A Disequilibrium Model of the Korean Credit Crunch

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Abstract

Our main purpose is to identify the periods of the Korean credit crunches after 1992 from which relevant data are available. To understand the time series properties of the data, we apply the Baxter-King band-pass filter and the Cochrane-Campbell-Mankiw variance ratio test to 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 show strong persistence. 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 permanent shocks.

Using a diseqilibrium model, we identify the periods of the Korean credit crunch. There appears no severe credit crunch in the first half of 1990s. However, five credit crunches have been identified since 1995. Three of them occurred before the financial crisis. An interesting fact of the Korean credit crunches is that they occurred between December and April of the next year. Such a phenomenon may show a seasonal pattern of the credit crunch. Even though the credit crunch right after the financial crisis did not last for 4 months, the decreasing trend of the real loans continued for a year. The most recent credit crunch started from February 2001 and is estimated to have lasted for 3 months.

The main cause of the recent credit crunch might come from the credit risk of firms and remaining uncertainty in the loan market. This uncertainty is in part caused by delay of the overall economic reforms. Regarding the policy to solve such a problem, the appropriate direction is to clear the loan market of uncertainty and reduce the credit risks of firms rather than to enforce credit expansion on commercial banks.

While estimation of a disequilibrium model obviously sheds light on some aspects of the Korean credit crunches, there is a certain limitation to understanding the underlying structure behind the estimation result. Investigation of changes in the economic system and institutional factors will supplement the lack of proper explanation of the credit crunches.

Key Words: credit crunch, disequilibrium model, balance sheet channel, bank lending channel

JEL Classification: C32, E44, G21

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I. 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 they 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.[1] 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 credit crunches. In this study we identify the periods of credit crunches 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.[2] 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 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 policy instruments and nominal income changes drastically.

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1 It took 20 months for the real credit to recover to the pre-crisis level.

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

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 use a more quantitative model to identify the existence of credit crunches and understand the underlying causes of the credit crunch 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 loans 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 the second half of 1999 under a different condition from the previous one. At that time the business cycle was in the boom stage but commercial banks had to restrict their private loans to maintain the capital-to-asset ratio above the minimum requirement level. Such a regulation possibly created a deep credit crunch in the financial market in early 2001.

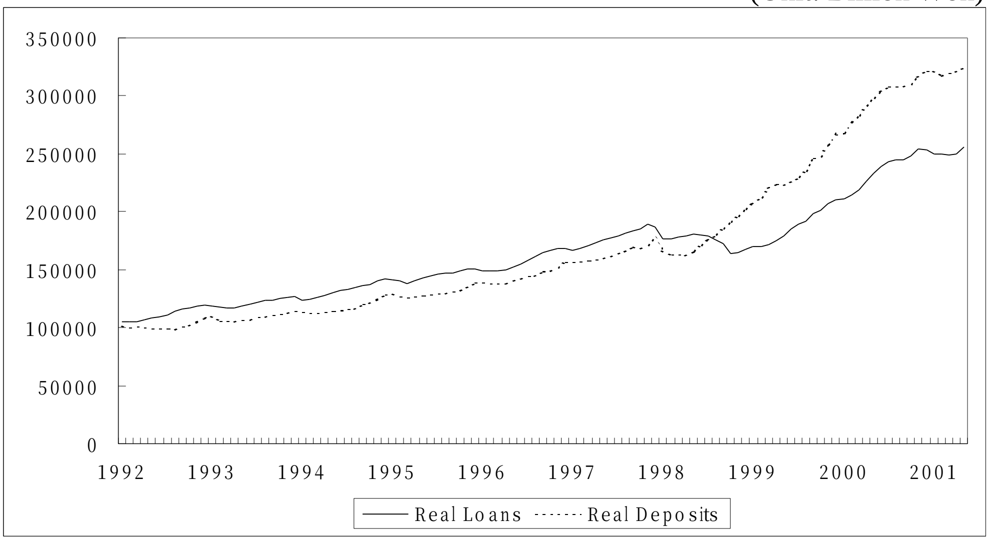
This paper is organized as follows. Section II examines time series properties of the bank deposits and loans using techniques of unit root test, cyclical component extraction and variance ratio test. These analyses help our understanding about the shocks hitting the data used in the following section. Section III explains the structure of our disequilibrium model and reports the estimation results. Main conclusions are in section IV.

