.45, 0.00)	
$R_t^l - R_t^{cd}$		-4.43E-3 (-5.31, 0.00)
$D_{t-1}$	3.48E-2 (15.79, 0.11)	
$D_{t-1} \times P_t$	4.81E-1 (2.81, 0.01)	
$RR_t$	-1.48E-3 (-0.91, 0.36)	
$RR_t \times P_t$	0.14 (5.81, 0.00)	
$Y_t$	-5.72E-2 (-1.43, 0.15)	0.12 (16.90, 0.00)
$\sigma_s$	1.31E-2 (7.68, 0.00)	
$\sigma_d$		1.34E-2 (10.23, 0.00)

Note: Estimation period is 1992:1-2005:6.  $z$ -statistic and  $p$ -value are in parentheses.

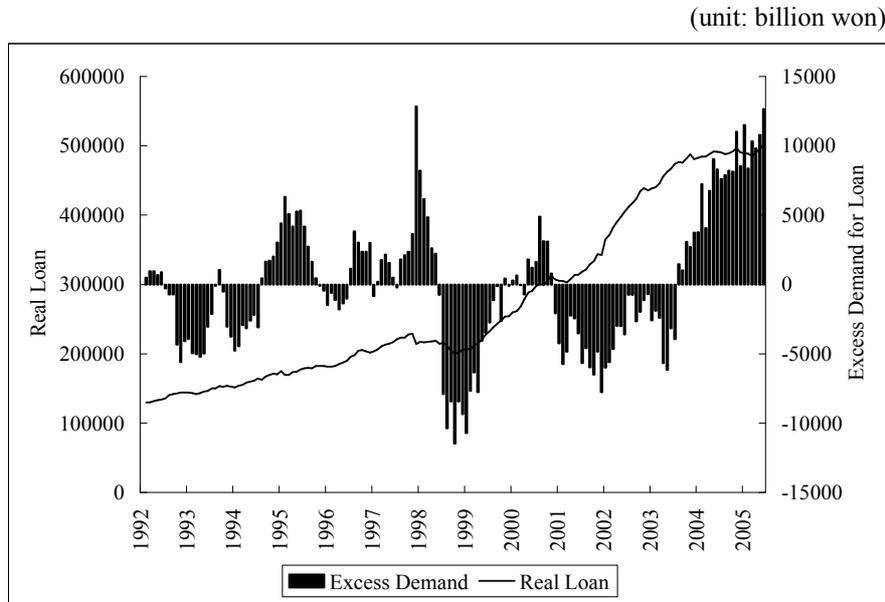
In the loan supply function, the interest rate differential  $R_t^l - R_t^{ycb}$  shows strong explanatory power. However,  $p$ -values of the real deposits and the industrial production index in the supply function are 11-15%, even though they have correct signs. The required reserve ratio is not significant at the 10% level. The BOK has continuously reduced the level of required reserve ratio since April 1996. We infer that lowering the ratio enables commercial banks to expand the capacity of loans if other things are equal.

**Figure 4 Estimated Loan Supply and Demand**

Three variables apart from the constant term appear as significant explanatory variables in the loan demand function. The interest rate differential  $R_t^l - R_t^{cd}$  has a correct sign and its p-value shows strong significance. The industrial production is used as an explanatory variable since it demonstrates high significance. Based on the above estimates, we can easily estimate loan supply and demand for loans for the whole estimation period. The results are in figure 4. The solid line and the dotted line indicate the estimated loan supply and loan demand respectively. It is found that excess demand or excess supply has never dominated the loan market for the whole period. One important finding is that excess demand for loans prevailed in the market just before the financial crisis, and it existed for a while after the outbreak of the crisis. This is reasonable since the lending interest rate in Korea was regulated until the early 1996.

We are now ready to infer the period of credit crunch. To be in a situation of credit crunch, two conditions should be satisfied. One is declining real loan supply and the other is excess demand for real loans.<sup>18)</sup>

<sup>18)</sup> We consider the situation as a credit crunch when it lasts at least for 2 months. The situation for just one month is ignored since it is regarded as temporary.

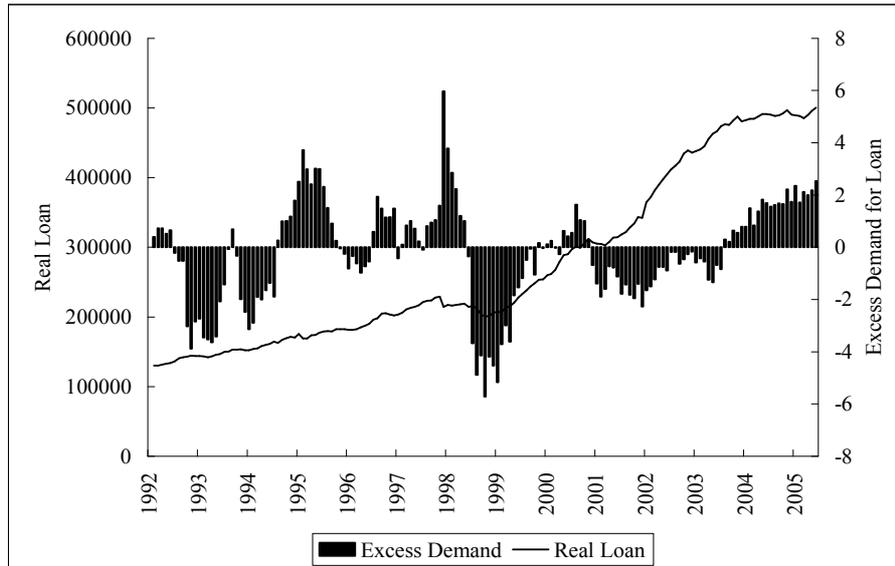
**Figure 5 Excess Demand for Loans and Supply of Loans**

The excess demand for loans is drawn in Figure 5 with the loan supply curve. The excess demand for loans was transformed into the percentage term out of total actual loans in figure 6. Therefore the bars of figure 6 are adjusted to the actual loan scale. Our analysis implies that both the loan demand and the supply decreased rapidly right after the crisis (Figure 4). Moreover the loan demand decreased faster than the loan supply for a long time (Figure 5 and 6). This is consistent with the analysis of Kim (1999).

