Bank Competition and Credit Booms:
Can Finance be Too Much, Too Cheap?*

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Abstract

A model of imperfectly competitive banks is examined under asymmetric information about borrowers. Greater bank competition and lower risk-free rate raise the screening costs, eventually leading to a pooling equilibrium involving larger credits at cheaper prices. These features as well as deterioration in average loan quality replicate those of credit booms. Multiplicity could result, opening room for nonlinear switches between normal and excess-credit equilibria. The model sheds light on the drivers of credit cycles, and how finance-neutral monetary policy could be defined. Theoretical predictions are consistent with recent international experiences and find some micro-level empirical support.

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1 Introduction

Interests in the nexus between economic growth, financial access, and financial stability have spawn research across a broad range of fields. Over the cyclical frequency, modern macro theory suggests that an easing of financial constraints of otherwise productive firms has a positive effect on growth. The linkage between financial and real sectors generates a short-term feedback mechanism known as financial accelerator, through which one can explain output fluctuations by financial shocks. Over longer horizons, raising financial access can unlock the economy's productive potential, improve risk-sharing, facilitate the allocation of information and capital, thereby raise economic growth (for a review, see Levine (2005)).

On the other hand, there is a growing recognition that such relationship may, at times, be unstable in practice. With history filled with financial crises, increasing financial access too much too fast is likely subject to diminishing returns at best, and can even lead to outright output losses. Despite ample evidence for this nonlinearity or reverse relationship, the exact mechanism of how excessive finance can result as an equilibrium phenomenon, and when it is harmful for growth and stability, is less well understood. Similarly, the role of policy in navigating the trade-off between growth and financial stability remains a relatively uncharted territory, unlike that between growth and inflation.

This paper contributes to the latter research agenda by proposing a simple model of 'credit boom' as a equilibrium phenomenon. Two key forces interact to determine the equilibrium. First, banks have an incentive to screen out bad clients by restricting the amount of lending per contract, as riskier firms are known to seek larger loans despite lower rate of success. Such screening entails costs to both banks and good firms, given that credits are being rationed to meet incentive compatibility conditions. This feature is essentially the classic credit rationing result in Stiglitz and Weiss (1981).

The second force comes into play when banks enjoy monopolistic power over their loan market bases, but can attempt to poach clients by offering cheaper loan contracts. Lowering prices of loans raise the screening costs, because it necessitates even greater credit rationing if banks were to screen out risky firms. When the degree of bank competition for borrowers is sufficiently intense, it becomes optimal for banks to stop screening and rush to dominate the market by offering contracts with larger loans to all firms. This new pooling equilibrium is characterized by low interest rate (relative to the average productivity of underlying projects),

larger loan size, and higher probability of loan defaults.

The model is used to analyse various issues of interests from financial stability and policy angles. Credit booms can be explained as an equilibrium outcome of overly fierce competition among financial intermediaries and/or loose monetary policy. Given that multiple equilibria are a possibility, there is an element of coordination failure which could lead to persistent credit booms. The notion of 'financial stability neutral' monetary policy can also be given an explicit definition, i.e. that which will prevent a pooling equilibrium from occuring. In the presence of intense bank competition, the limitations of using monetary policy to achieve financial stability objective can be illustrated.

1.1   Literature

Empirical works in recent years have extensively investigated the role of excessive credits in creating financial fragilities. Reinhart and Rogoff (2009) provide a broad sweep of assessment, highlighting the role of debt accumulation (private and public alike) in fueling financial bubbles, heightening systemic risks, and ultimately leading to financial/sovereign default crises. Their analysis over a long span of history across countries reaffirms the notion that excessive credits play an important role in the run-up of financial crises. Indeed, in a systematic early warning exercise, Borio and Drehmann (2009) find credit-to-GDP gap to be a good predictive indicator of crises in advanced economies when used in conjunction with asset prices. In Schularick and Taylor (2012), a long experience of developed economies also illustrates the power of credit booms as a predictor of financial crises. They show further that despite monetary policy being more aggressive in combating the fallout of financial crises after 1945, the output costs have not been reduced. These evidence point to the importance of understanding the emergence of financial fragilities and what role, if any, policy has in containing them.

To address issues raised by these empirical evidence, this paper employs a theoretical model grounded on competition among financial intermediaries under asymmetric information. There is a vast literature that takes an industrial organization approach to the study of banking (for a comprehensive review, see Freixas and Rochet (2008)). Of particular relevance, is the strand that studies competition's effects on banks' risk taking and financial stability (see Allen and Gale (2004) for a survey). Keeley (1990), in a seminal work, shows that competition raises banks' risk taking due to agency and risk-shifting problem. With limited liability, banks stand to gain from upside shocks to profit, while depositors (as debt holders) lose out in the downside.

Competition forces down charter value of banks, worsens risk-shifting and thereby increases banks' incentives to take more risks. These agency costs are exacerbated when depositors cannot monitor banks' risk taking or there is deposit insurance.

