Credit Crunch, Bank Lending, and Monetary Policy: A Model of Financial Intermediation with Heterogeneous Projects

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Introduction and Motivation

A credit crunch is generally defined as a decline in the supply of credit because, although banks are less willing to lend, lending rates do not rise. According to Green and Oh (1991), a credit crunch is an inefficient situation in which credit-worthy borrowers cannot obtain credit at all, or cannot get it at reasonable terms, and lenders show excessive caution, which may or may not be traceable to regulatory distortion, leaving would-be borrowers unable to fund their investment projects. A credit crunch can have several causes, such as regulatory pressures and over-reaction to deteriorating bank asset values and profitability. If regulatory pressure is the obstacle to credit growth, it should be removed, and credit growth can be restored. But if the crunch is caused by inefficient conservative lending by banks, it is an open question whether easing monetary policy can help. This paper attempts to develop a quantitative model to address the issue.

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A number of papers suggest that a credit crunch existed in several countries in the early 1990s. From survey data in Germany, Harholf and Korting (1998) find that firms in financial distress face comparatively high line-of-credit interest rates and reduced credit availability. Using Finnish data from the 1990s, Vihriala (1996) finds that tightening capital regulations, substantially depleting bank capital, and changing risk attitudes may explain banks' conservative lending. Using a disequilibrium econometric model, Pazarbasioglu (1996) also suggests that banks become less willing to supply credit during periods of deteriorating asset quality and reduced profits caused by declining regulatory protection from competition and a need to increase capital-adequacy levels.

In 1990–91, U.S. banks curtailed their lending. Sharpe (1995) claims this occurred because of losses of bank capital, stringent bank regulatory standards, and heightened market scrutiny of bank capital. The Bank for International Settlements risk-based capital standards were phased in beginning in late 1990 and took full effect in 1992. The reduced credit occurred at a time when banks had difficulty meeting their minimum-capital adequacy requirements. According to Bernanke and Lown (1991), the regulatory pressures on bank capital positions would shift the credit supply curve to the left, given constant real interest rates and the same quality of borrowers. Using New England bank data, Peek and Rosengren (1995) find empirical evidence supporting the hypothesis that banks have experienced a capital crunch caused by large capital losses and binding capital regulations.

An interesting, recent paper by Wagster (1999) examines the 1989–92 credit crunch in the United States, Canada, and the United Kingdom. Four supply-side credit crunch hypotheses are proposed: (i) voluntary risk reduction by bank managers, (ii) tighter scrutiny by bank regulators, (iii) risk-based capital requirements following the 1988 Basle Accord, and (iv) the unweighted capital ratio imposed by U.S. bank regulators. The results show that none of the four hypotheses can be eliminated as explanations for the U.S. credit crunch. For Canada, the results conform to the risk-based capital requirement and tighter regulatory scrutiny hypotheses. For the United Kingdom, tighter regulatory scrutiny is the explanation for the crunch.

The recent credit crunch in Japan has drawn a lot of attention from researchers and policy-makers. The banks' capital positions have been eroded by deteriorating loan quality and losses of banks' security holdings. Furthermore, banks were reluctant to issue new equities because of unfavourable market conditions. To meet the minimum-capital adequacy requirement, banks had to reduce their loans. This pushed marginal borrowers into bankruptcy, putting more pressure on the banks' capital position. Woo's (1999) empirical results based on the data suggest a credit crunch in 1997, but not during most of the rest of the 1990s. The Bank of Japan and the Japanese government have taken measures to deal with the crunch, such as lowering nominal short-term interest rates to near zero, injecting capital into several commercial banks, and relaxing capital adequacy requirements by way of accounting changes.

What can monetary policy do to help during a credit crunch when reduced bank lending leads to a shrinking economy? The question is related to the transmission mechanism of monetary policy. One transmission channel of monetary policy is credit. Expansions and contractions of credit affect both aggregate demand and aggregate supply, thus influencing aggregate activities and prices.

The credit channel of monetary policy has been drawing much attention from researchers recently. In the credit-channel stories, financial market imperfection is an important factor of the transmission mechanism—a financial accelerator effect. Because of frictions in credit markets, different financing sources are imperfectly substitutable, especially for bank credit. Given asymmetric information in financial markets, the impact of monetary policy will be amplified and distributed among borrowers through two channels: the lending channel and the balance sheet channel. The lending channel (Bernanke and Blinder 1988) works through the supply side of credit. A tight policy reduces the supply of bank loans, which in turn reduces spending by borrowers that depend on banks. The balance sheet channel (Bernanke and Gertler 1995) works through the demand side of credit. A tight policy weakens borrowers' balance sheets, which reduces their ability to borrow. A shrinking loan supply leads to a rising lending rate, which would discourage bank-dependent borrowers' activity. Instead of raising the interest rate on loans, banks can also ration credit. Banks ration credit rather than raise interest rates because of asymmetric information between borrowers and lenders. The problems of moral hazard and adverse selection can lead to credit rationing (Keeton 1979, Stiglitz and Weiss 1981). In addition, Williamson (1986) develops a model in which credit rationing arises from monitoring cost.

Several papers provide empirical evidence on credit channels of monetary policy. Banks lend more to large firms and less to small ones after a tightening policy (Gertler and Gilchrist 1994, Li 1997). Lang and Nakamura (1995) also find that banks make proportionally more safe loans during financial distress. Morgan (1998) uses a contractual difference across commercial bank loans to test for credit effects. Most commercial banks issue loans under a commitment contract, for example, revolving lines of credit. This kind of contract sets the terms of future lending in advance, which would prevent a sudden contraction in the supply of loans under commitment. However, banks have a choice to reduce loans not under commitment. Thus, by comparing the supplies of these two kinds of loans, one can examine credit effects of monetary policy. Morgan uses two monetary policy indicators, Romer and Romer dates, and the federal fund rate. The results show that a tight monetary policy slows the growth of loans not under commitment, while the growth of loans under commitment is unaffected or accelerates. By further examining the responses of bank loan officers and small firms to survey questions about the availability of credit, Morgan finds that the divergence reflects a shrinking loan supply due to credit effects.

