Financial Crisis and the Effects on Bank Credits – Evidence from Taiwan

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Abstract

In the aftermath of the Asian financial crisis, Taiwan's bank credits slowed down dramatically while the economy experienced one of the worst recessions in recent history. Whether the slowdown was mainly caused by the demand or the supply effect is unclear. An innovative approach is adopted in the empirical investigation, which uses the short-side rule of bank loans' market transactions to help infer the relative shifts of the demand and supply, as well as to identify factors contributing to the changes in demand and supply. For the disaggregate data, a novel model is proposed in this paper which accommodates the short-side rule and yet requires only data from the borrowers or the lenders. We find that a large decline in supply is mainly responsible for the slowdown, and we identify the deposit drain and the increase in overdue loans as the main contributing factors. On the demand side, the results indicate that smaller firms are disproportionately affected by the credit cutback. We also find that shrinkages in alternative financing sources may have indirectly contributed to the excess demand in the bank loan market.

Key words: Financial crisis, bank credit, credit crunch
JEL classification: C34, E50, G21

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1 Introduction

The credit market in Taiwan underwent a rapid development in the first half of the 1990s. As a step toward financial liberalization, the government lifted the ban on new establishments of commercial banks in 1991, pushing 18 new domestic banks to set up by the end of 1996. The 1997 Asian financial crisis, however, inflicted a serious blow to the market. The annual growth rate of bank

loan supply has an average of 17% from 1991 to 1996, but the figure dropped to 11% between 1997 to 2000. At the same time, the economy suffered the worst recession since 1950. Although it is widely acknowledged that the declining bank credit is one of the major causes of the recession, the sources of the credit contraction in the aftermath of the financial crisis are subjects to debate.

The purpose of this paper is to provide a novel empirical approach to discern the demand and supply effects of the changes in credit growth. The approach is based on the short-side rule of market transactions to infer the relative shifts of demand and supply. The novelty is particularly shown in our proposed micro data model in which only the demand- or the supply-side data is required for the analysis.

We use the model to examine whether the slowdown of the credit growth following the crisis came from a shift in the demand or a shift in the supply. In particular, we want to answer the following questions: How did the demand and supply of bank credits change after the financial crisis and what were the attributing factors? How did the changes explain the dramatic credit slowdown? What types of firms were affected the most in the credit slowdown? Results of this study should shed light on the causes and consequences of a dramatic change in the bank credit market in the event of a large and systematic shock.

Declines in bank lending can occur either because firms demand less credit or because banks cut back on loans. As for the demand side, firms may cut back investment due to pessimistic perspectives on the economy and thus reduce their demand for bank loans. More importantly, an unusual slowdown in demand may be due to deteriorations in borrowers' balance sheets, which in turn are the consequences of lowered collateral values, declining earnings, and debt overhangs in the post-financial crisis era. Therefore, firms may (involuntarily) restructure their balance sheets by reducing effective demand for external finance, particularly bank credit in a bank-based financial system.

A shift of bank loan supply by contrast may occur if banks' ability and willingness to extend loans are affected in a financial crisis. In the wake of a financial crisis, banks face higher default risk due to the weakness of borrowers' balance sheets. The increased risk of loan portfolios, which may be shown in the rise of overdue loans, would adversely affect banks' willingness to lend. When the initial overdues result in default, the erosion of bank capital constrains banks' ability to lend. The ability to lend is further affected if capital outflow that followed from the crisis causes deposit drain in the local banking system. The supply-side effect is particularly damaging to bank-dependent

firms, because it is difficult for these firms to replace bank credit with other sources of funds.[1]

Correctly identifying the cause of declines in bank credits has important implications for policy makers. For example, if the credit decline is on account of weak demand, then economic policies that aim at stimulating aggregate demand may be effective. If, on the other hand, the decline is due to weakened willingness and ability to lend on the supply side, then an easy monetary policy would simply raise excess reserves held by banks and have little effect on raising bank lending and investment.[2]

There is a vast amount of literature trying to disentangle the shift of loan supply from the shift of loan demand. One major strand has made much effort in identifying the loan supply shocks by providing evidence for the significance of the "bank lending channel;" see Kashyap et al. (1994) and Bernanke and Gertler (1995) for surveys of this view. Two strategies are commonly used in the literature. One is to compare the relative changes of aggregate variables, such as bank loans, commercial papers, interest rate spreads, and loans with commitment, to identify shifts in loan supply. For example, Kashyap et al. (1993) find that monetary tightening reduces the ratio of bank debt outstanding to the sum of bank debt plus commercial paper for the U.S. economy, which indicates support for the bank lending view. The other strategy uses firm-level data to show that smaller firms experience disproportionally large reductions in bank loans as well as other types of debts following monetary tightening. (Gertler and Gilchrist 1994; Oliner and Rudebush 1995, 1996b). Credit reallocation happens, because tight money causes firms' balance sheets to deteriorate, leading to higher external finance premiums. The situation is more serious for smaller firms, because they are more prone to asymmetric information problems. Both of the above approaches, however, are likely to suffer from criticism for not adequately controlling for loan demand factors (Oliner and Rudebusch 1996a,b, Kashyap and Stein 2000, Peek et al. 2000).[3]

[1]Bernanke and Gertler (1995) suggest that frictions such as imperfect information and costly enforcement of contracts interfere with the smooth functioning of financial markets, which drive a wedge between the cost of external funds and internal funds (external finance premium). This "financial accelerator" amplifies the depressing effect on firms' lowered collateral values and internal funds, which is broadly considered as a "balance sheet channel." For theoretical models, see Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). When bank credit is specifically concerned, as in this paper, the supply-side effect is close to what the literature call a "bank lending channel."

[2]Policy issues in this regard, such as recapitalization, preemptive supervisory measures, and more stringent regulations, have been proposed. However, the optimality of these policies and the ways to implement these policies are under much debate, which is beyond the scope of this paper.

[3]For instance, the credit reallocation implied by the aggregate-data-based mix may be due to a compositional shift,

In this paper two different yet complementary econometric models are used to identify the cause of credit contraction. Firstly, we use aggregate data to estimate a model that measures the degree of credit tightness as the extent of excess demand in the market. Excess demand may occur for various reasons. For instance, if the loan supply is not infinitely elastic, then interest rates may not adjust quickly and sufficiently enough to clear the market. The persistence of excess demand may also arise when banks do not raise the interest rate they charge to clear the market, because doing so may reduce their expected rate of return, e.g., Stiglitz and Weiss (1981) and Williamson (1987). The advantage of this approach is that, by explicitly incorporating the short-side rule of market transactions into the model, we can unambiguously determine the relative shifts of demand and supply during an episode of a significant credit decline. If the fall in bank credit is mainly caused by shifts in the supply, then we expect to see excess demand in the market; if it is due to shifts in demand, then excess supply is more likely.

Secondly, we derive a new model for micro data, which accommodates the short-side rule of market transactions in a demand-based or a supply-based model. Unlike the aggregate model in the first approach, the newly proposed model requires only borrowers' or lenders' data, alleviating the need for having matched demand and supply data which is difficult to come by at the disaggregate level. This advantage enables us to make use of the wealth of disaggregate data, based on which we are able to provide more precise estimates of the demand and supply parameters. We are also able to investigate whether the credit decline shows a general credit contraction, or whether the cutback is borne disproportionally by certain types of firms.

Estimation results from both the aggregate and disaggregate data clearly indicate that the credit growth decline in the post-1998 period is mainly caused by a large inward-shift of supply. We then identify deposit outflows and the increase in overdue loans as the most important factors leading to that event. Evidence also suggests a possible capital crunch effect in the data. The

with large firms faring better than small ones and actually demanding more credit. Since most commercial papers are issued by large firms, this may explain the changes in banks' debt ratio. Even with firm-level data, the differential responses of heterogeneous firms may still admit the story that aggregate demand fluctuations disproportionately affect the loan demand of small firms by weakening their creditworthiness, and thus reducing their ability to raise funds from any external source, not just banks. Alternatively, Kashyap and Stein (2000) use bank-level data to compare the differential responses on the lending behavior of small banks and large banks and find a clear result of the loan supply story. See also Peek and Rosengren (1997, 2000) for other identification schemes with bank-level data.

deposit drain coincided with the large scale capital outflow in Taiwan after the Asian crisis, and the high-rising overdue loans not only increased the overall credit risk perceived by banks but also raised the concern of capital loss. Furthermore, substitutability between bank credits and other types of financing (particularly the public debt) was impaired after the financial crisis, which could also have contributed to the tightness in the bank credit market. Finally, we find that smaller firms were more likely to have experienced unsatisfied loan demand, particularly after the financial crisis. This indicates that the credit decline in the aftermath of the crisis reflect the "flight to quality" of bank lending from lenders' attempts to restructure their loan portfolios, as widely documented in the literature (Bernanke et al. 1996).