The trade-off between bank competition and financial stability is not always straightforward. For example, in Boyd and De Nicolo (2005), firms are the ones that choose the level of risk to take when investing. Firms take more risks when their profit (analogous to charter value) is lower. In this instance, greater bank competition raises firms' profits, and in fact lowers the degree of risk taking by firms, fostering financial stability. De Nicolo and Lucchetta (2011) extend the model to the general equilibrium case where both banks and firms jointly set the level of risk taking, and show that perfect competition is optimal and encourages financial stability, as long as there are increasing returns to scale technology.

The point of departure in this paper is that the source of financial instability does not stem from the relationship between risk-shifting problem and banks' charter value. In fact, banks here are financed in its entirety by own capital. The lending decisions are made purely by banks as investors in risky assets. In this sense, this paper derives a stronger result than in the aforementioned literature, that even if the entire assets are exactly equal to banks' charter value (thus leaving no room for risk shifting), there can still be excessive risk taking as a result of bank competition. Abstracting away deposit market confers another advantage, in that the model could have broader applications than banking. For example, the mechanism can also be helpful for understanding endogenous debt market booms and compressed spreads.

The paper also contributes to an expanding literature that highlights the role of strategic interactions among banks as an important driver of credit cycle. Gorton and He (2008) consider a repeated game context, in which banks compete with each other by adjusting its private lending standards. The rich dynamic structure with history and belief dependence allow multiple equilibria, including one with periodic credit cycles. In Dell'Ariccia and Marquez (2006), credit booms occur when banks trade off borrower quality for greater market share by pooling in borrowers of unknown worthiness. As aggregate information about the borrowers declines (for example, when the pool of new borrowers grows relative to those that have been rejected by some banks), banks have greater incentives to lend more by lowering screening efforts. Aikman et al. (2014) proposes yet another mechanism, relying on bank managers' incentives to signal high abilities to shareholders (even if falsely) by keeping short-term earnings high. There are strategic complementarities, since one bank's greater signaling efforts pressure others to follow

suit.

The mechanism generating credit booms in this paper is novel, and relies on a relatively simple idea that bank competition raises screening costs. The multiplicity arises in the stage game itself, and stems from the basic failure to coordinate on low-competition equilibrium under sufficiently intense competition. The model also assumes a fixed and known pool of borrowers, where the incentives to compete for good borrowers must be balanced with the endogenous screening costs. Banks collectively may end up over-lending relative to the social optimum benchmark despite each bank (1) being rational individually and pursuing no other objectives than maximising own profit, (2) having the same horizon as the social planner, and (3) sharing common knowledge that high quality borrowers are limited in numbers.

1.2   The Roadmap

The main theoretical argument can be sketched as follows. Borrower types are not observable by outsiders. Everyone knows, however, that riskier borrowers are more inclined to take up larger loans despite lower probability of success. Banks have incentives to screen out these riskier firms by limiting loans and keeping prices high (credit rationing). But such agency costs may prove overwhelming when compounded by bank competition that exerts further downward pressure on loan prices. A bank can instead forgo the asymmetric information constraint, and aim to capture a higher market share by offering a cheaper and larger-amount contract. Intense bank competition can then lead to a discrete jump from a separating lending equilibrium to a pooling type, a caricature of credit boom.

To establish these results, a single bank is assumed to always prefer a contract that successfully separates out the high-risk firms (a separating contract), to an alternative pooling contract. Let π_s and π_p denote a single bank's profit when it is offering a separating and a pooling contract respectively. This assumption requires the profit under optimal separating contract to exceed that under optimal pooling contract:

$$\max \pi_s > \max \pi_p \tag{1.1}$$

where the maximum is taken with respect to the loan amount and interest rate specified in the contract. This inequality puts restrictions on the model's parameters, as shown in Section 3.

Section 4 examines the setting of two banks, where the loan market is imperfectly com-

petitive. Let π_{ss} represent a bank's profit when both banks are offering separating contracts (hence subscript ss), and let π_{pp} denote the profit when both are offering pooling contracts. Let π_{ps} be the profit of offering a pooling contract when the competitor is offering a separating contract (and conversely for π_{sp}). When the firms' cost of switching banks is sufficiently low, there may not exist a Nash equilibrium with both banks offering a separating contract, since the prohibitively high screening cost would make a deviation profitable

$$\max \pi_{ps} > \max \pi_{ss} \tag{1.2}$$

When this condition holds, rushing to dominate the market at the expense of worsened quality of loans yields a higher expected payoff. There exists some set of parameters such that conditions 1.1 and 1.2 are both satisfied. Intensifying competition can trigger an equilibrium with characteristics of credit booms, namely expansion in lending, compression of interest rates, and a deterioration of asset quality.

Multiple equilibria exist if

$$\max \pi_{ps} < \max \pi_{ss} \tag{1.3}$$

$$\max \pi_{sp} < \max \pi_{pp} \tag{1.4}$$

When these two conditions hold simultaneously, both joint separating and joint pooling are Nash equilibria. It is indeterminate in this case which would obtain. The multiplicity of equilibria, however, lends itself as a useful analogy of how credit market equilibrium can adjust nonlinearly in response to shocks, or why credit booms may persist.