Frictions in financial markets are thought to be an important channel for propagating monetary policy shocks. Studies of the credit channel by Fuerst (1995) and Fisher (1996) suggest that it is quantitatively unimportant. However, Bernanke, Gertler, and Gilchrist (1998) develop a model by considering external finance premiums and the net worth of borrowers. The model shows that credit market frictions may significantly amplify both real and nominal shocks to the economy. Cooley and Quadrini (1998) consider a model in which firms' financial decisions differ systematically with the amount of equity they issue. The capital structure of firms changes endogenously over time as a result of their financial decisions. The model provides insight on the importance of firm heterogeneity as a channel of transmission for monetary policy. Nevertheless, Cooley and Quadrini find the aggregate real effects of monetary shocks to be very small, similar to the empirical result of Sims (1992) and Leeper, Sims, and Zha (1996).

Several papers discuss credit-crunch models. Peek and Rosengren (1995) provide a simple one-period model of banks. Banks face binding capital constraints as a result of large loan losses and low or no earnings. This causes banks to behave differently than they would if the requirements were not binding. Chan-Lau and Chen (1998) consider a model of private-debt financing under inefficient financial intermediation, where inefficiency is characterized by costly loan monitoring. They use the model to study large capital outflow and credit crunches in Asian countries in recent years.

In this paper, we develop a dynamic heterogeneous-agent model to study credit crunches and the effectiveness of monetary policy. In this model, a credit crunch is caused by banks' conservative lending behaviour during periods of reduced profitability and financial distress. Banks collect deposits from households, and provide loans to firms according to their size. Banks equate expenses and revenues. The deposit rates are controlled by the central bank, and the lending rates are chosen by the banks. To accommodate a credit crunch, the banks can allocate their assets to loans and risk-free fixed-income securities. We assume that banks have a risk-management practice that is linked to a benchmark loss/deposit ratio. Banks in this model have no capital, so minimum-capital adequacy requirements cannot be applied here. The benchmark loss/deposit ratio is derived from a benchmark case—the normal state of the economy. This ratio is binding when the economy is in a bad state in terms of returns. The model is able to generate a credit crunch such that banks will reallocate balance-sheet assets from loans to government securities and cause a reduction in lending activity.

The model is then used to analyze monetary policy. In our first experiment, we examine the effectiveness of monetary policy during a credit crunch. Given a half per cent decrease in deposit rates, bank lending rates are lowered by 40 basis points. Banks lend to some smaller firms, but they still hold a large proportion of their assets in government securities. In a second experiment, we allow banks to relax the loss/deposit ratio so that banks have the same bond/deposit ratio as in the benchmark case. We find that the loss/deposit ratio must be doubled. These results may imply that if a credit crunch is caused by regulations or by a too-conservative risk-management practice, monetary policy has very limited effects compared with relaxing the regulations or banks' risk-management practices.

In Section 1, we describe the model. In Section 2, the model is calibrated to the Canadian economy. In Section 3, we use this model to generate a credit crunch and analyze the implications for monetary policy. In the last section, we offer conclusions.

1 The Model

In this section, we develop a general-equilibrium model of financial intermediation.[1] There are three agents in this economy: households, banks, and a central bank. Households are endowed with a number of investment projects in each period. Because they are short of internal funds, households must apply to banks for external financing. The banks screen loan applications according to the applicants' net worth. Successful applicants become entrepreneurs, and others become workers. Each worker also faces an idiosyncratic shock for unemployment. Employed workers get labour income, and unemployed workers receive unemployment benefits.

Banks collect deposits and provide loans to entrepreneurs or purchase risk-free government bonds. Banks have a risk-management lending policy that may cause conservative lending in periods of reduced profitability and financial distress. The central bank has control over deposit interest rates, and adjusting deposit rates will influence banks' lending behaviour.

1. The current model does not have aggregate shocks. Further extensions that include this type of shock may allow us to examine credit crunches over the business cycle.

1.1 Households

Households have a finite life expectancy. We denote the net worth of household *i* at period *t* as m_t^i. In each period, a household is endowed with *n* investment projects, x_t^{ij}, $j = 1, 2, \ldots, n$. Total investment is x_t^i $(=\sum_j x_t^{ij})$, and the investment for each project is x_t^i/n. The size of total investment is a fixed multiple ϕ of the current net worth of the household, m_t^i. If ϕ is above 1, then the household needs external financing. To simplify the problem, we assume that projects always need external financing:

$$x_t^i = \phi m_t^i \text{ with } \phi > 1 .$$

The returns on investment projects, r_t^j, are assumed to follow a normal distribution with mean *r* and standard deviation σ_r. r_t^j is drawn independently across all projects and individuals. Also, the returns face a positive probability of being sufficiently negative such that the bank faces losses from lending to some projects.

Households apply to banks for the extra funds needed to finance their investment projects. If loans applications are accepted by the bank, the household becomes an entrepreneur. The entrepreneur undertakes projects and receives the project returns. If the loan application is rejected, the household may become employed or unemployed, with given probabilities. Assume *u* to be the probability of being unemployed. The employed worker provides labour and receives labour income, *y*. The unemployed worker receives unemployment insurance benefits, θy, where θ is the replacement ratio. The remaining net worth is carried over to the next period.