The organization for the rest of the paper is as follows. Section 2 uses a descriptive analysis of key macro variables to provide a general background of the recent decline in bank credits in Taiwan. Section 3 estimates a demand and supply model using aggregate data. The estimated probabilities of excess demand are presented and their implications are discussed. Section 3.2 derives a novel model that accommodates the short-side rule of market transactions in a demand-based or a supply-based equation, and the model is applied to disaggregate data from borrowers and lenders. Section 4 concludes the paper.

2 The Bank Loan Cycles in Taiwan: 1991 - 2000

Figure 1 plots the growth rates of total loans outstanding (of domestic banks), the sum of commercial papers and corporate bonds, and the deposits. The vertical bar is drawn on the first quarter of 1998, which is the time at which many believe that the local markets began to feel the impact of the Asian financial crisis.

The figure shows that bank credit in Taiwan experienced a couple of cycles in the 1990s. The first cycle is between the periods of 1991:Q1 to 1993:Q3, the second is from 1993:Q4 to 1996:Q3, and the last cycle is from 1996:Q4 to 2000:Q3, which is the end of our sample. In the last cycle the bank loan growth rate started to decline in the beginning of 1998, chronicling the impact of the financial crisis on the local credit market.

On an observational basis, the last bank loan cycle appears to have quite different characteristics compared to the previous cycles. Firstly, in the first two bank loan cycles (on and before 1996:Q3), corporate debts (the sum of commercial papers and corporate bonds) are shown to be (imperfect)

substitutes for bank credits: When the growth rate of bank loans decreases, there is likely to be a corresponding increase in the growth rate of corporate debts. The correlation coefficient is -0.62. The observed phenomenon occurs if credit demand is stable while the banking and the corporate debt sectors experience uncorrelated disturbances. In this scenario, if one of the markets squeezes more than the other does, then substitutions can take place. However, in the last cycle, the negative correlation is no longer obvious, with the correlation coefficient equal to 0.01. In fact, after the third quarter of 1998, the growth rates of bank credits and corporate debts both showed a steady downturn. Among other things, this signals weakened demand for all types of debts. The observation is therefore tentative evidence of a demand-side story of the credit slowdown in the aftermath of the Asian financial crisis.

Secondly, the relationship between bank loans and deposits appears to be stronger in the last cycle; the correlation coefficient is 0.66 in the last cycle and is 0.53 in the first two. This indicates that a drop in bank deposits after 1998 may also contribute to the slowdown of bank credit. [4]

The Bank Loan Mix and the Interest Rate Spread

Figure 2 plots the loan-debt quantity mix and the interest rate spread. Kashyap et al. (1993) suggest that shocks to bank credit supply reveal themselves on the relative quantities and interest rates of bank loans vs.other financing substitutes. Following Kashyap et al., we examine the loan-debt quantity mix and the interest rate spread. The mix is defined as the ratio of total loans to the sum of total loans, commercial papers, and corporate bonds. The ratio measures bank credits as a fraction of total corporate liabilities. The interest rate spread here is the prime bank loan rate minus the six-month commercial paper rate. The assumption is that, to the extent that bank loans and commercial papers (and bonds) are not perfect substitutes, an adverse shock to bank credit supply should cause a drop in the mix while leading to an increase in the interest rate spread.

As shown in the figure, the mix had been at a relatively high level in the first half of the 1990s. Before 1996:Q3, the mix on average was equal to 0.913. Interestingly, it is obvious from the graph that movements of the mix and the spread were negatively correlated in these first two cycles. According to Kashyap et al. this indicates a supply-driven credit market in the first two cycles.

[4]The deposit drain coincided with the massive capital outflow during this period. Between 1991 and 1997, the annual average of capital outflow for direct and financial investment is equal to 5,629 billion US dollars with an annual growth rate equal to 17%. The annual average rises to 11,366 billion US dollars between 1998 and 2000 with the growth rate equal to 21%.

The last credit cycle, however, is quite a different story. The mix variable emits a big decline starting in 1996, which was likely caused by a surge in corporate debt growth at that time (see Figure 1). The trend then reversed itself starting around 1998:Q3 when the effect of the Asian financial crisis set in. In fact, the mix has been increasing throughout most parts of the post-Asian crisis era. The increase in the mix, however, does not necessarily imply easy credit in this time period. Note that although the mix increased, the spread did not fall correspondingly, indicating that the increase in the bank loan share did not result from a favorable shock to bank loan supply. In fact, instead of falling, the spread rose to its highest level of the 1990s in 1999.

Asset Prices

The local asset markets also took a severe blow from the Asian financial crisis. Figure 3 plots average real estate prices and the stock market index. Real estate prices are compiled by Hsin-Yi Real Estate, the largest and only publicly-traded real estate company on the Taiwan Stock Exchange. As shown here, by the end of 2000 average real estate prices in Taiwan had steadily declined by 35% from their peak at around 1993. The stock price index also exhibited sharp declines after 1997:Q3 and 2000:Q1. The drops in both property and equity values have important implications on the demand and supply of bank credits.

On the demand side, the falls in property and equity values signal declining economic perspectives and lower expected profitability, which adversely affect firms' willingness to engage in additional investment. The unfavorable economic conditions may also force firms to restructure their balance sheets in reaction to debt-overhang, further restraining the demand for outside credit.

On the supply side, the decline in equity and real estate values have direct impacts on the portfolios of banks which hold a substantial quantity of these assets. Because bank loans in Taiwan are mostly backed by these two major assets, the liquidation values and thus the expected returns of outstanding loans decline as a result. The subsequent loan losses after a firm defaults further erode banks' capital position. The worsening bank balance sheets together with the regulatory capital requirements restrict banks' capability to extend credit. Furthermore, declining asset prices reduce borrowing firms' collateral values as well as their net worth, which makes banks reluctant to extend additional loans.

Observations from figures in this section indicate that, although both demand and supply factors are likely to play parts in causing the episode of credit slowdown, a simple demand or supply side

story cannot fully explain the observations. Intertwining demand and supply factors were at work, and sophisticated econometric techniques are needed in order to disentangle the factors.

3 The Econometric Evidence

In this section we provide econometric evidence on the changes in the demand and supply of Taiwan's bank loan market during the 1991-2001 sample period. We will study how the demand and supply conditions changed after the Asian financial crisis, how the changes explain the credit slowdown, and whether the effects of a slowdown are common on different types of firms.

Two different models are used, one for aggregate data and the other for disaggregate data to investigate the issues. Both of the models incorporate the short-side rule of market transaction, which enables us to compute the probability of excess demand (supply) in the market for every time period. As explained in the Introduction, excess demand (supply) in the market may result if the interest rate does not adjust quickly and sufficiently enough, or if there is equilibrium credit rationing in the sense of Stiglitz and Weiss (1981) and Williamson (1987). While qualitative changes in the demand and supply conditions can be inferred from the parameters of the demand and supply determinants, the relative shifts of the demand and supply schedules are more informatively measured by the extent of excess demand and excess supply in the market. For instance, during a period of significant credit declines, excess demand implies a supply-driven story, while excess supply indicates a demand-driven phenomenon.

3.1 Aggregate Data: The Model

The model is specified as

$$D_t = X'_{d,t}\beta_1 + u_{d,t}, \tag{1}$$

$$S_t = X'_{s,t}\beta_2 + u_{s,t}, \tag{2}$$

$$Q_t = \text{Min}\left(D_t, S_t\right), \tag{3}$$

where D_t and S_t are the quantities of notional demand and notional supply at period t, respectively, $X_{d,t}$ and $X_{s,t}$ are the respective determinants of demand and supply, and $u_{d,t}$ and $u_{s,t}$ are error terms which are assumed to be normally and independently distributed with means equal to zero

and variances equal to σ_d^2 and σ_s^2, respectively.[5] The variable Q_t in equation (3) is the observed market transaction determined by the smaller of notional demand and notional supply (ie., the short-side rule).

Following Maddala (1986), the likelihood function of Q_t is

$$\begin{aligned} f(Q_t) &= f(Q_t \mid Q_t = S_t) \Pr(D_t \geq S_t) + f(Q_t \mid Q_t = D_t) \Pr(D_t < S_t) \\ &= \int_{Q_t}^{\infty} g(D_t, Q_t)\, dD_t + \int_{Q_t}^{\infty} g(Q_t, S_t)\, dS_t, \end{aligned} \tag{4}$$

where $f(Q_t \mid \bullet)$ is the conditional density function of Q_t, and $g(D_t, S_t)$ is the joint distribution of D_t and S_t. The first term on the right-hand-side of (4) is the probability of excess demand, and the second term is the probability of excess supply. Under the independence assumption of $u_{d,t}$ and $u_{s,t}$, the joint distribution $g(D_t, S_t)$ is the product of the distributions of D_t and S_t ($g_d(D_t)$ and $g_s(S_t)$, respectively), and so the model is simplified to

$$f(Q_t) = g_s(Q_t) \int_{Q_t}^{\infty} g_d(D_t) dD_t + g_d(Q_t) \int_{Q_t}^{\infty} g_s(S_t) dS_t \tag{5}$$

$$= \frac{1}{\sigma_s} \phi\left(\frac{Q_t - S_t}{\sigma_s}\right) \left[1 - \Phi\left(\frac{Q_t - D_t}{\sigma_d}\right)\right] + \frac{1}{\sigma_d} \phi\left(\frac{Q_t - D_t}{\sigma_d}\right) \left[1 - \Phi\left(\frac{Q_t - S_t}{\sigma_s}\right)\right]. \tag{6}$$

The terms $\phi(\cdot)$ and $\Phi(\cdot)$ are the density and the probability functions, respectively, of a standard normal distribution.