II. Time Series Characteristics of Loans and Deposits

We analyze the time series properties of loans and deposits by DMBs.[3] Time series data used in this section 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.[4]

<Figure 1> Real Loans and Deposits by Deposit Money Banks

(Unit: Billion Won)



Real loans and deposits in Figure 1 were jolted at the beginning of the financial crisis. While real deposits declined between January 1998 and May 1998, real loans decreased from December 1997 until October 1998. We can easily recognize that the real loans show more

[3] DMB consists of commercial banks and specialized banks in Korea.
[4] Base year of the consumer price index is 1995.

fluctuation than the real deposits. 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.

1. Unit Root Test

To test for the existence of unit root in the real loans and deposits series, we applied the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.[5] 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 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 during the 1990s. We presume that the rapid changes in the financial market generated those permanent shocks.

<Table 1> Unit Root tests

	ADF		PP	
	Loans	Deposits	Loans	Deposits
Level	t_m : -0.58 t_t : -2.74	t_m : 1.34 t_t : -1.27	t_m : 0.06 t_t : -1.78	t_m : 1.77 t_t : -1.67
Difference	t_m : -3.88** t_t : -3.88*	t_m : -4.43** t_t : -4.77**	t_m : -5.98** t_t : -5.96**	t_m : -8.15** t_t : -8.42**

Note 1: t_m is a test with drift, t_t is a test with drift and trend.
Note 2: 4 lagged variables were included in both the ADF and the PP tests.
Note 3: ** and * mean significant at 1% and 5%.

[5] Variables are log transformed for unit root tests.

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.[6]

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

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

where symmetry is imposed so that the filter does not induce a phase shift. 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:

$$\alpha(\omega) = 1 \ \text{ if } \begin{cases} p/36 \le |w| \le p/18 \\ 0 \ \ otherwise \end{cases} . \qquad (2)$$

This ideal filter is not feasible since it requires an infinite amount of data. Baxter and King

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6 Explanation of the BK filter cites Murray (2001).

employ the following truncated version of the ideal filter, which is the optimal approximation:

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

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.[7] The cyclical component of the loans 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 one cycle 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.[8] 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 early 1999. Even though we extract the cyclical component out of the real loans 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 may also decrease for other reasons, Figure 2 does not directly show credit crunches.

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.

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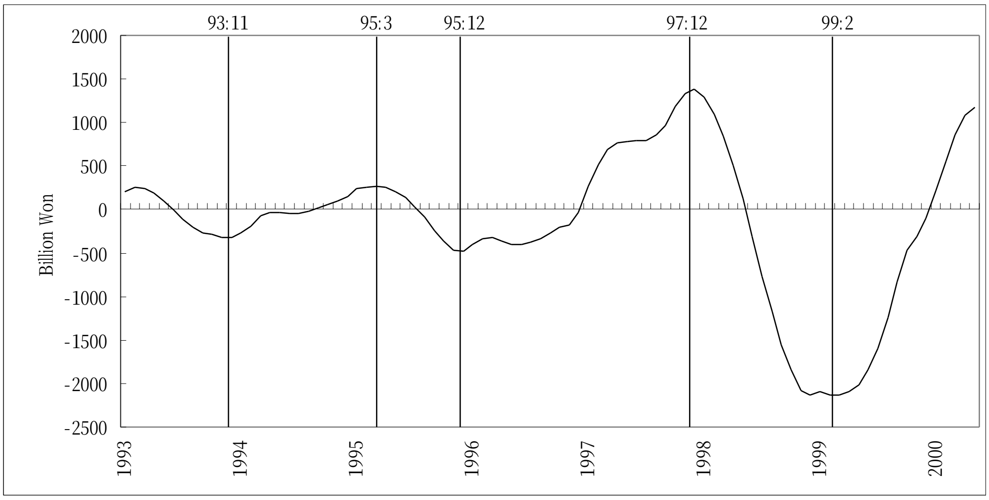
7 We used K=12 in both series.