Implications of the model are discussed in Section 5, after the model's solutions are derived explicitly under parametric assumption. The likelihood of a credit-boom equilibrium is shown to be inversely related to the risk-free interest rate, and positively related to bank competition (as well as any factor that indirectly promotes competition such as financial innovation). Given the existence of multiple equilibria, the efficacy of monetary policy in preventing a credit-boom equilibrium may be subject to limitations. Section 5 also addresses how financial stability may be incorporated into welfare considerations.

Section 6 highlights three broad sets of empirical observations and seeks to understand them through the lens of the model. First, the correlation between credit availability and

economic growth is shown to be at best mixed at the tail-end of distribution, i.e. when credits are excessive. Credit booms are also associated with higher growth volatility and financial crises, a property of the pooling equilibrium in the model. The second part discusses the role of US monetary policy in the decade leading up to the subprime crisis. It is argued that there was a genuine tradeoff between macroeconomic and financial stability. The final part looks at the latest episode of credit boom in Thailand during 2011-2013. Using micro-level contract data, an evidence is presented that there has been a surge in risk-taking by banks during the period.

Section 7 concludes.

2 The Model

A continuum of firms must borrow capital from the bank to finance their projects. Firms come in good and bad varieties, the sizes of which are commonly known to be 1 and γ respectively. Only the firm itself can observe its own type. The good firms can convert k units of capital into $F(k)$ units of output with probability p, and no output otherwise. The bad firms can produce $G(k)$, but with a lower success probability $q < p$. In addition to being riskier, the bad technology requires greater start-up capital to get the project going, but potentially yields a higher return as long as the capital input is sufficiently large. Specifically, it is assumed that $F(1) = G(1)$, with $F(k) > G(k)$ for all $0 < k < 1$, and $F(k) < G(k)$ for all $k > 1$. Figure 1 depicts a pair of technologies obeying such 'single-crossing' condition, which will enable bank to sort between the two types of firms by offering appropriate contracts.
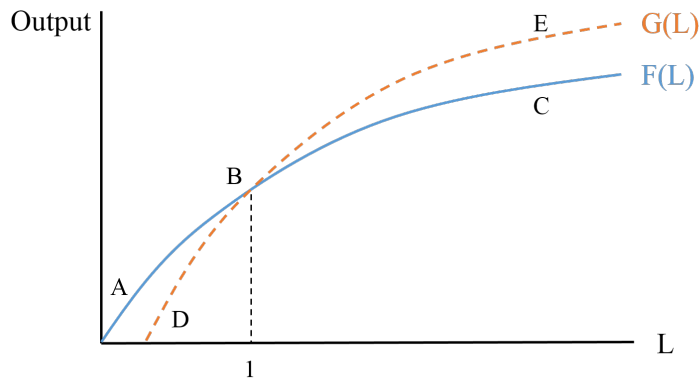

Figure 1: Single-crossing technologies

There are two periods. In the first period, the bank offers a take-it-or-leave-it loan contract to the firms, specifying the lending amount L and the gross interest rate R. Because firm types

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are not observable to the bank, only one contract can be offered to firms. Once a loan contract is agreed, production is carried out subject to the capital raised, and output is realized in the second period. Loans are then repaid, and residual output consumed by the firms. Perfect monitoring is assumed, so that loans and interests are always repaid in full provided the output is sufficient to cover the repayments. Firms are protected by limited liabilities, and can default if the production fails. Being risk-neutral, firms will only accept a loan contract if the expected payoff is greater than zero:

$$U_F = p(F(L) - RL) + (1 - p)0 \geq 0 \tag{2.1}$$

$$U_G = q(G(L) - RL) + (1 - q)0 \geq 0 \tag{2.2}$$

Thus, good and bad firms accept the contract $\{L, R\}$ if it gives them non-negative surpluses, i.e. if, respectively,

$$F(L) \geq RL \tag{2.3}$$

$$G(L) \geq RL \tag{2.4}$$

The bank is risk-neutral and can either lend to the firms or invest in a risk-free technology with gross interest rate R_f. The bank is funded entirely by own capital C, assumed large enough such that the bank is never constrained to lend. The marginal cost of lending is therefore always R_f. This simplifying assumption obviates the need to model deposit supply and interest rate, but is not critical for the analysis.

In the basic model, the bank exercises absolute monopoly power on its client base. An important case will also be considered, where two banks, A and B, compete in a monopolistic environment. In this case, a Hotelling-like spatial structure is assumed, where all firms are equally distributed over the interval $[0, 2]$, with Bank A located at point 0, and Bank B's position is at point 2. A firm living on point $\theta \in [0, 2]$ must pay a linear transaction (or distance) cost of $d\theta/2$ if it chooses to get a loan from Bank A, or $d(1 - \theta)/2$ if it were to get a loan from Bank B, where $d > 0$. A firm can only borrow from one bank, and chooses the one with the highest expected surplus net of the transaction costs.