The log-likelihood function of the model is then the sum of the log of $f(Q_t)$:

$$\mathcal{L} = \sum_{t=1}^{T} \ln f(Q_t). \tag{7}$$

Parameters of the model are estimated by numerically maximizing the log-likelihood function. After the parameters are estimated, we can calculate the normalized probability of excess demand at period t as

$$\begin{aligned} \Pi_t &\equiv \Pr(D_t > S_t \mid Q_t) = \frac{\int_{Q_t}^{\infty} g(D_t, Q_t)\, dD_t}{f(Q_t)} \\ &= \frac{\frac{1}{\sigma_s} \phi\left(\frac{Q_t - S_t}{\sigma_s}\right) \left[1 - \Phi\left(\frac{Q_t - D_t}{\sigma_d}\right)\right]}{\frac{1}{\sigma_s} \phi\left(\frac{Q_t - S_t}{\sigma_s}\right) \left[1 - \Phi\left(\frac{Q_t - D_t}{\sigma_d}\right)\right] + \frac{1}{\sigma_d} \phi\left(\frac{Q_t - D_t}{\sigma_d}\right) \left[1 - \Phi\left(\frac{Q_t - S_t}{\sigma_s}\right)\right]}. \end{aligned} \tag{8}$$

Excess demand is more likely than excess supply if the estimated probability is larger than 0.5, and vice versa.

[5] As with many applications of the model in the literature, we assume that the error terms are not serially correlated. This simplifying assumption yields consistent estimates even if the true model calls for serial correlations (Robinson 1982; Gourieroux et al. 1985).

3.1.1 Data and Variable Specifications

All the variables regarding the banking sector are those of the domestically-chartered banks. The main variable specification of the model is as follows:

$$
\begin{aligned}
Q_t: &\quad \ln L_t, \\
X_{d,t}: &\quad \{R^d_{t-1},\, \ln I_t,\, \ln INV_t,\, \Delta \ln S_t,\, \Delta \ln E_t,\, \Delta \ln H_t,\, \ln P_t,\, d98\ \}, \\
X_{s,t}: &\quad \{R^s_{t-1},\, \left(\tfrac{K}{A}\right)_t,\, \ln Dep_t,\, \ln Over_t,\, \Delta \ln E_t,\, \Delta \ln H_t,\, \ln P_t,\, d98\ \}.
\end{aligned}
$$

The dependent variable is the log of domestic banks' credit balance to private enterprises at 1996 constant prices. For the explanatory variables, the first four of them are different in the demand and in the supply equations, and they serve to identify the respective equation. In the demand equation, R^d_{t-1} is the lag of the interest rate spread between the short-term loan rate and the six-month commercial paper rate. The loan rate is compiled by the Research Department of Taiwan's Central Bank. The lag value is used to mitigate the possible endogeneity problem between the credit balance and the interest rate spreads. The variable $\ln I_t$ is the log of the private sector's real gross capital formation, which should be a major determinant of loan demand. The variable $\ln INV_t$ is the log of changes in the real values of inventory stocks. The effect of $\ln INV_t$ on the loan demand could be ambiguous, because while firms may need additional loans in order to finance increased inventory, accumulations of the inventory stock may also indicate a slowdown of the economy, leading to a cut back on loan demand.

The variable S_t is the producer's shipment index of the manufacturing sector, and thus $\Delta \ln S_t$ measures the growth rate of sales which is an important indicator of profitability. We expect higher growth rates of sales to entail stronger demand for bank loans. The variables $\Delta \ln E_t$ and $\Delta \ln H_t$ measure the growth rates of Taiwan's stock market index and real estate price index, respectively. The possible demand-side effects of the two asset-price variables are discussed in Section 2. We add the log of the consumer price index, $\ln P_t$, into the model to account for other nominal demand effects. The time dummy variable $d98$ is equal to 1 if the observation is on or after 1998, while it is equal to 0 otherwise.

On the supply side, R^s_{t-1} is the lag of the interest rate spread between the short-term loan rate and the deposit rate. The variable $(K/A)_t$ is the beginning-of-period capital asset ratio of the banking sector, which captures the effect of a capital crunch. We use the non-adjusted capital asset ratio, because information on risk-adjusted capital is unavailable for the whole sample period. The variable $\ln Dep_t$ is the log of total deposits at 1996 constant dollars. The variable $\ln Over_t$ is

the log of the amount of overdue measured at the beginning of period t.[6] The variable measures the perceived risk of the banking sector's assets, and that higher risk perceived at the beginning of period would discourage banks' willingness to lend during the period. Finally, $\Delta \ln E_t$, $\Delta \ln H_t$, $\ln P_t$, and $d98$ are the same as those used in the demand equation.[7]

Quarterly data from 1991:Q3 to 2000:Q3 is used in the analysis.[8] Similar to Oliner and Rudebusch (1996b), the variables are seasonally adjusted before estimation by filtering through a simple model of quarterly dummies and a time trend. For each of the demand and the supply equations, 36 observations are used to estimate 8 parameters. All the banking variables, including interest rates, are published by the Research Department of Taiwan's Central Bank. The shipment index, S_t, is published by the Statistics Department of the Ministry of Economic Affairs. The variable $\ln Over_t$ is compiled by the authors from the financial statements of 32 domestically-chartered banks. A weighted average is used in the compilation, with the weight equal to the amount of the banks' outstanding loans. All other variables are obtained from the Quarterly National Economic Trend published by the Directorate-General of Budget, Accounting and Statistics (DGBAS). Table 1 shows the statistics of the variables.

3.1.2 Estimation Results of the Aggregate Model

Table 2 reports the estimated parameters. For the demand equation, an important variable explaining loan demand is the capital formation variable (I_t), representing the need for capital investment. The estimate indicates that loan demand increases by 0.5% for every 1% increase in fixed capital formation. Another significant coefficient is on the $d98$ variable, which is 0.124, indicating that, controlling for all other factors included in the model, the demand for bank loan increased after the Asian financial crisis struck the economy.

The autonomous (one-time) shifting in demand after 1998 is intriguing. As will be shown later

[6] We did not use the overdue to total loan ratio because the ratio introduces negative correlation with the dependent variable by construction.

[7] We do not include interaction terms between $d98$ and the other variables, mainly from consideration of the degrees of freedom. If included, the estimated coefficients of the interaction terms were not statistically significant, and results of this analysis changed little. The insignificant interaction effects are likely due to the short time series after 1998 in our sample. As will be shown later, by using disaggregate data where full-fledged interaction specifications are possible, differential effects of the variables before and after 1998 are significant.

[8] After taking lags and differences of the variables, the estimation period starts at 1991:Q4. The sample period cannot start earlier, because the real estate data is unavailable until 1991:Q3.

from the disaggregate data analysis, the rise is likely to be due to the reduced viability of alternative financing sources, particularly those of commercial papers and corporate bonds. As a consequence of limited substitutability, demand for bank loans could not be easily substituted away through alternative sources of external finance. The possibility of reduced substitutability after 1998 draws support from Figure (1).

In explaining the observed slowdown in loan growth, we note that the annual growth rate of I_t, the dominating factor in the demand equation, has an average value of 13.34% between the years 1991 and 1997, and the value drops to 8.95% after that. The evidence thus suggests that the slowdown in demand due to weakened capital investment is part of the story.

On the supply side, the deposit variable is the most important determinants, with the estimated elasticity equal to 1.024. The steep decline of deposit shown in Figure 1 indicates that the supply could have slowed down due to the deposit factor.

Is it the demand or the supply that is more responsible for the large slide in bank loans after 1998? We use the short-side rule of market transactions to assist in answering the question. As discussed before, during an episode of credit slowdown excess demand implies a larger shift-in of loan supply compared to loan demand. We therefore compute the excess demand probability of each period according to equation (8); excess supply probability is just 1 minus the excess demand probability. The results are reported in Table 3 and are conveniently graphed in Figure 4.