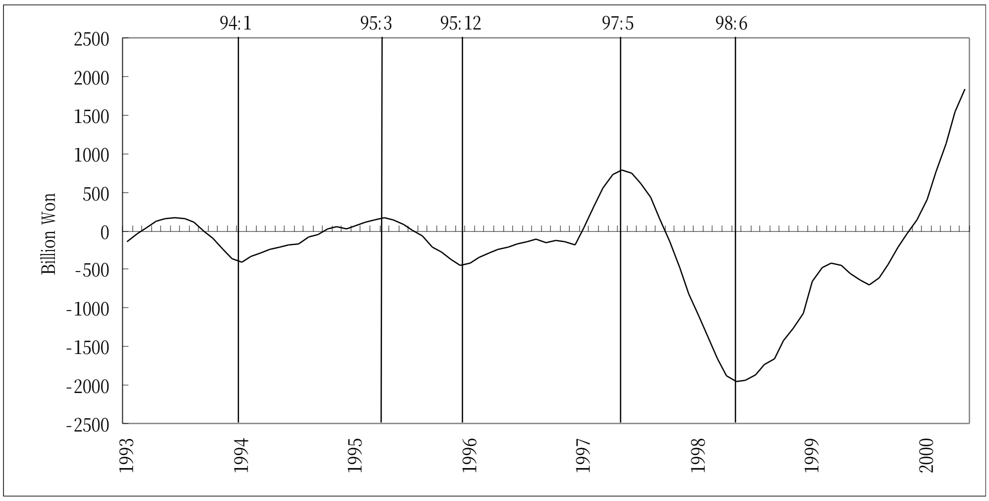
8 The average period of business expansion is 33 months and the average period of business contraction is 17 months in Korea.

<Figure 2> Cyclical Component of Real Loans



Note: Vertical lines denote the turning points.

<Figure 3> Cyclical Component of Real Deposits



Note: Vertical lines denote the turning points.

In spite of extracting the cyclical components of the two series, we have no idea how persistent the series are. To estimate the degree of persistence, we apply some variance ratio tests developed by Campbell and Mankiw (1987) and Cochrane (1988) to the two series. We investigate the measurement of persistence in the next subsection.

3. Variance Ratio Test

To see how persistent the given time series is, we measure $\hat{V}^k(1)$ by Cochrane (1988) as well as $\hat{A}^k(1)$ by Campbell and Mankiw (1987). The degree of persistence of a time series is another way of evaluating the presence of a unit root. Cochrane proposed a nonparametric measure of persistence based on the variance of its long differences. $\hat{V}^k(1)$ is the variance of the *k*th difference of a time series divided by k-times the variance of its first difference. Using the sample autocorrelation between Δy_t and Δy_{t-j}, $\hat{r}_j$, $\hat{V}^k(1)$ can be written as (5).

$$\hat{V}^k(1) = \frac{\mathrm{var}(y_t - y_{t-k})}{k\,\mathrm{var}(y_t - y_{t-1})} \qquad (4)$$

$$\hat{V}^k(1) = 1 + 2\sum_{j=0}^{k}\left(1 - \frac{j}{k+1}\right)\hat{r}_j \qquad (5)$$

The asymptotic standard error of $\hat{V}^k$ is given as equation (6) where T is the sample size. And the measure of persistence by Campbell and Mankiw (1987) is given in equation (7).

$$s.e.[\hat{V}^k] = \frac{\hat{V}^k}{\sqrt{\frac{3}{4}\frac{T}{(k+1)}}} \qquad (6)$$

$$\hat{A}^k(1) = \sqrt{\frac{\hat{V}^k}{1-\hat{r}_1^2}} \qquad (7)$$

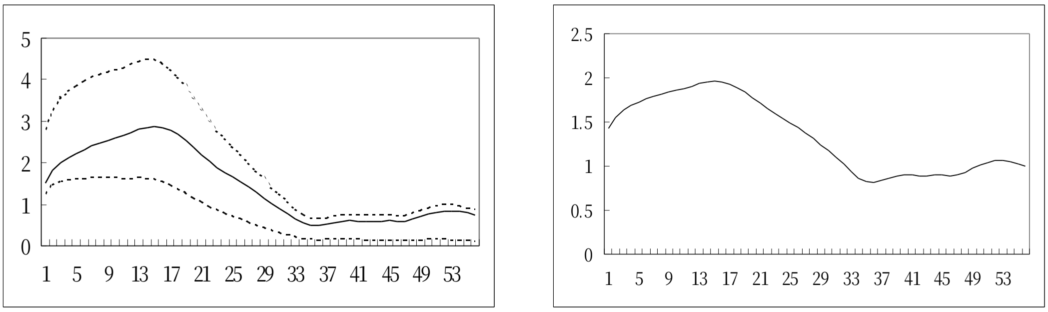
Using (6) and (7), we measured the degree of persistence of the two series. From their estimates in Figure 4 and 5, we recognize that the loans and deposits show strong persistence.[9] If one series is generated by stationary process or trend stationary process, $\hat{V}^k$ and $\hat{A}^k(1)$ should decrease rapidly just like figures in Figure 6 and 7. We artificially generated two series whose number of observations, slopes of fitted lines, means and standard deviations are exactly