In addition, being either an entrepreneur or a worker, each household faces a probability τ of forced retirement. After retirement, the household can earn income only from deposits and pensions. Finally, retirees face a probability δ of dying. They are then replaced by new agents with no assets. Remaining assets are lost (there are no bequests in the model).

The momentary utility function for workers, entrepreneurs, and retirees is

$$U^{oc}(c) = \frac{(\xi^{oc} c^{1-\rho})^{1-\rho} - 1}{1-\rho},$$

where *oc* is occupational choices and the set of *oc* is {*W*, *U*, *E*, *R*}, in which *W*, *U*, *E*, and *R* are employed workers, unemployed workers, entrepreneurs, and retirees, respectively. *c* is consumption, and σ and ρ are positive parameters. ξ^W, ξ^U, ξ^E, and $\xi^R > 0$.

Now we describe the value functions for each agent. We denote V^W, V^U, V^E, and V^R as the value functions of workers, the unemployed, entrepreneurs, and retirees. m^* is the minimum net worth eligible for external financing. A worker with net worth $m(< m^*)$ in the current period has probability $(1-u)$ of being employed.[2] Once employed, the worker gets labour income y, deposits his or her net worth in banks, and receives interest income, $R^d m$. The total income is then allocated to consumption, c, and savings, m'. If unemployed, the worker receives unemployment benefits, θy, and also deposits his or her net worth in banks. The total resources are also allocated to consumption, c, and savings, m'. In the following period, the worker faces a probability τ, of retiring. Otherwise, the worker may become an entrepreneur or remain a worker, depending on his or her net worth, m'.

For a worker,

$$V^W(m) = \max_{\{c^W, m'\}} \{U^W(c^W) + \beta[(1-\tau)[(1-u)V^W(m')$$
$$+ uV^U(m') + E_{r'} V^E(m', r')] + \tau V^R(m')]\}, \tag{1}$$

subject to

$$c^W + m' = (1 + R^d)m + y,$$

$$V^W(m) = 0 \text{ if } m \geq m^*.$$

For an unemployed worker,

$$V^U(m) = \max_{\{c^U, m'\}} \{U^U(c^U) + \beta[(1-\tau)[(1-u)V^W(m')$$
$$+ uV^U(m') + E_{r'} V^E(m', r')] + \tau V^R(m')]\}, \tag{2}$$

subject to

$$c^U + m' = (1 + R^d)m + \theta y,$$

$$V^U(m) = 0 \text{ if } m \geq m^*.$$

An entrepreneur invests in n projects and gets return r^j for project x^j for $j = 1, 2, \ldots, n$. He or she also receives labour income, y, and pays the borrowing cost, $R^l(x - m)$; what is left can be consumed or saved. The net wealth is constrained to be non-negative (this is a liquidity constraint). Project losses may, however, drive net wealth down to negative numbers, in which case the household consumes a minimal consumption allowance,

2. Since we use a yearly model and the duration of unemployment is below one year, u is not state-dependent.

c^{min} (funded by the banks), declares bankruptcy, and defaults on its debt.[3] In that case, the household starts next period with no assets and no liabilities. In the following period, the entrepreneur has a probability τ of retiring.

$$V^E(m, r) = \max_{\{c, m'\}} \{U^E(c) + \beta[(1-\tau)[(1-u)V^W(m') + uV^U(m') + E_{r'} V^E(m', r')] + \tau V^R(m')]\}, \tag{3}$$

subject to

$$c = \max\left\{c^{min}, m + y + \sum_{j=1}^{n} (1 + r^j)x^j - R^l(i - m) - m'\right\},$$

$$\sum_{j=1}^{n} x^j = \phi m,$$

$$V^E(m, r) = 0 \text{ if } m < m^*.$$

Also, V^E, V^W, and V^U have to satisfy a participation constraint,

$$E_r V^E(m^*, r) \geq (1-u)V^W(m^*) + uV^U(m^*), \tag{4}$$

which implies that, at the margin, the household would prefer to be an entrepreneur (applying for a loan) rather than a worker.

Once a household retires, it receives pension income, y^R. The net worth and pension income are allocated to consumption and savings. In the following period, the household has a probability δ of dying.

$$V^R(m) = \max_{\{c, m'\}}\{U^R(c) + \beta[(1-\delta)V^R(m')]\}, \tag{5}$$

subject to

$$c + m' = (1 + R^d)m + y^R.$$

One aspect of credit crunches that has been largely ignored in the literature is heterogeneity among both investment projects submitted and the methods used by banks to screen them. In this model, we introduce heterogeneity in several ways: individual unemployment risk; risk of project returns; and risk of the life cycle (retirement, death, and birth). Households are then heterogeneous along several dimensions: active or retired;

3. There is no moral hazard problem here, since banks constantly monitor the returns.

entrepreneur; worker or unemployed; and, most importantly for our question, wealth.

In this model, households have several motivations to accumulate assets: to save for retirement; to maximize returns through investment projects instead of deposits [participation constraint, constraint (4)] and to protect themselves against unemployment shocks that are imperfectly insured. Banks take the bankruptcy risk of their clients into account when they make loan decisions, so we need bankruptcy in this model. But bankruptcy is very tough on households: In one bad period, they lose all their accumulated assets and may, for example, jeopardize their retirement assets. For this reason, we have introduced the possibility of investing in several projects at a time, which spreads the risk.

1.2 Banks

The bank in our model accepts deposits from workers and retirees, and makes loans to entrepreneurs to finance investment projects. The deposit interest rate, R^d, is considered to be given by monetary policy. For projects that lose money, the bank pays an auditing fee, μ, to recover the salvage value of the project.