As shown, excess supply (i.e., $\Pi_t < 0.5$) is shown in late 1991 and early 1992, which is perhaps a result of weak demand following the 1990-1991 recession. As the economy gradually recovered, excess demand became the likely scenario. The probability of excess demand made a significant rise beginning from 1997, chronicling the incipience of the financial crisis in Southeast Asia. Although impacts of the crisis were not significantly felt in Taiwan until 1998, the loan market already reacted to the event due to the international linkage of financial markets. As the result clearly presents, the credit market was characterized by persistent excess demand after 1998. With credit growth falling in the post-1998 period, the observation of excess demand implies a large inward-shift of supply relative to the shift of demand.[9]

Evidence presented in this section indicates that, generally speaking, Taiwan's bank loan market

[9]We constructed confidence intervals of $\hat{\Pi}_t$ based on the linear approximation of (8), i.e., the delta method. Although the result is in general agreement with the described observations, a report on the result may not be warrantable, because a rigorous application of the delta method requires a large sample size and a smooth function around the approximation point. Neither is true for this model.

in the 1990s is characterized by excess demand, although there are also times when excess supply is observed. Excess demand is particularly obvious and persistent after 1998. Given the credit slowdown after 1998, the result thus suggests that the reduction of supply should account for a larger share of the change in Taiwan's bank loan market in the aftermath of the financial crisis.

3.2 Further Evidence from Disaggregate Data

In this section we use the disaggregate data of both the firms and banks to provide additional evidence on Taiwan's credit market conditions. A new model is derived and estimated for this purpose. In particular, we show that the market transaction with the short-side rule can be represented as the demand equation adjusted for non-negative excess demand, or represented as the supply equation adjusted for non-negative excess supply. The advantage of this approach is that only borrowers' *or* lenders' data is required in the estimation, and we thus avoid needing matched demand and supply data for every period which is difficult to come by at the disaggregate level. The ability to use micro data in the analysis not only allows us to take advantage of the wealth of the micro data, but also enables us to answer questions such as whether the financial crisis had different impacts on different types of firms.

3.2.1 The Model with Disaggregate Data

The short-side rule dictates that the observed market transaction is the smaller of demand and supply. Equation (3) specifies the rule in the aggregate level. Here, we show that the short-side rule can be exploited to derive a model that uses only demand-side data or only supply-side data.

Demand-Based Model

From the point of view of market demand, the short-side rule of market transactions of bank loans implies that

$$Q_t = \begin{cases} D_t & \text{if } D_t \leq S_t, \\ D_t - \tilde{E}_t^d, \quad \tilde{E}_t^d > 0 & \text{if } D_t > S_t, \end{cases}$$

where $\tilde{E}_t^d$ is positive-value excess demand. The model can be more compactly written in a single equation by defining a non-negative excess demand, E_t^d, as in

$$Q_t = D_t - E_t^d, \quad E_t^d \geq 0, \tag{9}$$

where $E_t^d = 0$ if $D_t \leq S_t$, and $E_t^d = \tilde{E}_t^d > 0$ if $D_t > S_t$.

We next observe that excess demand at the aggregate level implies excess demand at the disaggregate level (although the converse is not necessarily true, i.e., the fallacy of composition). Using lower cases to denote variables at the disaggregate level and appending the statistical error $v_{d,it}$, the demand-based market transaction model is thus

$$q_{it} = d_{it} - e_{it}^d + v_{d,it}, \tag{10}$$

where $e_{it}^d \geq 0$ is the firm-specific and time-specific measure of excess demand.

This model differs from the traditional one only in the presence of the term of excess demand, $-e_{it}^d$, which accommodates possible gaps between notional demand and actual supply owing to sluggish market adjustments or asymmetric information problems. In the estimation we assume e_{it}^d is a random variable, and the effect of excess demand is identified by imposing a distributional assumption on e_{it}^d. Together with an assumed distribution for v_{it}, the likelihood function of the model is derived, based on which we obtain the maximum likelihood estimates of the model.

Supply-Based Model

The above derivation can be easily extended to an alternative, supply-based model. Following similar notations, the model is

$$Q_t = S_t - E_t^s, \quad E_t^s \geq 0. \tag{11}$$

Here, E_t^s is the non-negative excess supply for which $E_t^s = 0$ if $D_t \geq S_t$, and $E_t^s > 0$ if $D_t < S_t$. The micro model then is

$$q_{it} = s_{it} - e_{it}^s + v_{s,it}. \tag{12}$$

Here, $e_{it}^s \geq 0$ is the firm-specific and time-specific measure of excess supply, and $v_{s,it}$ is the statistical error of the supply equation. Given the distributional assumptions of e_{it}^s and $v_{s,it}$, the likelihood function of the model can be derived.

The Likelihood Function

Because of the similarity between the demand-based and the supply-based models, we present only the likelihood function of the demand-based model of (10). With trivial modifications, the likelihood function of the supply-based model is readily obtainable from the result.

For the stochastic excess demand e_{it}^d, we impose a distribution that has a positive value for every possible realization of the random variable, and the distribution accounts for the different degrees of excess demand on the observational basis. We use the technique developed in the *stochastic frontier* literature for this purpose. In particular, a proposed model by Wang and Schmidt (2002) is used, which leads to the following specification of e_{it}^d:

$$e_{it}^d \sim h(\boldsymbol{z}_{it},\, \boldsymbol{\delta}) \cdot N^+(\tau,\, \sigma_d^2), \tag{13}$$

where $h(\cdot)$ is a non-negative and non-stochastic function of the $K \times 1$ vector of excess-demand determinants $\boldsymbol{z}_{it}$ and the corresponding coefficient vector $\boldsymbol{\delta}$, and $N^+(\tau,\, \sigma_d^2)$ denotes the positive truncation of a normal random variable with the (pre-truncation) mean and variance being τ and σ_d^2, respectively. Here, the $h(\cdot)$ function is modeled as

$$h(\boldsymbol{z}_{it},\, \boldsymbol{\delta}) = \exp(\boldsymbol{z}_{it}'\boldsymbol{\delta}). \tag{14}$$

Wang and Schmidt (2002) show that (13) exhibits a scaling property of the latent variable, which is the excess demand in our case. With the scaling property, the excess demand's underlying basic distribution $N^+(\tau,\, \sigma_d^2)$ is the same for all the observations, and the distribution is shrunk and stretched by the scaling function $h(\cdot)$ to accommodate different degrees of excess demand in the observations. The model can be shown to include many of the popular models in the literature as special cases.

An attractive property of the above model is the ease of interpretation on the estimated coefficients. The kth coefficient of $\boldsymbol{\delta}$ ($\delta[k]$) is the marginal effect of $z[k]$ on the percentage change of the excess demand: $\delta[k] = \partial \ln(e_{it}^d)/\partial z[k]$. If $z[k]$ is in logarithm, then $\delta[k]$ is simply the elasticity. This interpretation is not feasible for many of the other models in the literature. This result also implies that the determinant's effect is independent of the underlying distribution $N^+(\tau,\, \sigma_d^2)$, which is a desirable feature for applied researche studies.

The parameterization of (14) is important in our analysis. Since e_{it}^d measures excess demand, the parameterization is intended to explain the expected value of excess demand with a vector of exogenous variables $\boldsymbol{z}_{it}$. For instance, it is often hypothesized that smaller firms are more likely to be denied credit, because of the informational problem (ex., Gertler and Gilchrist 1994). The hypothesis can then be investigated by having a size variable in the vector of $\boldsymbol{z}_{it}$ and testing whether it is significantly and positively correlated to e_{it}^d. To investigate whether the availability of

alternative financial sources affects the tightness in the bank loan market, we incorporate proxies of alternative financing in the vector of $\boldsymbol{z}_{it}$.

The other random variable of model (10) is $v_{d,it}$, which is assumed to follow a normal distribution:

$$v_{d,it} \sim N(0,\, \sigma^2_{d,v}). \tag{15}$$

The two positive constants of σ^2_d and $\sigma^2_{d,v}$ in (13) and (15) are parameterized as follows in the estimation:

$$\sigma^2_d = \exp(c1), \qquad\qquad \sigma^2_{d,v} = \exp(c2). \tag{16}$$

Based on the above setup, the log-likelihood function of an observation is given below.

$$-\frac{1}{2}\ln(\sigma^2_{d,v}+\sigma^2_u) + \ln\left[\phi\left(\frac{\epsilon_{it}+\mu}{\sqrt{\sigma^2_{d,v}+\sigma^2_u}}\right)\right] + \ln\left[\Phi\left(\frac{\mu_*}{\sigma_*}\right)\right] - \ln\left[\Phi\left(\frac{\tau}{\sigma_d}\right)\right], \tag{17}$$

where

$$\begin{aligned}
\mu &= \tau\cdot\exp(\boldsymbol{z}'_{it}\boldsymbol{\delta}), && (18)\\
\sigma^2_u &= \exp(\boldsymbol{z}'_{it}\boldsymbol{\delta})^2\cdot\sigma^2_d, && (19)\\
\mu_* &= \frac{\sigma^2_{d,v}\;\mu - \epsilon_{it}\,\sigma^2_u}{\sigma^2_{d,v}+\sigma^2_u}, && (20)\\
\sigma^2_* &= \frac{\sigma^2_{d,v}\;\sigma^2_u}{\sigma^2_{d,v}+\sigma^2_u}. && (21)\\
\epsilon_{it} &= q_{it} - d_{it}. && (22)
\end{aligned}$$

The variables $\phi(\cdot)$ and $\Phi(\cdot)$ are respectively the density and the cumulated probability functions of a standard normal distribution. Maximum likelihood estimates of the model parameters can be obtained by numerically maximizing the sum of the log-likelihood functions. The likelihood function of the supply-based model is similar to (17)–(22), with the obvious substitutions of d_{it}, $\sigma^2_{d,v}$, and σ^2_d by s_{it}, $\sigma^2_{s,v}$, and σ^2_s (similarly defined), respectively.