9 Dotted lines show bounds equivalent to one standard error from the mean.

same as the original loans and deposits.[10] However their shapes of $\hat{V}^k$ and $\hat{A}^k(1)$ are very different from the originals. These simulation data actually fail to show strong persistence as in Figure 4 and 5.

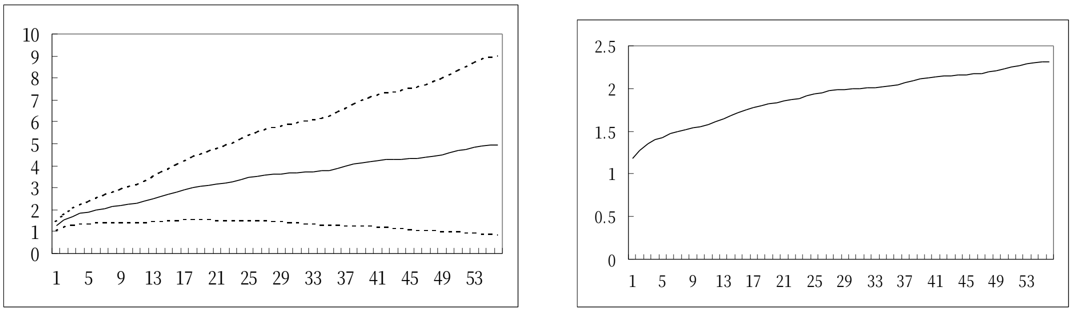
<Figure 4> Persistence Measures of Loans

$\hat{V}^k(1)$ $\hat{A}^k(1)$



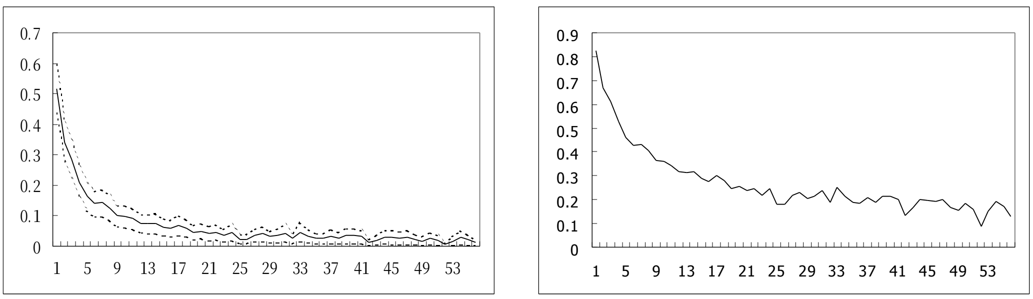
<Figure 5> Persistence Measures of Deposits

$\hat{V}^k(1)$ $\hat{A}^k(1)$



<Figure 6> Persistence Measures of Simulated Loans

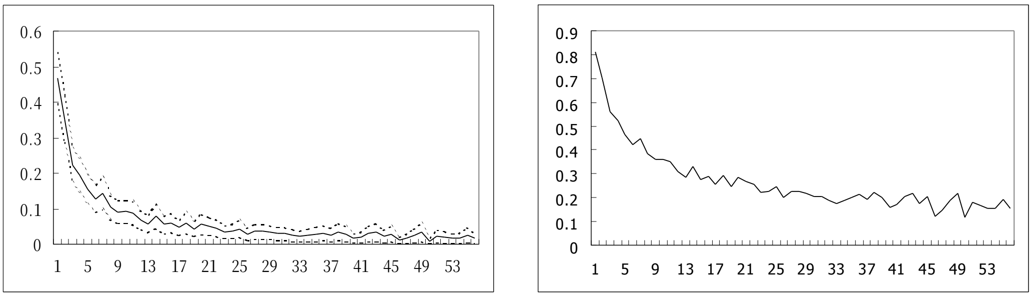
$\hat{V}^k(1)$ $\hat{A}^k(1)$



[10] Same slopes and intercepts were used to generate the simulation data. For log-transformed loans and deposits, regression equations were obtained as y=11.568+0.0072x and y=11.355+0.0109x, means were 0.001858 and 0.040953, standard deviations were 0.053984 and 0.08732 respectively. Random variables were generated from the GAUSS.