3 Optimal Contract under a Single Bank

With only one bank to borrow from, firms have no choice but to accept any contract offering non-negative surplus. It is thus optimal for the bank to give no more than zero surplus to the firms it wishes to attract. Complications arise because the bank may want to have only good firms on its portfolio, but cannot identify them a priori. The contract design must perform dual functions of extracting surplus as well as sorting firm types. In particular, if the bank were to lend any more than 1, it cannot offer a contract acceptable to the good type without also attracting the bad type. Such a pooling contract lies on the arc BC in Figure 1, which would give good firms zero surplus and bad firms positive surplus $G(L) - F(L)$. The offered contract $\{L, R\} = \{L, F(L)/L\}$ gives the bank an expected profit of

$$\pi_p(L) = R_f(C - (1 + \gamma)L) + (p + \gamma q)F(L) \tag{3.1}$$

for $L > 1$. The first term on the right hand side is the return from safe asset investment, given that a pooling contract will attract both types of borrowers, and hence the aggregate lending is $(1 + \gamma)L$. The second term is the return from lending, given that the good firms can (just) repay the debt of $RL = F(L)$ with probability p, while a mass γ of bad firms can repay the same amount with probability q.

Maximizing equation 3.1 gives the optimal lending amount under pooling contract L_p, which solves

$$F'(L_p) = \frac{(1 + \gamma)R_f}{p + \gamma q} \tag{3.2}$$

The existence of an interior solution $L_p > 1$ to equation 3.2 is necessary (but not sufficient) for the pooling equilibrium to be supported. Unless it is satisfied, the bank will always offer a separating contract on the segment AB in Figure 1 as a unique optimal contract. The necessary condition $L_p > 1$ can be equivalently stated as $F'(1) > \frac{(1+\gamma)R_f}{p+\gamma q}$, satisfied as long as

$$R_f < \overline{R} \equiv \frac{(p + \gamma q)F'(1)}{1 + \gamma} \tag{3.3}$$

Intuitively, the bank is ever interested in lending a larger amount, which is a characteristic of a pooling contract, only if the competing risk-free return is not too high. To focus on interesting

cases where a pooling equilibrium is possible, this condition is assumed to hold.

If the bank instead wishes to screen out the bad firms, it must limit its lending and offer a contract along the arc AB in Figure 1. This will give the bank an expected profit of

$$\pi_s(L) = R_f(C - L) + pF(L) \tag{3.4}$$

valid for $L \leq 1$. The optimal loan size L_s does not obey the first-order condition $F'(L_s) = \frac{R_f}{p}$, but instead is a corner solution

$$L_s = 1 \tag{3.5}$$

since condition 3.3 implies that $F'(1) > \frac{(1+\gamma)R_f}{p+\gamma q} > \frac{R_f}{p}$.

Assumption 1. *A separating equilibrium prevails under one bank, i.e. despite condition 3.3 being met, the bank prefers to screen out bad firms*

$$\pi_s(1) > \pi_p(L_p) \tag{3.6}$$

Conditions 3.3 and 3.6 jointly imply

$$\underline{R} < R_f < \overline{R} \tag{3.7}$$

where $\underline{R}$ is the level of R_f that solves

$$R_f = \frac{(p + \gamma q)F(L_p) - pF(1)}{(1 + \gamma)L_p - 1} \tag{3.8}$$

In general, the right-hand term needs not be monotonic in R_f. But for large enough R_f, it is decreasing in R_f. A solution $\underline{R}$ therefore exists. When more than one solution exists, the smaller one applies, i.e. $\underline{R}$ is the lowest possible rate that makes the bank indifferent between separating and pooling. Assumption 1 requires $\underline{R}$ to be less than $\overline{R}$.

An interpretation is in order. For a moderate range of risk-free interest rate, the bank prefers a contract with limited lending to select only good firms, over a large-lending pooling alternative. Too high an interest rate would constrain the optimal lending amount to below 1, rendering the asymmetric information constraint non-binding in the first place. Too low an interest rate would incentivize the bank to increase its risky investment, which is possible only

by extending loans to both types of firms in the pooling equilibrium.

The separating equilibrium has the standard feature of credit rationing along the line of Stiglitz and Weiss (1981). The bank would want to lend more than $L = 1$ to good firms but is constrained by the adverse selection problem which threaten to dilute the quality of asset pool. The good firms are in turn denied more financing even though they have a productive means to employ the resources, and despite their willingness to pay a higher interest rate.