Data and Variable Specifications

The data is obtained from the quarterly financial statements of Taiwan's publicly-traded non-financial firms (demand side) and banks (supply side). A total of 484 firms and 32 banks are included, and quarterly data spanning from 1991:Q4 to 2000:Q2 is used. Summary statistics of the demand and supply variables are in Table 1.

The variable specification for the model of bank loan demand is as follows. We use lower cases to indicate that the variables are constructed from disaggregate data.

q_{it}: $\ln debt_{it}$,

d_{it}: $\{R^d_{t-1}, \ln \mathrm{i}^d_{it}, \ln inv_{it}, \Delta \ln s_{it}, \Delta \ln E_t, \Delta \ln H_t, \ln P_t, \ln asset_{it}, d98\ \}$,

z_{it}: $\{\ln asset^f_{it}, \ln cpb_{it}, \ln nstock_{it}\ \}$.

The variable $debt_{it}$ is the sum of firm i's short-term installment and long-term borrowing from financial institutions at time t. Given that banks are the dominant financial lending institutions in Taiwan, this variable should reasonably approximate the amount of bank credit borrowed by the firm. The figure of $debt_{it}$ does not include the proceeds from commercial paper and corporate bond issuing.

Definitions of the lower-case variables in the d_{it} function are the disaggregate counterparts of the upper-case aggregate variables discussed in Section 3.1.1. Exceptions include $\Delta \ln s_{it}$, which measures the growth rate of sales based on the firm's actual sales (instead of the sales index). Another exception is the inclusion of $\ln asset^f_{it}$, which is the log of the firm's fixed assets. We include this variable mainly to control for the scale effect in the data.

For the variables in $\boldsymbol{z}_{it}$, $\ln asset^f_{it}$ is defined above and cpb_{it} is the sum of the firm's commercial paper and corporate bond balances, which is the firm's alternative debt financing. The variable $nstock_{it}$ represents proceeds from new issues of stock which is the amount of equity financing. The asset size variable is used to test the hypothesis that smaller firms are more likely to be denied credit and thus experience unfilled demand. Variables $\ln cpb_{it}$ and $\ln nstock_{it}$ are used to investigate whether the excess demand of bank credit is related to the use of alternative financing. Because the degrees of freedom are not a problem for the disaggregate data, we also add interaction terms between the dummy ($d98$) and all other variables in d_{it} and z_{it}.

For the supply-based bank loan model, we have the following variable specification.

q_{it}: $\ln l_{it}$,

s_{it}: $\{r^s_{it-1}, (\frac{k}{a})_{it}, \ln dep_{it}, \ln over_{it}\ , \Delta \ln E_t, \Delta \ln H_t, \ln P_t, \ln asset^b_{it}, d98\ \}$.

The dependent variable is $\ln l_{it}$, which is the log of total loans outstanding of bank i in period t. All other lower-case variables are similarly defined as the upper-case counterparts in Section 3.1.1. The log of the bank's fixed asset variable, $\ln asset^b_{it}$, is added to control for the scale effect.

Note that unlike the demand-based model, we estimate a restricted version of the model of (17) in which $h(\cdot) = 1$ and $\tau = 0$, and the excess supply is determined by a sole constant parameter σ^2_s.

The resulting specification is essentially that of Aigner et al. (1977). As will be shown later, the assumption of excess supply is not supported in the data, and non-existence is most easily shown by using the single parameter model suggested here.

3.2.2 Estimation Results

The demand-based model

Table 4 reports the estimation results of the demand model. Inventory financing, the economic perspective approximated by the growth of the stock market index, and the nominal demand effect all have significant effects on bank loan demand. The growth of sales is marginally significant at the 14% level. Although the insignificant capital investment effect may seem somewhat surprising, it is caused by the inclusion of the fixed asset variable, $\ln asset^f_{it}$, in the model. Because fixed assets are an accumulation of capital investment after depreciation, the two variables are closely related both economically and statistically. The correlation coefficient is 0.660 between the two variables. If we drop the asset variable from the model, then the coefficient of $\ln i^d_{it}$ is 0.415, which is highly significant.[10]

As in the aggregate model, the effect of the intercept shifter $d98$ is large and highly significant, predicting a possible scenario of excess demand. The coefficients of variables interacting with $d98$ indicate changes of the effect after 1998. Among others, the elasticity of inventory investment increases by almost 40% ($0.055/0.141 \approx 0.39$) after 1998. The predictive power of sales, on the other hand, decreases marginally after 1998. The results are in general consistent with firms facing greater financial difficulty.

The estimated effects of $\ln asset^f_{it}$, $\ln cpb_{it}$, and $\ln nstock_{it}$ on the excess demand parameter reveal interesting observations of credit tightening. The elasticity of asset sizes ($\ln asset^f_{it}$) on excess demand is -0.051, which is statistically significant. Since the result is obtained after controlling for determinants of loan demand, the interpretation is that smaller firms have more difficulty raising outside finance, and therefore they are more likely to experience unfulfilled credit demand in the market. The finding echoes a large body of existing literature that emphasizes small firms' asym-

[10] In spite of the problem, we opt to keep the asset variable in the model. As will be discussed, one of the purposes of estimating this model is to investigate the determinants of excess demand based on e^d_{it}. Because e^d_{it} can be treated as part of the composite error of the model, its estimation to a certain extent is affected by the specification of d_{it}. Therefore, our priority is to have a reliable estimate of d_{it}.

metric information problem in the financial market.[11] As indicated by the interaction of $\ln asset_{it}^{f}$ and $d98$, the assets' effect on excess demand exacerbates after 1998. Smaller firms appeared to have *increased* difficulty borrowing from banks after the financial crisis. The evidence implies that, although smallers firms had been having disadvantages in the bank credit market, the situation worsened after the financial crisis. The evidence thus suggests that credit tightening is not a general credit contraction; rather, it is the restructuring of banks' loan portfolios that put smaller firms in further difficult positions. The restructuring corresponds to the observation of "flight-to-quality" behavior of banks, as first investigated by Bernanke et al. (1996).

The use of commercial papers and corporate bonds ($\ln cpb_{it}$) and equity financing ($\ln nstock_{it}$) are also negatively correlated with excess demand of bank credit. This indicates that bank credits and other types of financing are substitutes and that the extent of excess demand of bank credits can be mitigated by resorting to other types of financing. The substitution effect draws support from Figure 1, in which the growth rates of bank loans and corporate debts move in opposite directions before the financial crisis.

Substitutability is compromised after 1998, as shown by the positive coefficients of the variables' interactions with $d98$. The coefficients are significant at the 1% level for equity financing, and they are significant at the 11% level for paper and bond financing. The reduced substitutability is likely due to the correlated shocks to the different financial sectors brought about by the financial crisis. One implication of the constricted financing sources is that the post-1998 excess demand of bank credit shown in Figure 4 can be attributed not only to the reduced loan supply, but also to the shrinkage of alternative financing sources. This possibility is consistent with the finding of the increased loan-paper mix and loan-paper spread shown in Figure 2.

To check the robustness of the results, we estimate additional models with alternative distribution assumptions on e_{it}^{d} in (13). Specifically, we estimate models assuming e_{it}^{d} has a half-normal distribution (i.e., Caudill et al. 1995), a truncated-normal distribution (i.e., Battese and Coelli 1995), and an exponential distribution (i.e., Wang 2003). All of them accommodate the observation-specific $\boldsymbol{z}_{it}$ in explaining excess demand. The estimations all show very consistent results in these alternative models, and conclusions of this paper are not affected by the alternative distributional

[11] Most of the existing evidence is in the context of capital investment, in which smaller firms' investment are found to be sensitive to internal cash flow (e.g., Fazzari et al. 1988, Whited 1992). Our result provides corresponding evidence in the context of credit demand.

assumptions.