<Figure 7> Persistence Measures of Simulated Deposits

$\hat{V}^k(1)$ $\hat{A}^k(1)$



Strong persistence implies that the permanent component dominates the transitory component. Such a time series normally preserves the effect of a shock for a long time. It is interesting that loans and deposits show such strong persistence. If shocks given to these series had only transitory impact, $\hat{V}^k$ and $\hat{A}^k(1)$ should rapidly converge to 0. Figures 4 and 5 show that they do not converge to 0 even after 50 months. This implies that shocks given to loans and deposits have permanent effects.

Considering the characteristics of shocks, we can regard most of them as structural shocks rather than random shocks. Such a result is consistent with the result of unit root tests. Since the Korean financial market has experienced dramatic changes during the 1990s, structural shocks bearing permanent effects on the given series may dominate the market.

III. A Disequilibrium Model for Credit Crunch

Even though we extracted cyclical components and investigated time series properties in the previous section, 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.[11]

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 1991-92. 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

[11] Recently Ding et al. (1999) adopted this identification method.

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 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.[12] The model consists of the supply equation, the demand equation, and the transactions equation below

$$L_t^s = a' x_{1t} + u_t^s \qquad \text{(supply function)} \qquad (8)$$

$$L_t^d = b' x_{2t} + u_t^d \qquad \text{(demand function)} \qquad (9)$$

$$L_t = Min(L_t^s, L_t^d) \qquad \text{(transactions equation)} \qquad (10)$$

The variables L_t^s, 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.[13] The error terms u_t^s, u_t^d are distributed with mean 0 and covariance matrix S. Ordinarily they are assumed to be jointly normal and independent over time. L_t^s and L_t^d are not observed by the econometrician, only L_t is observed. This model makes the assumption of

12 Maddala and Nelson (1974) classified disequilibrium models into 4 different categories. Among them Model A is used in this paper.

13 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.

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, $L_t = L_t^d$.

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 section.[14] Given the p.d.f. of error terms u_t^s, 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

$$h(L_t) = f(L_t \mid L_t^d < L_t^s)\Pr\{L_t^d < L_t^s\} + f(L_t \mid L_t^d \geq L_t^s)\Pr\{L_t^d \geq L_t^s\} \qquad (11)$$

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

$$f(L_t \mid L_t^d < L_t^s) = \int_{L_t}^{\infty} g(L_t, L_t^s \mid L_t^d < L_t^s)\, d\, L_t^s$$

$$= \int_{L_t}^{\infty} g(L_t, L_t^s)\, d\, L_t^s / \Pr\{L_t^d < L_t^s\} \qquad (12)$$

and for $f(L_t \mid L_t^d \geq L_t^s)$ the conditional density function is calculated in a similar way. Substituting (12) and a corresponding expression for $f(L_t \mid L_t^d \geq L_t^s)$ in (11) yields

$$h(L_t) = \int_{L_t}^{\infty} g(L_t, L_t^s)\, d\, L_t^s + \int_{L_t}^{\infty} g(L_t^d, L_t)\, d\, L_t^d \qquad (13)$$

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14 For further discussion of the model, refer to Quant (1988).

The likelihood function is then

$$L_F = \prod_{t=1}^{T} h(L_t) \tag{14}$$

The customary assumptions are first that (u_t^s , u_t^d) are jointly normally distributed with mean 0, covariance S, and second that (u_t^s , u_t^d) are temporally uncorrelated. In our case we assume s_{sd} =0, then (13) becomes

$$\begin{aligned} h(L_t) &= \frac{1}{\sqrt{2p}\, s_s} Exp\{-\frac{1}{2}\frac{(L_t - a' x_{1t})^2}{s_s^2}\}[1-\Phi(\frac{L_t - b' x_{2t}}{s_d})] \\ &+ \frac{1}{\sqrt{2p}\, s_d} Exp\{-\frac{1}{2}\frac{(L_t - b' x_{2t})^2}{s_d^2}\}[1-\Phi(\frac{L_t - a' x_{1t}}{s_s})] \end{aligned} \tag{15}$$

The maximum likelihood estimate of (14) is proved to show strong consistency under standard conditions. Equation (14) and (15) are used to estimate the parameters a and b .