4   Bank Competition

Consider the case of two banks, A and B, competing in a monopolistic environment. Heterogeneous costs of accessing banks are now assumed, which lend each bank some market power on its natural client base. For any pair of contracts offered by banks, there exists a cutoff firm $\hat{\theta} \in [0, 2]$, where all firms $\theta < \hat{\theta}$ choose to be with Bank A and all $\theta > \hat{\theta}$ choose to be with Bank B, because of the increasing transaction cost $d\theta/2$, where $d > 0$. When deciding which bank to borrow from, each firm compares the surpluses under the two contracts, against the transaction costs. Let S_A and S_B denote surpluses that firms enjoy under Bank A's and Bank B's contracts respectively, then $\hat{\theta}$ represents the indifferent firm:

$$S_A - S_B = \frac{d\hat{\theta}}{2} - \frac{d(2 - \hat{\theta})}{2} = d(\hat{\theta} - 1) \tag{4.1}$$

thus

$$\hat{\theta} = 1 + \frac{1}{d}(S_A - S_B) \tag{4.2}$$

The market share for Bank A, $\hat{\theta}$, is thus an increasing function of $S_A - S_B$, and is more sensitive to contract surplus if the cost function is relatively flat. In the extreme case of homogeneous costs where $d \to 0$, the competition becomes that of Bertrand.

Bank competition introduces two levels of strategic calculations. Each bank must decide what *type* of contracts to offer (separating or pooling), taking into account the rival bank's offer type. Conditional on the resulting combination of contract types, each bank then determines the optimal contract specification $\{L, R\}$, again taking into account its rival's actions. Nash equilibrium concept can be used in both stages of interactions, in a backward induction.

In determining the optimal contract specifications, there exist four main cases correspond-

ing to the 2x2 combination of contract types offered by two banks. The two cases where both banks offer the same type of contracts are potential candidates for a symmetric Nash equilibrium of the overall game. The Nash equilibria with joint pooling and joint separating contracts represent the 'credit boom' and 'credit rationing' equilibria respectively. Under a credit-rationing equilibrium, both banks find it optimal to maintain a healthy portfolio by lending only to good firms. With a credit-boom equilibrium, both banks choose not to screen out risky borrowers, and maximise total profits unconstrained by the asymmetric information problem. A credit boom in the model is therefore characterised by higher total credits (both per firm, and the number of firms getting credits) and higher proportion of defaults.

To verify the strategic stability of each potential Nash equilibrium, two deviation scenarios will be analyzed—'rushing to dominate' and 'picking the cream'—where a bank is attempting to break a symmetric equilibrium by offering a contract of a different type in the most optimal way. When such profit-maximixing deviation delivers a higher payoff to the bank than before, the original contract configuration cannot be a Nash equilibrium.

Strategic considerations matter for the design of optimal lending contracts specifications through both market share competition and informational frictions. The interest rate set determines the split between a bank's profit and firms' surpluses, which in turn affects market share. With banks competing to offer more attractive, cheaper contracts, firms would benefit by getting positive surpluses in equilibrium. The optimal loan amount, on the other hand, may be affected by worsened adverse selection problem, as competition intensifies.

4.1 Credit Boom Equilibrium

Consider first the case where Bank A is offering a pooling contract, knowing that its competitor is also doing the same. Bank A has a choice of giving some surplus S_A to the firms, which could boost its client base to $\hat{\theta} > 1$ if $S_A > S_B$. If both banks offer pooling contracts, the composition of the firm types is the same to both banks regardless of the surpluses offered, as long as they are positive for the good type (i.e. without violating the participation constraint). The ratio of bad to good types therefore remains γ. Bank A's expected profit is given by

$$\pi_{pp}(L) = R_f(C - \hat{\theta}(1 + \gamma)L) + \hat{\theta}(p + q\gamma)(F(L) - S_A) \tag{4.3}$$

The optimal contract design consists of two steps. First, Bank A maximizes profit over L,

taking as given the surplus $S_A > 0$ that it plans to give to good firms (as well as S_B set by the opponent), and thus the resulting market share $\hat{\theta}$. The first-order condition with respect to L of 4.3 gives the same optimal lending amount as equation 3.2 in the single bank case. Competition therefore does not matter for the amount of lending in the joint pooling equilibrium, and the optimal contract continues to entail L_p.

In the second step, Bank A optimizes over S_A (taking S_B as fixed) by changing the gross interest rate charged. The first-order condition is

$$\hat{\theta}(p + q\gamma) = \frac{\partial \hat{\theta}}{\partial S_A} \left[(p + q\gamma)\left(F(L_p) - S_A\right) - R_f(1 + \gamma)L_p \right] \tag{4.4}$$

In the symmetric Nash equilibrium where $\hat{\theta} = 1$, either the optimal surplus is the interior non-negative solution to equation 4.4, or the participation constraint is binding and $S_A = 0$. Thus

$$S_A = \max\left\{ 0, F(L_p) - d - \frac{R_f(1 + \gamma)}{p + q\gamma}L_p \right\} \tag{4.5}$$

The profit accrued to Bank A in a joint pooling equilibrium is then reduced to

$$\pi_{pp}^* = \begin{cases} R_f C + d(p + q\gamma) & \text{if } S_A > 0 \\ R_f C + (p + q\gamma)F(L_p) - (1 + \gamma)L_p & \text{otherwise} \end{cases} \tag{4.6}$$

Each bank's profit in equilibrium is less than the monopoly counterpart $\pi_p(L_p)$ as long as a positive surplus is offered to firms. However each bank retains some supernormal profit above the risk-free return on its capital, given its market power captured by the term $d(p + q\gamma)$. As market power weakens (and d decreases), this supernormal profit declines.