We lastly estimate a restricted version of (13), in which $\tau = 0$ and $h(\cdot)$ is a constant of 1. The model thus reduces to that of Aigner et al. (1977), who assume a half-normal distribution for the latent variable without heteroscedasticity. The half-normal distribution has a single parameter σ_d^2, and the existence of excess demand implies a large and significant σ_d^2. This simplified model is thus instrumental in detecting the existence of excess demand. The estimated $c1$ of (16) equals 2.683, which is significant at the 1% level, and the estimated $c2$ equals -0.908. Given the half-normal distribution, the implied variance ratio of var($\hat{e}_{it}^d$) to the sum of var($\hat{e}_{it}^d$) and var($\hat{v}_{d,it}$) is 0.93. Therefore, 93% of the total variance is attributed to the variance in excess demand. Detailed results of these alternative models are available from the authors upon request.

As a check of the robustness, we add lagged (1 period) variables of capital investment, inventory investment, and growth of sales in the model, and we compute the accumulated effects and test the joint significance. The results change little for the effects of inventory investment. Although the estimates of the capital investment and the growth of sales do have some changes, the implications we can draw from them are not affected.

The supply-based model

Table 5 shows the estimation results of the supply equation. For this model, excess supply is virtually non-existent which is evident by the result that $\hat{\sigma}_s^2 = \exp(-20.754) \approx 0$ of the simplified model. The result implies that excess supply is not a likely scenario in the sample period, which we found to be broadly consistent with our earlier analysis using aggregate data.

As in the aggregate model, the loan supply's elasticity with respect to deposits ($\ln dep_{it}$) is very large (0.936) and is highly significant. The elasticity is not shown a structural change after 1998. The micro-level data shows that the quarterly growth rate of individual banks' deposits experiences a significant drop from the average level of 8.4% prior to 1998[12] to 2.4% after 1998. Given the significant impacts of deposits on loan supply both before and after 1998 (the finding of no structural change in not consequential here), the drop in deposit after 1998 is likely to be one of the factors leading to the observed decline in loan supply.

[12]Some large numbers are included in the calculation of the average growth rate, and they are from the year 1993 when newly-established banks entered the market. If we consider only the growth rates in 1996 and 1997, the two years prior to the Asian financial crisis, then the average growth rate is 4.2%.

For the variable of overdue loans ($\ln over_{it}$), it does not have important effects on loan supply prior to 1998, but its elasticity is $-0.023 - 0.565 = -0.588$ with a standard error equal to 0.157 (computed from the covariance matrix of the estimates) in the post-1998 period, which is highly significant.[13] Note that the increase in the overdue loan in the post-1998 era could have indicated the precipitation of bank capital deterioration.[14] Therefore, the significant effect of overdue loans on the supply in the post-1998 period reflects not only the industry's reaction to market risk in general, but also signals the industry's concerns on the capital adequacy in particular.

The capital asset ratio ($(k/a)_{it}$) has significant effects on loan supply *only before 1998*: a 1% increase in the ratio leads to a 0.81% rise in supply. The post-1998 effect of the capital asset ratio on loan supply is $0.810 - 0.828 = -0.018$ (standard error = 0.332), which is statistically insignificant. Therefore, the relationship between the two quantities was no longer obvious after 1998.

One possible reason for the differences in the sub-samples regarding the capital asset ratio can be attributed to the capital crunch effect. The average of the capital asset ratio from the data for the first sub-sample is 9.2% with a standard deviation equal to 0.051; the average in the second sub-sample is a mere 8.4% with a standard deviation equal to 0.026. With the average capital asset ratio hovered dangerously close to the 8% capital adequacy requirement of the Basel Accord, it is possible that local banks were constrained or became more cautious in extending loans particularly when the market was risky in the second sub-sample. The tightening in supply could be industry-wide and is irrespective to the individual bank's capital asset ratio which did not show much variation across banks in the second sub-sample. Therefore, the cross-bank variations in capital asset rations appear inconsequential to the loan supply in the post-1998 period, which might explain why in the estimation the post-1998 effect of the capital asset ratio on loan supply is insignificant.

For sensitivity analysis, we add lagged (1 period) variables of deposits, overdues, and capital asset ratios in the model, and we compute the accumulated effects and test the joint significance. For deposits and overdues, the inclusion of the lagged variable do not change the results. For the

[13] The qualitative result is the same if the ratio of overdue loans to fixed asset is used in the estimation. We do not use the ratio of overdue loans to total loans because such measure introduces negative correlation with the dependent variable by construction.

[14] Amid of the piling up of overdue loans, the Ministry of Finance took strict measures to ensure local banks stay solvent. For instance, in July 1999 the Ministry of Finance required local financial institutions to reduce before September their overdue loan ratios to or below the levels at April. Institutions fail to comply would be subject to close inspections. If the institutions' capital adequacy are adversely affected by the measure, the institutions are allowed to issue special stocks and subordinate debts to strengthen capital structures.

capital asset ratio, adding the lag variable causes the effect to be insignificant before as well as after 1998.

4 Conclusion

In this paper we identify the demand and supply effects of the credit decline in Taiwan following the Asian financial crisis and investigate the causes and the consequences of such a dramatic change in the credit market. A descriptive analysis of key macro variables provides useful insights to the nature of the problem. Econometric tools are then used to rigorously analyze the data. We estimate an aggregate model of demand and supply and then infer their relative changes by measuring the extent of excess demand in the market. We then propose a novel model that accommodates excess demand or excess supply in a demand-based or a supply-based market transaction model. Since we do not need to have matched borrowers' and lenders' data for this model, we take advantage of the wealth of micro data to provide more precise estimates and further evidence on the issue.

Results from both the aggregate and disaggregate data analysis indicate that the slowdown in supply was the main reason causing the large credit growth decline in the post-1998 period. We identify deposit outflows and the increase in overdue loans as the most important factors leading to that event. There is also suggestive evidence that capital crunch could have also played a role in the event. The policy implication is that measures aimed at restoring the momentum of credit supply are important in getting the economy out of the credit crunch scenario.

As a consequence of the drastic shift in supply, the existence of excess demand in the market is clearly observed in the data. An interesting finding is that bank credits and other types of financial sources are substitutes, but the substitutability between the major sources of funds was impaired after the financial crisis. We suspect that the diminished ability to choose among alternative financing may have also indirectly led to the tightness in the bank credit market.

Heterogeneous effects of the credit crunch on different types of firms are also observed. We find that smaller firms were more likely to have experienced unsatisfied loan demand, and the size discrimination worsened further after the financial crisis. The credit decline in the aftermath of the crisis is thus not a general credit cutback, but may rather reflect the "flight to quality" of bank lending from lenders' attempts to restructure their loan portfolios. The reallocation of credit between large and small firms worsening after a crisis not only makes borrowers face relatively high

agency cost to bear the brunt of the shrinkage of loan supply, but also exacerbates the impact of such a crisis, as was found in Bernanke et al. (1996).

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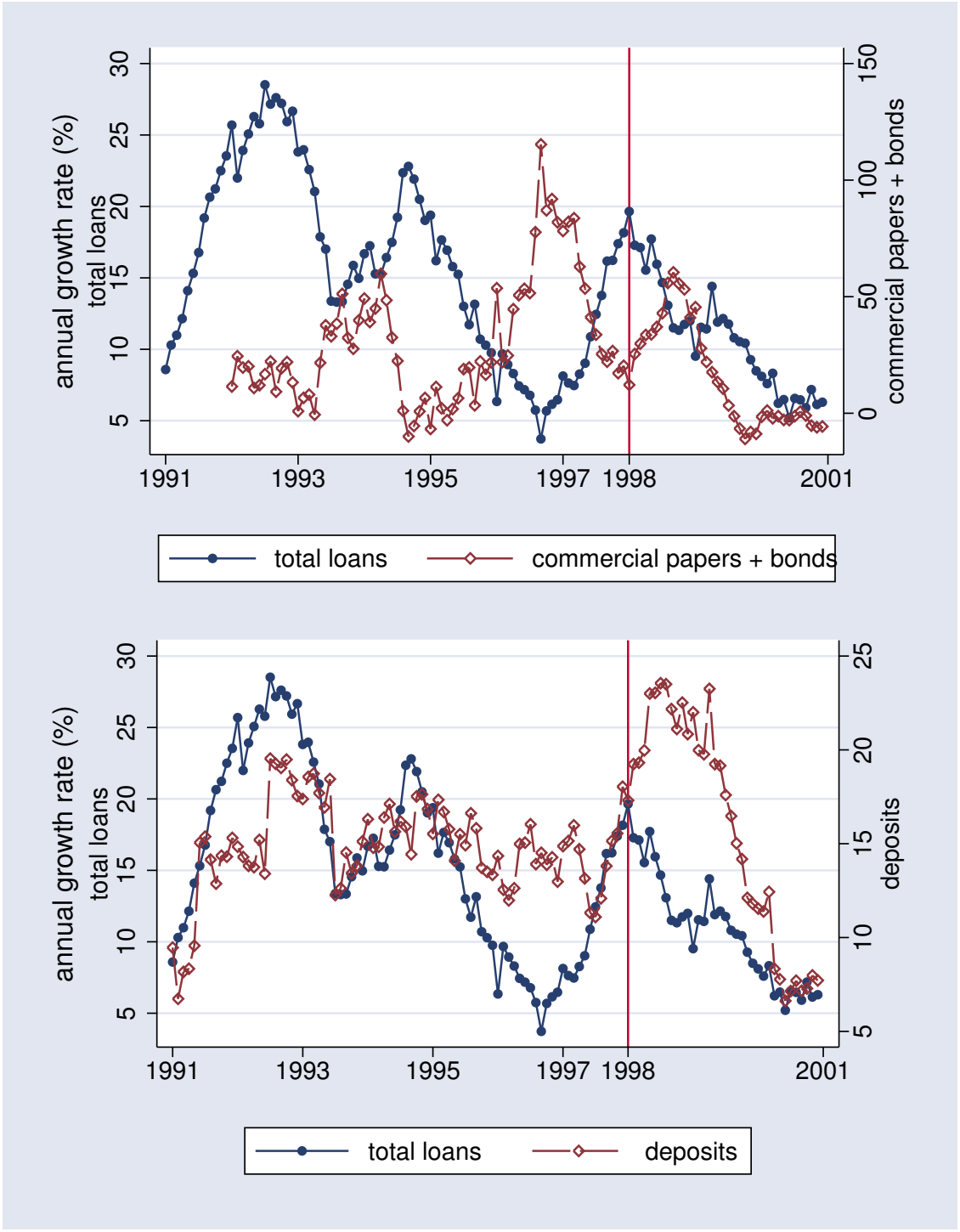