2. Specification

The Korean loan market is characterized as follows:

$$L_t^s = a_0 + a_1 L_{t-1} + a_2 (R_t^l - R_t^{ycb}) + a_3 D_t + a_4 RR_t + a_5 Y_t + u_t^s \tag{16}$$

$$L_t^d = b_0 + b_1 L_{t-1} + b_2 (R_t^l - R_t^{cd}) + b_3 Y_{t-1} + u_t^d \tag{17}$$

Credit variable, L_t , is the real loans of commercial banks.[15] 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 (D_t), required ratio of reserves (RR_t) and industrial

[15] CPI is used as a deflator for real loans. This variable is the same as the one in the previous section.

production (Y_t). 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 of the previous period (Y_{t-1}).[16] 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 deposits, the required reserve ratio and the lending interest rate. Obviously the coefficients of deposits and the required reserve ratio are positive and negative respectively. However, 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.

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.[17]

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

[16] The industrial production index is seasonally adjusted.

[17] Lending rate, yields on CD, yields on government bonds, call rates, and time deposit rates (instead of yields on corporate bonds) were used in the supply of loans 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 improvement in estimation results either.

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.[18] This model is estimated from January 1992 to May 2001.

3. Estimation Results

The estimation results of (16) and (17) 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.

<Table 2> Estimates of Supply and Demand Function of Loans

Variable	Loan Supply	Loan Demand
Constant	1.10 (3.62, 0.00)	0.514 (1.12, 0.26)
L_{t-1}	0.848 (27.16, 0.00)	0.892 (15.37, 0.00)
$R_t^l - R_t^{ycb}$	3.55E-3 (3.04, 0.00)	
$R_t^l - R_t^{cd}$		-6.00E-3 (2.85, 0.00)
D_t	3.83E-2 (1.61, 0.11)	
RR_t	-1.80E-3 (1.64, 0.10)	
Y_t	6.33E-2 (1.56, 0.12)	
Y_{t-1}		0.172 (2.80, 0.01)
s_s	1.10E-2 (9.18, 0.00)	
s_d		1.27E-2 (5.46, 0.00)

Note 1: Estimation period is 1992:01~ 2001:05.

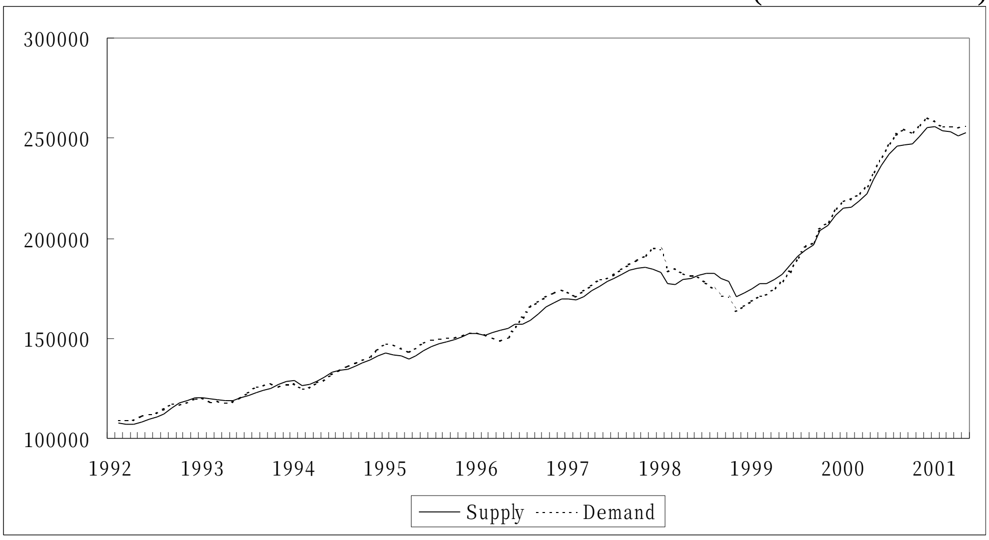
18 We estimated various types of demand functions other than that of Table 2 using different interest rates, but the result was unsatisfactory.