The bank chooses m^*, and the interest rate for loans, R^l, such that

(i) disbursements for deposits equal revenue from loans:

$$\sum_{m_t^i < m^*} R_t^d m_t^i = E_r\left\{\sum_{m_t^i \geq m^*} R_t^l (x_t^i - m_t^i) - \sum_{m_t^i \geq m^*} L_t^i\right\}$$
$$+ R_t^d \max\left\{0, \sum_{m_t^i < m^*} m_t^i - \sum_{m_t^i \geq m^*} (x_t^i - m_t^i)\right\}, \tag{6}$$

in which losses are defined as:

$$L_t^i = \max\{0, (1+\mu)[(1+R_t^l)(x_t^i - m_t^i) - x_t^i(1+r_t^i)] + g_t^i\},$$

where g_t^i represents additional losses incurred if a household has to be granted its minimal consumption;

(ii) expected losses incurred from loans do not exceed a certain share, α, of the deposits,

$$E_r\left\{\sum_{m_t^i \geq m^*} L_t^i\right\} \leq \alpha \sum_{m_t^i < m^*} m_t^i; \tag{7}$$

(iii) banks cannot lend more than the value of deposits they have accepted,

$$\sum_{m_t^i \geq m^*} (x_t^i - m_t^i) \leq \sum_{m_t^i < m^*} m_t^i . \tag{8}$$

Through the households' choices of m^i and banks' choice of m^*, the total quantity of loans is determined endogenously. The left side of the equation represents the loans, and the right side of the equation represents the deposits that can be used for loans or bonds. Bonds represent safe assets used by the banks to reduce the loss/deposit ratio.

The loss/deposit ratio α can be interpreted in two ways. First, it can be linked to the internal risk management (a rule of thumb) and the value at risk (VaR). Second, it can be seen as an external regulatory constraint. Such a constraint is often related to capital-adequacy requirements. However, in this model banks have no capital. Nevertheless, the loss/deposit ratio can be converted to a loss/capital ratio.

Banks screen projects according to borrowers' net worth. Because investment projects earn significantly higher expected returns than do deposits, each household would like to be approved for a loan, which is necessary to run a project. Given that projects, and therefore loans, are proportional to the collateral provided by the household (its wealth), banks use household wealth to screen projects: Only projects backed up by collateral above a certain threshold are approved.

Other observations can back up this hypothesis: Many households have little wealth, and do not invest it in assets other than deposits. They may want to invest in profitable projects, but they know they will not be approved for credit. Also, when banks tighten credit rules, small businesses are most likely to suffer.

1.3 The central bank

The central bank's only influence is through setting the interest rate on deposits, R^d, which can be viewed as the stance of monetary policy and/or economic conditions.

How does the central bank affect bank lending behaviour? A private bank's lending policy involves two options: the cutoff point, m^*, for loans and the lending rate, R^l. If the central bank lowers the deposit interest rate, how would banks change their lending policy? If the banks fix one of these two options, then the answer is straightforward. When the lending cutoff point, m^*, is held fixed, a decline in banks' deposit cost will lower the lending rate accordingly, to equalize costs and revenues. Similarly, if the bank holds lending rates fixed, then profits will increase, and banks could lower m^*.

Moreover, if banks can adjust both variables, it would be difficult to determine the analytical consequences, because both R^l and m^* could be lowered or increased. In the next two sections, we attempt a quantitative analysis based on a calibrated model to address this question.

1.4 Computing steady-state equilibrium

In describing the computational procedure used to solve the model, we first define the equilibrium concept and then outline a procedure for finding the equilibrium. Let z be the set of parameters that describe the economy, a set that can be altered from the benchmark for computational experiments. An equilibrium is a collection of a loan interest rate, $R^l(z)$, a loan threshold, $m^*(z)$, a law of motion of the agents in the economy, $\lambda' = g(\lambda;z)$, and decision rules for households, $m^W(m;z)$, $m^U(m;z)$, $m^E(m, r;z)$, and $m^R(m;z)$, such that:

(i) households solve their optimization problems shown in equations (1), (2), and (3);

(ii) the banks break even, equation (6). Their loss/deposit ratio does not exceed the benchmark value α, constraint (7). And they cannot lend more than deposits accepted, constraint (8). The participation constraint, constraint (4), is also satisfied.

To solve for this equilibrium, we define a grid for all household types (worker, unemployed, entrepreneur, retired), asset levels, and project returns. For initial values of R^l and m^*, we computed utilities for all feasible decisions, and then calculated iteratively the value functions. Once optimal decision rules are determined, they are used, along with the laws of motion, to find the invariant distributions of households across types, asset levels, and project returns. Given this distribution, the banks' equilibrium constraints are evaluated. If they are not within a reasonable range, R^l and m^* are modified and the whole procedure starts again. Once everything has converged, we draw aggregate statistics.

2 Calibration: The Benchmark State

The model is calibrated to the Canadian economy according to annual data from 1988 to 1992, a period for which we have the distribution data of the return on equity (Statistics Canada 1994). Following the literature, ρ and β are set to 2.5 and 0.96, respectively. σ is set to 0.67. ξ^E, ξ^W, ξ^U, and ξ^R are set to be consistent with standard models with explicit leisure specification, i.e., $\xi^E = \xi^W = \xi^U = 0.55^{0.67}$, and $\xi^R = 1$, which implies that the working hours of employed workers and entrepreneurs and the search effort of the unemployed are set to 0.45. The labour income of workers and entrepreneurs, y, and the retirement income, y^R, are set at 1 and 0.3, respectively. The probability of retirement, τ, and the mortality rate of retirees, δ, are set at 5 per cent and 10 per cent, respectively.