Given the excess loan demand figures, we can draw the following conclusions on the credit market. First, excess loan supply has existed in the early 1990s. But excess loan demand appeared dominantly from August 1994 until the outbreak of the crisis mainly because of the lending interest rate regulation. Even though the excess loan supply had been observed a few times during this period, the duration and scale of these instances were not big enough to generate economic problems. Second, there was a debate about the existence of credit crunch after the outbreak of the financial crisis.

**Figure 6 Ratio of Excess Demand for Loans and Supply of Loans**

(unit: %)



Our estimation result gives a clear answer to this question. Around the financial crisis, there existed excess loan demand for more than three years and the ratio once went up to 6.0% of the total loans. However, the credit crunch period was identified as the period between February 1995 and March 1995 and the period between November 1996 and December 1996 as in table 3.

Third, the excess loan supply began to appear from June 1998. It has completely different characteristics from the one that occurred in the early 1990s. The duration of the excess loan supply of 1998 is 17 months and the scale is 5.7% of total loans at its maximum.<sup>19)</sup> Examination of the estimated loan supply and demand during this period tells us that the deep recession due to the financial crisis reduced the demand for loans tremendously.<sup>20)</sup>

<sup>19)</sup> The amount is 11.5 trillion won in real term.

<sup>20)</sup> Elasticity of loan demand with respect to industrial production is much larger than the elasticity of loan supply with respect to the same variable.

**Table 3** Periods of Credit Crunch<sup>21)</sup>

Number	Period
1	1995:2 - 1995:3
2	1996:11 - 1996:12
3	2004:6 - 2004:8
4	2004:12 - 2005:3

The credit contraction at that time cannot be called a credit crunch because of the excess loan supply. Great reduction of the loan demand was mainly caused by the severe recession and the following market uncertainty. In the second half of 1998, the Korean government started to push economic reforms such as financial and corporate restructuring. On June 29 of 1998, five commercial banks were forced to close. The prevailing uncertainty in the loan market did not disappear for a while in spite of the closure of the 5 banks. Owing to the upturn in the business cycle in the third quarter of 1999, the excess supply of loans vanished slowly and excess loan demand reappeared in the market in November 1999. Finally, the second credit crunch has not been yet studied in depth in the literature. It was estimated to occur between June 2004 and March 2005 except 3 months for the period due to the decline of deposits from February 2004 to March 2005.

We have established whether the loan contraction around the financial crisis came from the supply side or demand side using a disequilibrium model. While the disequilibrium model obviously sheds light on some aspects of the credit crunch problem, there is a certain limitation to understand the fundamental causes behind the estimation results and give appropriate policy prescriptions. To make policy prescriptions against the credit crunch, we need more information about the relationships between bank lending behavior and institutional factors as well as financial statements

<sup>21)</sup> The periods such as 1994:9, 1995:9, 1997:12, 1998:2, 2000:9, 2003:9, 2003:12, 2004:3 also satisfy the conditions of the credit crunch. But they are ignored since they last for only one month.

from commercial banks. Since most institutional data and financial statements are announced quarterly or annually, a monthly model such as ours is not enough to examine policy effect and its evaluation.

#### 4. CONCLUSION

Our main interest in this paper is to identify the period of credit crunch in the Korean financial market and to understand the characteristics of the credit crunch. Throughout the empirical analysis based on time series and a disequilibrium model analysis, the following major conclusions can be reached.

To understand the time series properties of the data, we apply the ADF and PP unit root tests and the Baxter-King band-pass filter to the Korean loans and deposits. Cyclical components of the two series have shorter periods than the average business cycle and their amplitudes become huge around the financial crisis. Also, the two series have a unit root so that the two series are nonstationary. We presume that rapid changes in the Korean financial market such as financial liberalization, capital market opening and introduction of the deposit insurance system etc. during the 1990s generated those nonstationary series.

Using a disequilibrium model, we identify the periods of the Korean credit crunch. There appears no severe credit crunch in the first half of 1990s, but four credit crunches were identified since 1995. Two of them occurred before the financial crisis. The most recent credit crunch started from December 2004 and is estimated to have lasted for 4 months.

The main cause of the recent credit crunch might come from credit risk of firms, remaining uncertainty in the loan market or decline of deposit. Regarding the policy to solve the Korean credit crunch, the appropriate policy direction is to clear the loan market uncertainty and to reduce the credit risks of firms rather than to enforce credit expansion on commercial banks. Elimination of factors of declining deposits will also be helpful.

While estimation of a disequilibrium model obviously sheds light on some aspects of the recent Korean credit crunch, there is a limit to our understanding of the fundamental causes behind the estimation results. Understanding changes in the economic system, institutional factors and financial statements of commercial banks will supplement the shortcoming of the monthly disequilibrium model to develop better policies against credit crunches.

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