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 11-12%, even though they have correct signs. The required reserve ratio is marginally significant at the 10% level. The BOK has continuously reduced the level of required reserve ratio since April 1997.[19] We infer that lowering the ratio enables commercial banks to expand the capacity of loans if other things are equal.

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 the correct sign and its p-value shows strong significance. The lagged term of industrial production is used as an explanatory variable since it demonstrates higher significance than the current term. Based on the above estimates, we estimated the loan supply and loan demand. The results are in Figure 8.

<Figure 8> Estimated Loan Supply and Demand

(Unit: Billion Won)



The solid line and the dotted line indicate the estimated loan supply and loan demand

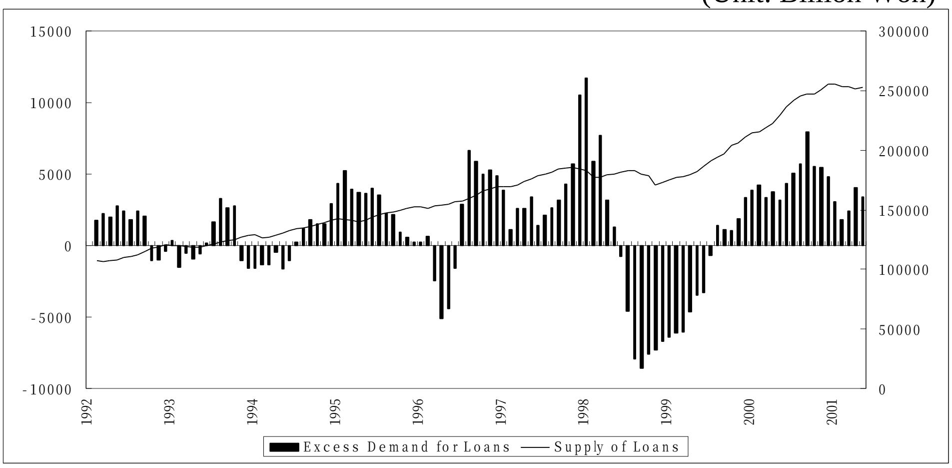
19 The average required reserve ratio was 11.5% before April 1996, but it decreased to 2% after February 1997.

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 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 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.[20] The excess demand for loans is drawn in Figure 9 with the loan supply curve. The excess demand for loans was transformed into the percentage term out of total actual loans in Figure 10. Therefore the bars of Figure 10 are adjusted to the actual loan scale. Our analysis implies that both the loan demand and the supply decreased rapidly right after the crisis. Moreover the loan demand decreased faster than the loan supply for a long time. This is consistent with the analysis of Kim (1999).[21]

<Figure 9> Excess Demand for Loans and Supply of Loans

(Unit: Billion Won)

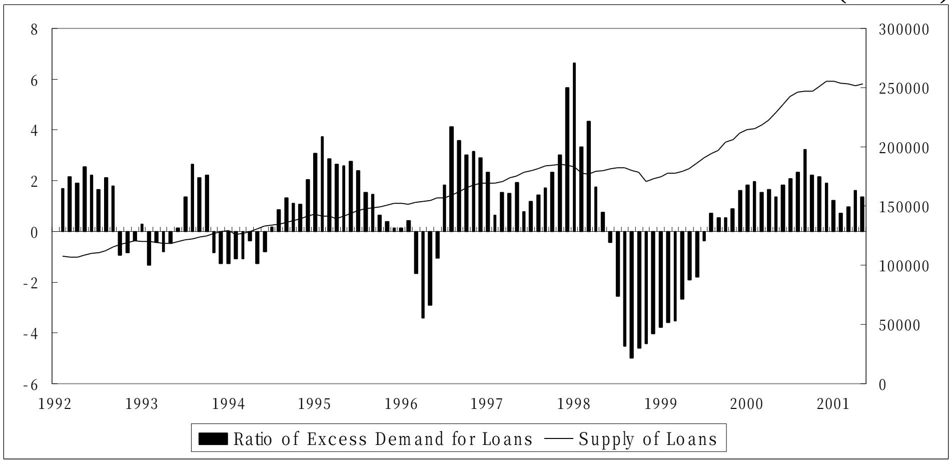


[20] We only consider the situation as a credit crunch when it lasts at least for 2 months.