Calculated from the real Guaranteed Investment Certificate rates and the real savings deposit rates, the deposit rate, R^d, is set at 1.00 per cent. The unemployment insurance benefit is 29.29 per cent of wage rates.[4] Minimum consumption is assumed to be the same as the unemployment benefit.

The investment/net worth ratio, ϕ, is calculated from the debt/equity (D/E) ratio. The average D/E ratio during the reference period is 1.2, which implies ϕ to be 2.2. The auditing fee, μ, is set at 6 per cent.

Statistics Canada (1994) reports the distribution of return on equity for non-financial enterprises from 1988Q4 to 1992Q4. For each quarter, the average returns on equity are reported for the top, middle, and bottom tertiles. For our model, we also use discrete-return distribution to simplify computation. The returns of projects are calculated from the return-on-equity data of firms by assuming normal distributions. During the period, this distribution implies discrete returns of r = {–50 per cent, 4.52 per cent, 60 per cent} with probabilities of {0.0098, 0.9817, 0.0085}, respectively. The lowest return is chosen to generate occasional bankruptcies, the middle one to match the average return.

The lending rate, R^l, and the asset for the minimum qualified firm, m^*, are chosen such that banks equilibrate their income and disbursements and the bond/deposit ratio is close to the average of the bond-holding ratios over the reference period. The lending rate, R^l, is calculated to be 1.18 per cent, and m^* to be 6.76. In the benchmark steady state, the number of workers is 0.58, the number of entrepreneurs is 0.09, and the number of retirees is 0.33. With respect to the wealth distribution, the benchmark economy has a Gini coefficient of 0.65.

In this benchmark model, there are some loan losses for banks because of the possible negative returns. The loss/deposit ratio is found to be 0.166 per cent. We use this ratio as a benchmark for banks' lending policy. It turns out that, during periods of reduced return, this ratio becomes binding,

4. The measure is based on the replacement rate constructed in Hornstein and Yuan (1999). The following elements of unemployment insurance (UI) benefits are considered: the legislated replacement rate, the percentage of the labour force covered by UI (the coverage rate), the maximum number of benefit weeks for a minimally qualified claimant, and the minimum number of working weeks needed to qualify for UI.

which leads to banks' conservative lending behaviour and causes a credit crunch.

3 Credit Crunch, Bank Lending Behaviour, and Monetary Policy

We now use this model to generate a credit crunch. The return-on-equity data show that firms' returns in 1992Q4 are less than the average of the reference period. We calculate the annualized return distribution according to 1992Q4. Our calculation suggests the returns of projects to be $r = \{-50$ per cent, 2.57 per cent, 60 per cent$\}$ with probabilities $\{0.0179, 0.9742, 0.0079\}$. The unemployment rate in the reference period is 11.57 per cent, and ϕ is 2.3. The deposit rate is set to be identical to the benchmark case, 1.00 per cent, so that we can examine the banks' lending behaviour during periods when banks see reduced profitability, but the central bank does not change its monetary policy stance.

To generate a possible credit crunch, we choose m^* and R^l, such that the bank loss/deposit ratio matches the benchmark case, 0.166 per cent, and banks equilibrate revenues and expenses.

In equilibrium, we find that the last qualified firm has asset m^* of 6.84; that size is larger than that of the benchmark case, 6.76 (see Table 1). This suggests that the banks have reduced loans to smaller firms. The total loans are reduced dramatically, by more than 60 per cent in the credit-crunch state, compared with the benchmark state. The lending rate is calculated to be 1.30 per cent, which is higher than the benchmark lending rate, 1.18 per cent. In the distribution of bank assets, we see a big increase in the ratio of bank deposits allocated to bonds. The ratio increases to 58 per cent compared with the benchmark result of 13 per cent. The restriction of the loss/deposit ratio effectively mimics the bank's conservative lending behaviour. This avoids explicitly modelling changes in bank risk-aversion in lending under different economic states.

We also find that more people become workers (0.64 compared with 0.58) and fewer become entrepreneurs (0.03 compared with 0.09). The Gini coefficient decreases to 0.62, compared with the benchmark case, 0.65, and the average utility decreases from –0.23 to –0.26 during this credit crunch.

In this state, bankruptcies occur more often because projects post lower returns and lending rates are higher. Banks are tied by their loan strategy and, as losses increase as a share of loans, banks must reduce the quantity of loans. As m^* is increased, some entrepreneurs become workers, which drives down the quantity of loans. The decrease in the number of loans is partially offset by the increase in the average size of the remaining

Table 1
Steady-state analysis

	Benchmark		Credit crunch		Monetary policy		Lending policy	
Deposit rate, R^d	0.0100		0.0100		0.0050		0.0100	
Return distribution	–0.5000	0.0098	–0.5000	0.0179	–0.5000	0.0179	–0.5000	0.0179
	0.0452	0.9817	0.0257	0.9742	0.0257	0.9742	0.0257	0.9742
	0.6000	0.0085	0.6000	0.0079	0.6000	0.0079	0.6000	0.0079
Cut-off point, m^*	6.76		6.84		6.55		6.72	
Lending rate, R^l	0.0118		0.0130		0.0090		0.0140	
Bonds/deposit (%)	13		58		57		14	
Loss/deposit, α (%)	0.166		0.166		0.166		0.345	
Total loans	0.76		0.27		0.26		0.80	
Total deposits	0.87		0.65		0.60		0.92	
Number of workers	0.58		0.64		0.64		0.58	
Number of entrepreneurs	0.09		0.03		0.03		0.09	
Number of retirees	0.33		0.33		0.33		0.33	
Gini coefficient	0.65		0.62		0.62		0.64	
Average utility	–0.23		–0.26		–0.27		–0.23	

loans. This process continues until the banks find the m^* that yields the original loss/deposit ratio. Along the way, the banks must also modify the loan rate to recuperate the higher costs per loan due to losses.