Figure 1: Annual Growth Rates of total loans, deposits, and commerical papers and bonds.

The vertical bar indicates the beginning of 1998.

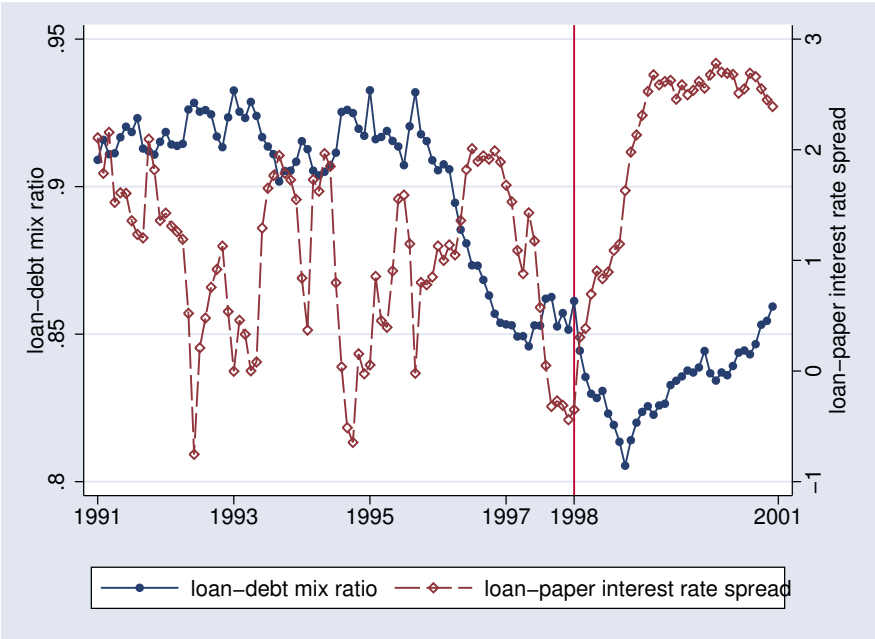

Figure 2: The Mix and the Interest Rate Spread.

The vertical bar indicates the beginning of 1998. The mix is defined as the ratio of total loans to the sum of total loans, commercial papers, and corporate bonds. The interest rate spread is the difference between the prime loan rate and the six month commercial paper rate. The mix and the spread moved in the opposite directions before 1996, and the negative correlation is not obvious in the later periods.

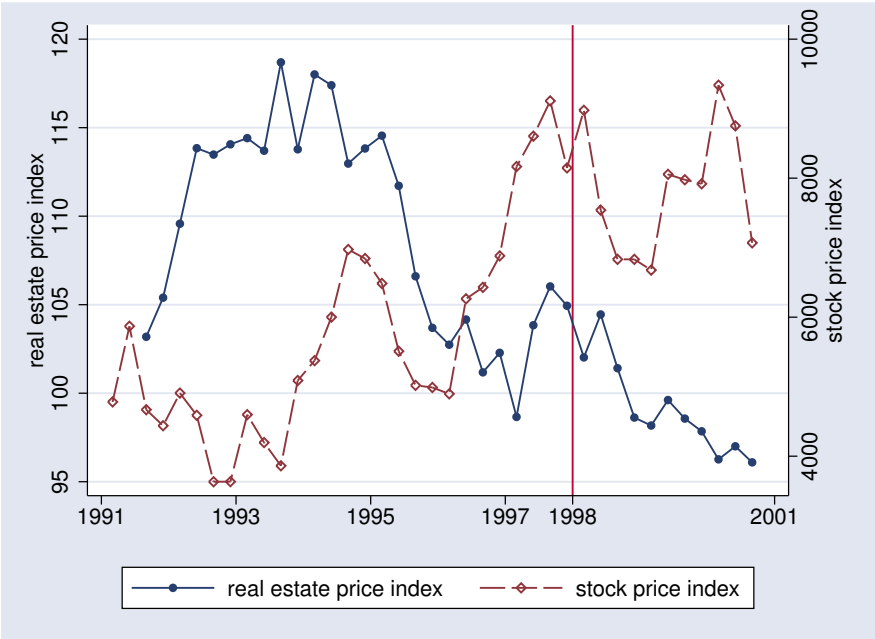

Figure 3: Asset Prices.

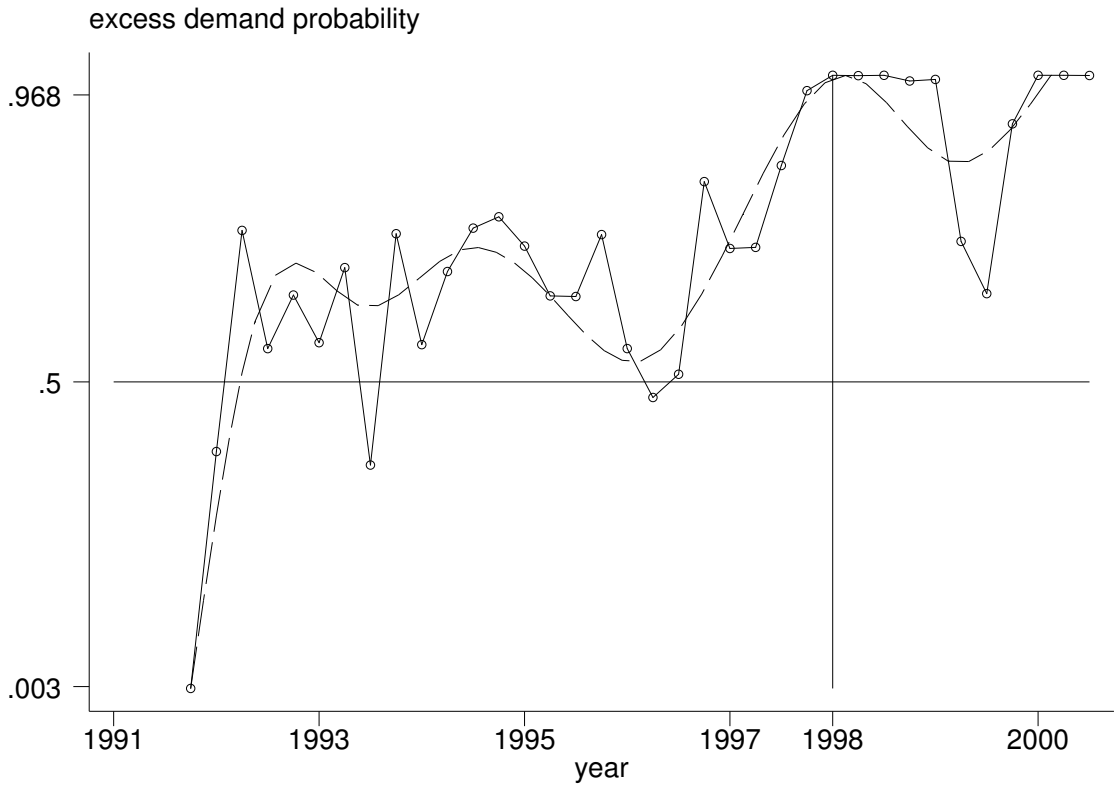

Figure 4: The Excess Demand Probability of Taiwan's Bank Credit Market: 1991:Q4 – 2000:Q3. The dashed curve draws the median bands of the data points with cubic spline. It shows the tendency of the probability distribution. The graph indicates persistent excess demand after 1998, which, in an episode of credit decline, implies that the market is dominated by inward shifts of supply.