4.2 Credit Rationing Equilibrium

When both banks are offering separating contracts, the lending amount and the surplus given to firms cannot be decided independently from each other. Recall that the single-bank separating contract on point B in Figure 1 is just out of reach for the bad firms. If a bank were to offer a positive surplus to good firms while keeping bad firms out, it has no choice but to curtail its lending amount below 1. At the same time, banks have no interest in cutting back the lending amount any more than required by the adverse selection constraint, since they were already

lending less than if they were unconstrained (recall that $F'(1) > \frac{R_f}{p}$).

The optimal separating contract with bank competition therefore always lies on the schedule G (or rather just above it), namely the segment DB in Figure 1. By choosing to lend L along this curve, a bank is automatically choosing to give good firms a surplus of $F(L) - G(L)$. The surplus and lending choices are effectively one decision to make, as the binding adverse selection constraint removes one degree of freedom. The profit function of Bank A under joint separating contracts is therefore

$$\pi_{ss}(L) = R_f(C - \hat{\theta}(L)L) + p\hat{\theta}(L)G(L) \tag{4.7}$$

where $\hat{\theta}(L)$ is the market share implied by the decision to lend L, and is the solution to

$$S_A - S_B = F(L) - G(L) - S_B = d(\hat{\theta}(L) - 1) \tag{4.8}$$

Curtailing lending boosts a bank's market share by

$$-\frac{\partial \hat{\theta}}{\partial L} = \frac{G'(L) - F'(L)}{d} \tag{4.9}$$

guaranteed to be positive around the neighbourhood of $L = 1$ due to the single-crossing property.

Offering a surplus to firms is doubly costly for banks because, in addition to being a direct transfer from banks to firms, it requires further deviation from the unconstrained optimal lending. Lower per-contract loan must therefore raise market share sufficiently that it ends up raising total loans. Deviating from the zero-surplus contract of $\{L, R\} = \{1, F(1)\}$ gives a bank positive profit if the derivative of equation 4.7 is negative, namely

$$p(\hat{\theta}G' + G\hat{\theta}')|_{L=1} < R_f(\hat{\theta} + \hat{\theta}')|_{L=1} \tag{4.10}$$

In such case, the bank has the incentive to continue lowering per-contract loan to expand its market share until the marginal benefit of doing so is equal the marginal cost of risk-free investment:

$$p(\hat{\theta}G' + G\hat{\theta}')|_{L=L_{ss}} = R_f(\hat{\theta} + L\hat{\theta}')|_{L=L_{ss}} \tag{4.11}$$

In a symmetric Nash equilibrium, banks end up splitting the market share equally. If

condition 4.10 is satisfied, then the equilibrium contract is $\{L_{ss}, G(L_{ss})/L_{ss}\}$ where $L_{ss} < 1$ solves

$$p(G' + G\hat{\theta}')|_{L=L_{ss}} = R_f(1 + L\hat{\theta}')|_{L=L_{ss}} \tag{4.12}$$

Otherwise, the optimal contract in equilibrium is simply $\{1, F(1)\}$, the same as in the single-bank separating case.

Bank's profit in equilibrium is

$$\pi_{ss}^* = R_f(C - L_{ss}) + pG(L_{ss}) \tag{4.13}$$

which is less than π_s because of lower investment in loans at a lower return.

4.3   Rushing to Dominate

So far, the focus has been on the optimal contract specifications when the competing bank is assumed to offer the same type of contract. A bank may however offer a different type of contract from its competitor's. When such unilateral deviation is profitable, the joint equilibrium contract cannot be sustained.

Consider first the case where Bank A attempts to break away from a joint separating equilibrium by offering a pooling-type contract. Bank A's motivations come from the fact that it can freely offer surplus to firms without being constrained by the adverse selection. It may therefore 'rush to dominate' the loan market by offering cheaper contracts to all firm types. Such unilateral strategy would subject Bank A to more severe adverse selection, as it would attract bad firms more than proportionately since Bank B is not competing in that sector.

Let $\hat{\theta}_g$ and $\hat{\theta}_b$ denote Bank A's market shares of good and bad firms respectively, which satisfy

$$S_A = d(\hat{\theta}_b - 1) \tag{4.14}$$

$$S_A - S_B = d(\hat{\theta}_g - 1) \tag{4.15}$$

where $S_B = F(L_{ss}) - G(L_{ss})$ is the surplus offered by Bank B to good firms under the joint separating equilibrium. Bank B is not offering any surplus to the bad types as its contract is separating. Equations 4.14 and 4.15 suggest that $\hat{\theta}_b > \hat{\theta}_g$, as Bank A attracts more bad firms

than good ones by deviating from the joint separating equilibrium.