3.1 Steady-state policy experiments

We now carry out a steady-state monetary policy experiment, in which the central bank lowers the deposit rate in the credit-crunch state. In this experiment, R^d is reduced by one-half per cent. We examine the changes in the banks' lending behaviour, i.e., how banks change R^l and m^*. Banks choose R^l and m^*, such that revenues equal expenses and the loss/deposit ratio matches the benchmark case (0.166 per cent).

Given a one-half per cent decrease in the deposit rate, bank lending rates are lowered by 40 basis points to 0.90 per cent. Banks increase their lending to small firms by reducing the cut-off point for lending, m^*, to 6.55 from the credit crunch level of 6.84. The bond-holding ratio remains the same as in the crunch case. The total deposit and total loans are reduced slightly. Overall, the effects of reduced deposit rates are quite limited.

Reducing interest rates is largely ineffective, because the banks are mostly constrained by their loss/deposit ratio, α. However, the interest rate change has various effects. Lower deposit rates give workers less incentive to save deposits. However, the banks have fewer interest payments to make, so they can reduce the loan rate to balance their books, thereby inciting some workers to opt for entrepreneurship. But all these effects are small.

To evaluate the relative effectiveness of this policy change, we conducted another experiment, in which banks relax their loss-control rule, i.e., the loss/deposit ratio, α, is increased. Banks choose $m*$ and R^l, such that revenues equal expenses and the bond/deposit ratio matches the benchmark case (13 per cent) as closely as possible. The last column of Table 1 shows that once the loss/deposit ratio α is increased to 0.345 per cent, about double the ratio in the benchmark case, the bond/deposit ratio is reduced to 14 per cent, which is close to the value in the benchmark case. Compared with the credit-crunch state, more people become entrepreneurs and fewer become workers. The average utility is restored to the same level as in the benchmark case.

This policy is much more effective, because it relaxes the most binding constraint on the banks. Indeed, although the loss/deposit ratio, α, increases, the banks are still able to balance their books with only a slight increase in loan rates. The lowering of $m*$ incites some workers to become entrepreneurs, and the impact of lower returns largely disappears: While projects have a lower average return than in the benchmark—without a credit crunch—they still have a higher return than do deposits. With more projects, the returns realized in the economy as a whole increase.

Conclusions

In this paper we have developed a dynamic general-equilibrium model of financial intermediation that is innovative in that it takes account of the heterogeneity of investment projects. Furthermore, the decision to become a loan-contracting entrepreneur is endogenous, and workers decide on deposits that the bank can use for loans and bonds. Given that projects and even individuals can go bankrupt in this model economy, banks take explicitly into account possible losses from loans. This self-regulation, which has recently been imposed on the banks by the Basle Accord, appears to be the determining factor in a credit crunch. Calibrated for the Canadian economy, our model finds that monetary policy can do little to ease a credit crunch that arises because of increasing loan risk. However, more flexible loans regulation, in particular, rules that allow the banks to take more losses that are compensated by higher loan rates, is very effective.

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Discussion

Emanuela Cardia

Yuan and Zimmermann construct a model that can generate "credit crunches," i.e., inefficient conservative lending, and examine whether monetary policy, loan regulation, or both, can reduce the impact of credit crunches. They find that, while loan regulation can eliminate the effects of a credit crunch, monetary policy can do little to alleviate the credit crunch itself.

The Yuan and Zimmermann paper is an interesting contribution to the literature on credit crunches. While several empirical papers have suggested that in the early 1990s Germany, Finland, the United States, and Japan were constrained by inefficient conservative lending, few have tried to develop a theoretical framework in which to examine this issue.

The authors use a general-equilibrium model with several types of households and heterogeneous projects. The most important type of heterogeneity comes from assuming that households can be workers if their net assets, m, are smaller than a certain critical level, m^*, a choice variable of the banking system, and that households can be entrepreneurs if $m \geq m^*$. A household will ask for lending if the desired project implies outlays greater than its net assets. Only if $m \geq m^*$ will the household see the project approved and become an entrepreneur. This set-up is essential for creating the possibility of credit crunches. The authors also assume that households retire with a fixed probability, τ, can be unemployed with a fixed probability, $1 - \mu$, and have a finite life expectancy. However, Yuan and Zimmermann do not explain how these additional sources of heterogeneity are essential to the study of credit crunches. From Table 1, I see that the number of retirees does not change across all experiments. Perhaps we would lose nothing by omitting this feature. If this is the case, I think that it would be best to omit retirement in the model and add a footnote to explain that nothing would change if we were to assume that households can retire.

The authors should discuss the channel in their model through which credit crunches may affect unemployment, and they should also report how unemployment changes across the different experiments. Again, I believe that if unemployment does not add much to the result it should be omitted. Finally, I don't understand how finite horizons can make a difference. Although these elements do generate different reasons for why people may save, they are not the focus of the paper. Unless they are shown to affect the results, they should not be included, as they dilute the contribution of the paper and render the model and results difficult to understand.

The banking system chooses the critical level, m^*, and the lending rate, R_l, and takes as given the rate on the deposit, R_d, and the loss/deposit ratio, α. This is where one important element of the lending inefficiency is introduced: α may not be optimal. The central bank sets the interest rate on deposits, R_d. There is another constraint, i.e., that m has to be greater than m^*. This is also a source of inefficiency, and is probably used to describe the idea that small projects have less chance of getting financed. The authors should discuss the sources of lending inefficiency in the model.