[21] Kim (1999) also estimated a disequilibrim loan market model for a different time period. But he found there was an excess demand for loans around the outbreak of the crisis. The estimation period is from February 1993 to April 1998.

<Figure 10> Ratio of Excess Demand for Loans and Supply of Loans

(Unit: %)



Given the excess loan demand figures, we can draw the following conclusions on the credit market. First, excess loan demand was greater than excess loan supply during the whole period because of the lending interest rate regulation that was in place until 1996. Even though the excess loan supply had been observed a few times before the crisis, 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. Our estimation result gives a clear answer to this question. Around the financial crisis, there existed excess loan demand for approximately two years and the ratio once went up to 6.7% of the total loans. However, the credit crunch period was identified as the period between December 1997 and March 1998 in Table 3, because the loan supply bounced back from April 1998.

Third, the excess loan supply began to appear from June 1998. It has completely different characteristics from the one that occurred before. The duration of the excess loan supply of 1998 is 14 months and the scale is 5% of total loans at its maximum.[22] 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.[23] The credit contraction at that time cannot

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[22] The amount is 8.6 trillion won.

[23] Elasticity of loan demand with respect to industrial production is much larger than the elasticity of

be called a credit crunch, since it was mainly caused by the severe recession and the following market uncertainty.[24] 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.

<Table 3> Periods of Credit Crunch

Number	Period
1	1995:2~1995:4
2	1996:1~1996:2
3	1997:1~1997:2
4	1997:12~1998:3
5	2001:2~2001:4

Note: Shaded rows are pre-crisis credit crunches.

Finally, the second credit crunch was not given much attention in the relevant literature relative to the first. It was estimated to occur between February and April 2001 in our study.[25] A recent report of the BOK supports our finding. The BOK thought that the second credit crunch appeared in 2000, so they made an effort to develop appropriate counter-measures.[26] According to the BOK report, the second credit crunch is distinguished from the first one in

loan supply with respect to the same variable.

24 It is the period between August 1998 and November 1998. A similar market phenomenon occurred between January and April 1994.

25 Since we use the data up to May 2001, we are not sure if the second credit crunch really finished in April.

26 Hahm and Jung (2000) share the viewpoint of the BOK about the second credit crunch.

some respects. The second one occurred during a period of low interest rate whereas the first one was accompanied by high interest rates. It argued that the main factor of the second credit crunch was the credit risk of firms and remaining uncertainty in the loan market. This uncertainty was caused by the delay of the overall economic reforms.

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 underlying structure 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 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.

IV. Conclusion

Our main interest in this paper is to identify the credit crunches in the Korean financial market and to understand the characteristics of the credit crunches. The empirical analysis of this paper is based on time series analysis of a disequilibrium model and suggests the following major conclusions.

To understand the time series properties of the data, we apply the Baxter-King band-pass filter and the Cochrane-Campbell-Mankiw variance ratio test 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 show strong persistence. We presume that rapid changes in the Korean financial market during the 1990s, such as financial liberalization, capital market opening, and the introduction of the deposit insurance system, generated those permanent shocks.

Using a diseqilibrium model, we identify the periods of the Korean credit crunch. Apparently, there was no severe credit crunch in the first half of the 1990s, but five credit crunches were identified since 1995. Three of them occurred before the financial crisis. Interestingly these Korean credit crunches occurred between December and April of the next year and this may reflect seasonal patterns in credit crunches. Even though the credit crunch right after the financial crisis did not last for 4 months, the decreasing trend of the real loans continued for a year. The most recent credit crunch started from February 2001 and is estimated to have lasted for 3 months.

The main cause of the recent credit crunch might come from credit risk of firms and remaining uncertainty in the loan market. This uncertainty is partially caused by delay of the overall economic reforms. Regarding the policy to solve such a problem, the appropriate policy direction is to clear the loan market of uncertainty and reduce the credit risks of firms rather than to force credit expansion on commercial banks.

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 underlying structure behind the estimation results. Understanding changes in the economic system, institutional factors and financial statements of commercial banks could supplement analysis yielded by the monthly disequilibrium model and help develop better policies to deal with credit crunches.

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