Profit function for Bank A is given by

$$\pi_{ps}(L) = R_f(C - (\hat{\theta}_g + \hat{\theta}_b\gamma)L) + (\hat{\theta}_g p + \hat{\theta}_b q\gamma)(F(L) - S_A) \tag{4.16}$$

whose first-order condition pertaining the lending amount is

$$F'(L_{ps}) = \frac{(\hat{\theta}_g + \hat{\theta}_b\gamma)R_f}{\hat{\theta}_g p + \hat{\theta}_b q\gamma} > \frac{(1+\gamma)R_f}{p + q\gamma} = F'(L_p) \tag{4.17}$$

Thus, $L_{ps} < L_p$ as Bank A takes into account the deterioration of average loan quality. It is also clearly the case that $L_{ss} \leq 1 < L_{ps}$.

The first-order condition for the optimal surplus is given by

$$(F(L_{ps}) - S_A)(p + q\gamma) = d(\hat{\theta}_g p + \hat{\theta}_b q\gamma) + R_f L_{ps}(1 + \gamma) \tag{4.18}$$

Equations 4.17 and 4.18 together determine the optimal contract features should Bank A choose to deviate from a credit-rationing equilibrium.

4.4   Picking the Cream

Bank A may finally opt to deviate from a joint pooling equilibrium and offer a contract of the separating type. By 'picking only the cream', Bank A's profit function is identical to that of equation 4.7, since the contract may entice only good firms. The market share is given by 4.8, where the surplus offered by the competing bank, S_B, is that under the joint pooling equilibrium in equation 4.5.

Combining these relationships with the first-order condition results in the following joint conditions

$$p(\hat{\theta}G' + G\hat{\theta}')|_{L=L_{sp}} = R_f(\hat{\theta} + L\hat{\theta}')|_{L=L_{sp}} \tag{4.19}$$

$$F(L_{sp}) - G(L_{sp}) - F(L_p) + \frac{R_f(1+\gamma)}{p + q\gamma}L_p = d(\hat{\theta}(L_{sp}) - 1) - d \tag{4.20}$$

which together determine the optimal L_{sp} and S_A. A bank has an incentive to deviate from the joint pooling equilibrium when the market share foregone is more than made up by the improvement in credit quality pool.
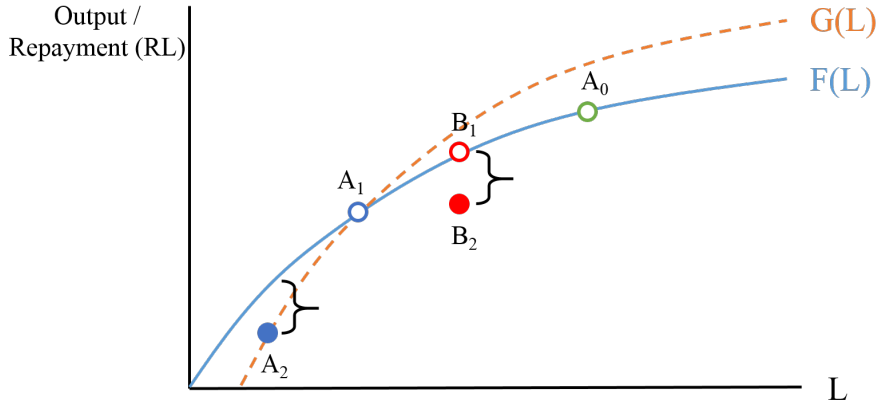
4.5 The Intuition

Figure 2: How bank competition fosters credit boom

Figure 2 outlines the basic mechanism of how bank competition may foster a credit boom. If there was only one bank who could identify firm types and thus lend an unrestricted amount only to the good firms, it would equate the risk-adjusted marginal product of capital to the risk-free return. Being a monopoly, it would also leave the good firms with only zero profits. Let this first-best optimal contract be represented by contract A_0 in Figure 2.

Constrained by asymmetric information, the monopoly bank can either offer an optimal separating contract A_1, or an optimal pooling contract B_1. By Assumption 1, contract A_1 is preferred to B_1, although both are inferior to the first-best outcome where contract A_0 is accepted by only the good firms.

With banks competing, more surplus needs to be given to firms in equilibrium. For pooling contracts, banks can lower the interest rate and offer a contract such as B_2 (as established in Section 4.1, the optimal lending amount remains unchanged from the single bank case). For separating contracts, however, banks cannot lower the interest rate without attracting the bad firms. To satisfy the screening constraint, banks must exercise further credit rationing as they compete to offer more surplus to good firms. Such competition to screen for good firms are doubly costly for banks, as not only do they need to forgo more surplus, but they need to curtail lending further away from the already second-best amount. Although contract A_2 offers the same surplus to good firms as contract B_2, the former entails greater cost for banks. As competition intensifies, banks could prefer B_2 to A_2, even if initially they prefer A_1 to B_1. Credit boom could then arise as a Nash equilibrium.