Table 1: Statistics of the Variables

aggregate model			disaggregate demand model			disaggregate supply model		
variables	mean	std. dev.	variables	mean	std. dev.	variables	mean	std. dev.
$\ln L_t$	11.047	0.312	$\ln debt_{it}$	-0.547	2.884	$\ln l_{it}$	14.149	0.898
R^d_{t-1}	1.718	0.937	R^d_{t-1}	1.762	0.906			
$\ln I_t$	7.837	0.343	$\ln \mathrm{i}_{it}$	-1.089	1.748			
$\ln INV_t$	4.595	0.103	$\ln inv_{it}$	1.522	1.791			
$\Delta \ln S_t$	0.013	0.047	$\Delta \ln s_{it}$	0.035	0.394			
$\Delta \ln E_t$	0.012	0.127	$\Delta \ln E_t$	0.017	0.136	$\Delta \ln E_t$	0.017	0.131
$\Delta \ln H_t$	-0.002	0.026	$\Delta \ln H_t$	-0.003	0.027	$\Delta \ln H_t$	-0.005	0.024
$\ln P_t$	4.584	0.053	$\ln P_t$	4.593	0.049	$\ln P_t$	4.602	0.042
R^s_{t-1}	2.875	0.148				r_{it-1}	3.711	1.186
$\left(\frac{K}{A}\right)_t$	0.066	0.009				$\left(\frac{k}{a}\right)_{it}$	0.094	0.056
$\ln Dep_t$	11.161	0.359				$\ln dep_{it}$	14.270	0.893
$\ln Over_t$	7.500	0.936				$\ln over_{it}$	2.703	0.092
			$\ln asset_{it}$	3.835	1.116	$\ln asset_{it}$	14.149	0.898
			$\ln cpb_{it}$	-4.226	1.476			
			$\ln nstock_{it}$	-3.893	1.890			
# of obs. = 36			# of obs. = 13579			# of obs. = 860		

[1.] Before taking logarithms and differences, the level variables are in 100 millions of New Taiwan Dollars. The L_t is domestic banks' total loans to private enterprise, $debt_{it}$ is the publicly traded firm's short-term installment and long-term borrowing from financial institutions, and l_{it} is the domestic bank's total outstanding loans. See the text for definitions of other variables.

Table 2: Estimation Results of the Aggregate Model

demand equation			supply equation		
variables	coef.	std. err.	variables	coef.	std. err.
R^d_{t-1}	-0.018	(0.012)	R^s_{t-1}	0.082**	(0.035)
$\ln I_t$	0.520***	(0.183)	$\left(\frac{K^s}{A}\right)_t$	-1.131	(2.618)
$\ln INV_t$	-0.324	(0.268)	$\ln Dep_t$	1.024***	(0.340)
$\Delta \ln S_t$	0.248	(0.271)	$\ln Over_t$	0.035	(0.029)
$\Delta \ln E_t$	0.041	(0.099)	$\Delta \ln E_t$	-0.037	(0.040)
$\Delta \ln H_t$	-0.545*	(0.328)	$\Delta \ln H_t$	-0.182	(0.265)
$\ln P_t$	-0.033	(1.060)	$\ln P_t$	0.633*	(0.368)
$d98$	0.124***	(0.035)	$d98$	-0.009	(0.006)
σ_d	0.036***	(0.010)	σ_s	0.025***	(0.004)
log-likelihood value = 76.232					

[1] The dependent variable is $\ln L_t$, log of the total outstanding loans. $*$: significant at the 10% level; $**$: significant at the 5% level; $***$: significant at the 1% level.

Table 3: The Estimated Excess Demand Probability of Taiwan's Bank Credit Market

year	quarter	prob.	year	quarter	prob.	year	quarter	prob.
1991	1	–	1995	1	0.7214	1999	1	0.9932
1991	2	–	1995	2	0.6402	1999	2	0.7290
1991	3	–	1995	3	0.6392	1999	3	0.6439
1991	4	0.0001	1995	4	0.7402	1999	4	0.9208
1992	1	0.3863	1996	1	0.5542	2000	1	0.9999
1992	2	0.7469	1996	2	0.4745	2000	2	0.9999
1992	3	0.5542	1996	3	0.5124	2000	3	0.9997
1992	4	0.6416	1996	4	0.8265			
1993	1	0.5639	1997	1	0.7176			
1993	2	0.6863	1997	2	0.7194			
1993	3	0.3643	1997	3	0.8528			
1993	4	0.7416	1997	4	0.9749			
1994	1	0.5606	1998	1	0.9999			
1994	2	0.6800	1998	2	0.9994			
1994	3	0.7508	1998	3	0.9999			
1994	4	0.7692	1998	4	0.9907			

[1] See Figure 4 for a plot of the probabilities.

Table 4: Estimation Results of the Model of Demand

	coeff.	std. err.			coeff.	std. err.
R^d_{t-1}	-0.012	(0.020)	h function			
$\ln \mathrm{i}^d_{i\,t}$	-0.022	(0.015)		$\ln asset^f_{it}$	-0.051***	(0.009)
$\ln inv_{i\,t}$	0.141***	(0.012)		$\ln cpb_{it}$	-0.037***	(0.008)
$\Delta \ln s_{i\,t}$	0.091	(0.061)		$\ln nstock_{it}$	-0.038***	(0.005)
$\Delta \ln E_t$	0.243*	(0.128)		$\ln asset^f_{it} \times d98$	-0.035**	(0.016)
$\Delta \ln H_t$	0.300	(0.511)		$\ln cpb_{it} \times d98$	0.019†	(0.012)
$\ln P_t$	-2.591***	(0.404)		$\ln nstock_{it} \times d98$	0.023***	(0.009)
$\ln asset^f_{it}$	0.864***	(0.023)		$d98$	0.381***	(0.074)
$R^d_{t-1} \times d98$	-0.069*	(0.040)	τ		-8.350***	(1.098)
$\ln \mathrm{i}^d_{i\,t} \times d98$	-0.043**	(0.021)	σ^2_d	$c1$	3.299***	(0.116)
$\ln inv_{i\,t} \times d98$	0.055***	(0.020)	$\sigma^2_{d,v}$	$c2$	-0.904***	(0.043)
$\Delta \ln s_{i\,t} \times d98$	-0.124	(0.095)				
$\Delta \ln E_t \times d98$	-0.075	(0.223)				
$\Delta \ln H_t \times d98$	-3.241**	(1.487)				
$\ln P_t \times d98$	-4.028***	(1.245)				
$\ln asset^f_{it} \times d98$	0.022	(0.044)				
$d98$	18.851***	(5.815)				
constant	11.595***	(1.843)				
			log-likelihood value = -29838.882			

[1] The dependent variable is $\ln debt_{it}$, which is log of the sum of firm i's short-term installment and long-term borrowing from financial institutions at time t. Standard errors are heteroscedastic-consistent based on White (1980). $*$: significant at the 10% level; $**$: significant at the 5% level; $***$: significant at the 1% level.

† This coefficient is significant at the 11% level.

Table 5: Estimation Results of the Model of Supply

	coeff.	std. err.			coeff.	std. err.
r^s_{it-1}	-0.078***	(0.010)	σ^2_s			
$\left(\frac{k}{a}\right)_{it}$	0.810***	(0.123)		$c1$	-20.754***	(0.166)
$\ln dep_{it}$	0.936***	(0.025)				
$\ln over_{it}$	-0.023	(0.134)	$\sigma^2_{s,v}$			
$\Delta \ln E_t$	0.006	(0.053)		$c2$	-3.837***	(0.123)
$\Delta \ln H_t$	0.149	(0.274)				
$\ln P_t$	-0.645***	(0.225)				
$\ln asset^b_{it}$	0.047***	(0.015)				
$r^s_{it-1} \times d98$	-0.023	(0.017)				
$\left(\frac{k}{a}\right)_{it} \times d98$	-0.828**	(0.354)				
$\ln dep_{it} \times d98$	0.052	(0.039)				
$\ln over_{it} \times d98$	-0.565***	(0.206)				
$\Delta \ln E_t \times d98$	-0.032	(0.085)				
$\Delta \ln H_t \times d98$	0.561	(0.624)				
$\ln P_t \times d98$	0.724	(0.468)				
$\ln asset^b_{it} \times d98$	0.019	(0.027)				
$d98$	-2.608	(2.220)				
constant	3.539***	(0.985)				
			log-likelihood value = 445.967			

[1] The dependent variable is $\ln l_{it}$, which is log of the total loan outstanding of bank i at time t. Standard errors are heteroscedastic-consistent based on White (1980). $*$: significant at the 10% level; $**$: significant at the 5% level; $***$: significant at the 1% level.