My main difficulty with the paper concerns the results. The results presented in Table 1 present four scenarios. The first is the benchmark case. The second is the credit-crunch case where returns are (exogenously) lower. The other two cases examine how monetary and lending policies could allow us to go from the credit-crunch situation to the benchmark one. The credit-crunch situation occurs because lending has decreased (from 0.76 to 0.27). However, even without inefficient lending, lending would have decreased in response to a drop in the projects' returns. The question is to know how much more lending has decreased because of inefficient lending. To know that, one would have to compare the situation with one in which there is no inefficient lending. I don't know whether this is feasible in the current set-up; however, it seems crucial to me to know the contribution of the lending inefficiency versus the effects on lending due to lower returns. When the policy experiments are examined, the authors compare the results of the policies with the benchmark case. However, returns were higher in the benchmark case. The paper's objective was to examine the role of monetary and lending policies in alleviating the effects of credit crunches, not the effects of reduced profitability. The objective should be redefined or the policy experiment clarified. I would also like to see the effects of reduced profitability on m and y.

Discussion

Shouyong Shi

Yuan and Zimmermann pose the following question: Can monetary policies help the economy recover from a credit crunch? Their answer is: Not much, if banks manage risks conservatively by imposing an upper bound on the loan loss/deposit ratio. In fact, if the central bank cuts the deposit rate during a credit crunch, the total deposits and total loans fall. Therefore, easing monetary policies during a credit crunch is counterproductive.

The authors reached this conclusion by calibrating a dynamic general-equilibrium model with credit market imperfections. They took the year 1992 as one of a credit crunch relative to the sample period, 1988–92, and assumed that a negative shock to borrowers' project returns generated the crunch. The authors computed how the equilibrium would change if the central bank cut the deposit rate by one-half per cent during the crunch. The effects are as follows. Bank lending rates would fall, and banks would increase their lending standards. However, the total deposits and total loans would fall, both by small magnitudes.

To demonstrate how the model generates these results, let me briefly describe the model. It has one private bank and many agents. Agents are grouped into employed workers, unemployed workers, entrepreneurs, and retirees. At the beginning of each period, all agents, except retirees, can apply for loans, but only those who have enough wealth get loans. If an agent obtains a loan, he/she becomes an entrepreneur and invests the funds in projects. Otherwise, the agent becomes employed, unemployed, or retired, and deposits some of the wealth at the bank. The bank pools all of the deposits and makes loans, taking the deposit rate as given. The loan decisions are the lending rate and the lending standard, a cut-off level of borrowers' wealth above which a loan is provided. The bank balances its books, i.e., to equate the expected revenue from loans and the interest payment on deposits.

In this model, agents are rationed if their wealth levels are below the lending standard. Such credit rationing is generated by three imperfections of the loan market, highlighted in the following assumptions:

(A1) Borrowers have limited liability—their consumption cannot be negative—and so the bank cannot recover the loan when a project has a sufficiently low return.

(A2) For each unit of a loan loss, the bank must incur an additional cost and may also provide a minimum consumption level for the bankrupt agent.

(A3) The bank is conservative in lending—it imposes an upper bound on the loan loss/deposit ratio, α.

These imperfections compel the bank to set a lending standard above agents' lowest wealth. While the first two imperfections are standard in credit-rationing models, the last is relatively new, and is critical for a credit crunch.

A credit crunch occurs in the model as follows. When there is a negative shock to entrepreneurs' project returns, the expected revenue from loans falls. More borrowers declare bankruptcy and, by (A1) and (A2), the bank faces a higher loan loss. To balance the books, the bank increases the lending rate and the lending standard. The loan market becomes tighter and, in particular, more small (poor) borrowers are squeezed out. The loan market becomes tighter in this way even without the conservative lending constraint, (A3), but this tightening might not be large enough to constitute a credit crunch. A credit crunch occurs when the bank further increases the lending standard and greatly reduces the loan supply to meet the conservative lending constraint.

I like the following two aspects of the model. First, it has a general-equilibrium flavour and is dynamic—each agent lives for quite a long time. The long lifetime and the general-equilibrium feature allow the authors to fully incorporate how loan market imperfections affect consumption and savings and how these effects in turn affect the loan market through deposits. In contrast, most other models allow agents to live for only two periods, and thus the loan market imperfections do not have a strong feedback effect through savings (e.g., Williamson 1987, and Bernanke and Gertler 1989).

Second, loan applicants are endogenously divided into entrepreneurs and depositors, according to their wealth: Rich applicants are entrepreneurs and poor applicants are depositors. There is even a wealth distribution among entrepreneurs. This modelling approach not only makes loan supply and demand endogenous, but also allows a credit crunch to generate distributional effects. For example, poor and small borrowers suffer the most in a credit crunch, since they are the first ones to be rationed when the lending standard increases. Agents are also heterogeneous in other ways. Some are employed and some are not; some are in the labour force and others are retired. Thus, the current model is useful for addressing both the aggregate effects and the redistributional effects of credit market policies.

Now, let me offer some criticisms on the paper.

The authors should explain more clearly why conservative lending can generate a credit crunch. The model appears to have picked up a strong negative wealth effect on depositors, which reduces loans through the conservative lending constraint. In the model, total loans fall from 0:76 in the sample to 0:27 in 1992, accompanied by only a small increase in the lending standard (from 6:76 to 6:84), but by a large drop in deposits (from 0:87 to 0:65). This drop is responsible for the sharp increases in the bank's bond holdings/deposit ratio (from 13 to 58) and in the lending rate (from 1:18 per cent to 1:30 per cent). In this sense, the credit crunch in the model is more precisely a deposit crunch.

This is how the conservative lending constraint is important for the credit crunch. When entrepreneurs' wealth falls after a negative shock to project returns, the bank is severely restricted by the conservative lending constraint, for two reasons. First, those entrepreneurs who are lucky enough to be entrepreneurs again in the future will require more external financing, which increases the expected loan loss. Second, and more important, those who cease to be entrepreneurs in the future save less and deposit less. The two effects both increase the loss/deposit ratio and, to maintain the conservative lending constraint, the bank greatly reduces loans. My guess is that such a credit crunch will occur in the model even when the bank's lending standard does not change.

The behaviour of deposits might also explain why a lower deposit rate does not help the economy to recover. In fact, it further reduces depositors' wealth and makes loans even more difficult to obtain. As the numerical exercises indicate, when the central bank reduces the deposit rate by one-half per cent, total deposits and total loans both fall in spite of the fact that the lending rate and the lending standard both decrease. Since a negative shock to project returns generates a credit crunch by greatly reducing deposits, the monetary authority should increase rather than decrease the deposit rate during a credit crunch.

The authors did not explicitly outline why banks are conservative in lending, although they offered several reasonable explanations. Since the main results of the paper depend so much on this conservative lending constraint, one cannot help but wonder about such an exogenous restriction on the bank's behaviour. How can we be sure that the upper bound on the loan loss/deposit ratio does not change during a credit crunch? More important, how can we be certain that the bound does not react to monetary policies? By maintaining an exogenous lending constraint, the authors cannot be confident in the policy evaluation.

To illustrate this point, consider the explanations that the authors provided for the conservative lending constraint. One concerns the bank's assessment of the value at risk; the other concerns capital-adequacy requirements. Both explanations suggest opposite adjustments in the upper bound on the loss/deposit ratio during a credit crunch. If the bank is conservative in lending because of the value at risk, the negative shock to project returns increases the value at risk per unit of loan and induces the bank to become more conservative. That is, the bank should reduce the upper bound on the loss/deposit ratio. In this case, the shock generates a more severe credit crunch than in the model. On the other hand, if the bank is conservative because of the capital requirement, the reduction in loans during a credit crunch should make the bank less conservative. This is because the bank holds government bonds the value of which does not change during the credit crunch in the current model. With fewer loans, the bank can still meet the capital requirement if it increases the upper bound on the loss/deposit ratio. The conservative lending constraint becomes less binding in this case, and the credit crunch less severe.

Monetary policies have different effectiveness in these two cases. If the value at risk is the reason for the upper bound on the loan loss/deposit ratio, the central bank can achieve little by reducing the deposit rate. But if the capital requirement is the reason for the upper bound, an expansionary monetary policy can reduce the interest rate, increase the value of government bonds, and make the capital-adequacy requirement less binding. In this case, the policy induces the bank to increase the upper bound on the loss/deposit value and greatly mitigates the credit crunch.

There is a wide range of heterogeneity in the model, but the authors did not fully explore it. As mentioned, this wealth of heterogeneity allows a credit crunch to have redistributional effects. The authors mentioned only one that was already in the literature, i.e., a credit crunch hurts small entrepreneurs more than large entrepreneurs. But the authors can explain much more with this model. How does a credit crunch redistribute wealth between entrepreneurs and depositors? Are employed and unemployed workers affected differently? How do monetary policies redistribute wealth among agents?

Even if the authors are not interested in redistributional effects, they can still help us understand which heterogeneity is important for the aggregate effects. For example, this model includes unemployment, which is absent in previous models with credit rationing. It is interesting to find how important unemployment is for the aggregate behaviour of the loan market. My guess is that unemployment contributes very little to the credit crunch. This is because, as argued above, the crunch is driven primarily by the large fall in deposits, which can occur even if everyone is employed.

In summary, the authors undertook the challenging task of modelling a credit crunch in a dynamic general-equilibrium environment. They found that banks' conservative lending behaviour was critical for a credit crunch. The model is useful for evaluating both the aggregate and redistributional effects of a credit crunch and monetary policies. Although banks' conservative lending behaviour needs to be explicitly modelled, this paper is a good beginning in our understanding a credit crunch.

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General Discussion

Immediately after discussants Emanuela Cardia from the University of Montreal and Shouyong Shi from Queens University delivered their respective comments on the paper entitled “Credit Crunch, Bank lending and Monetary Policy: A model of Financial Intermediation with Heterogeneous products”, the floor was open to questions and comments.

A few of the visiting participants from the Federal Reserve Bank spent time reiterating how to go about properly modelling a credit crunch and urged the authors to clearly outline this procedure in their paper. Others suggested that lending policy implications such as the returns on projects could have been pursued further. Finally, under the heading of policy advice implications, it was noted that although in a dynamic situation it made sense to deal with a credit crunch by easing policy, in a static situation the solution obtained may not be an attractive one. These comments offered additional in sights and extensions to the paper under discussion.

Several specific and technical questions were posed. For instance, discussant Shouyong Shi as well as audience members, questioned as to why the authors used so many different sources of heterogeneity in their model. Zimmerman in response to this, stated it was done in an attempt to construct a real world model, a model representative of the Canadian context capable of yielding meaningful results. Furthermore, having noted the authors use of heterogeneous agents, a conference participant then sought information on how they calibrated the distribution of returns, robustness and conducted sensitivity analysis.

* Prepared by Andrea Losier.

Finally, a couple participants suggested and the authors agreed, that the calibration of various numbers such as screening costs and unemployment insurance benefits needed to be outlined more clearly in the paper.