5 Equilibrium and Implications

5.1 Baseline Solution

The model's solution will now be derived under explicit functional form and parameterization, chosen to illustrate a variety of possible outcomes. Let the production functions take the power form, $F(L) = b_1 L_1^a$ and $G(L) = b_2 L_2^a$. Consider the parameterization in Table 1 (under which all optimal contract features satisfy interior solutions described in the previous section). As depicted in Figure 3, the single-crossing condition is satisfied under this pair of technologies.

Table 1: Parameterization 1

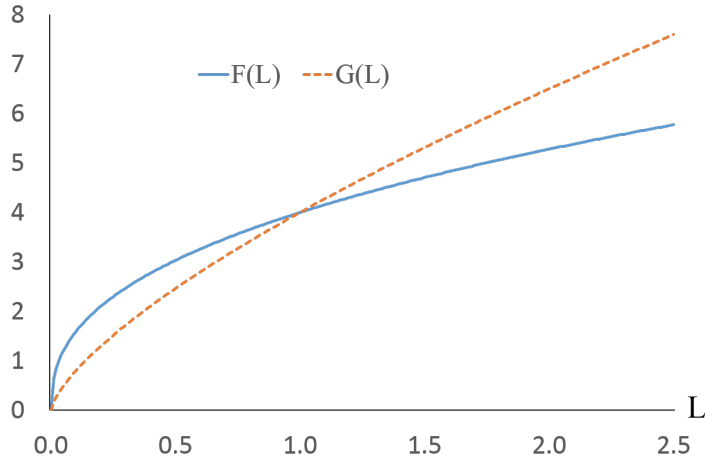| a_1	b_1	a_2	b_2	p	q	γ	C	d
0.4	4	0.7	4	0.9	0.1	0.2	10	2

Figure 3: Technologies under parameterization 1

Under this parameterization, $\underline{R} = 0.915$ and $\overline{R} = 1.227$. For R_f within this interval, a single bank always wants to offer a separating contract $\{L, R\} = \{1, 4\}$. With competition, banks must compare profits under optimal contracts for four cases, namely 'credit rationing', 'credit boom', 'rushing to dominate' and 'picking the cream'. Figure 4 plots these profits as a function of $R_f \in [0.915, 1.227]$.

Three possibilities can emerge with bank competition, even if the risk-free rate still falls in the range $[0.915, 1.227]$. For sufficiently low R_f (below 1.00), the joint-pooling equilibrium of credit boom is the unique Nash equilibrium. Over this interval, the joint-separating outcome of credit rationing cannot be supported as a Nash equilibrium, as a bank can increase its profit by rushing to dominate. On the other hand, for sufficiently high R_f (above 1.12), the joint-
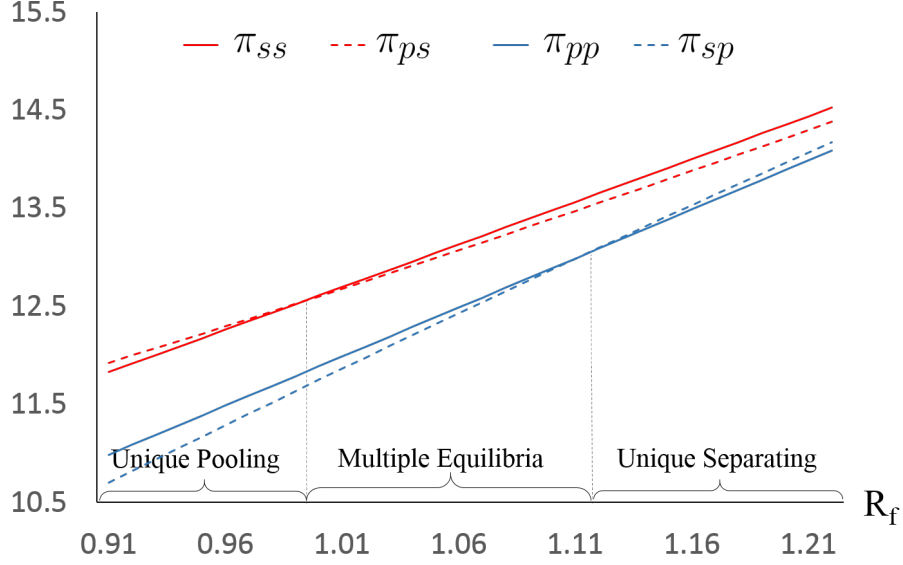
Figure 4: Banks' equilibrium profits under parameterization 1

pooling equilibrium of credit boom is dominated by picking-the-cream strategy, so that credit rationing is the unique Nash equilibrium. When R_f falls within the interval $[1.00, 1.12]$, both credit rationing and credit boom are symmetric Nash equilibria, and it is indeterminate which outcome will obtain without further equilibrium refinement criterion.
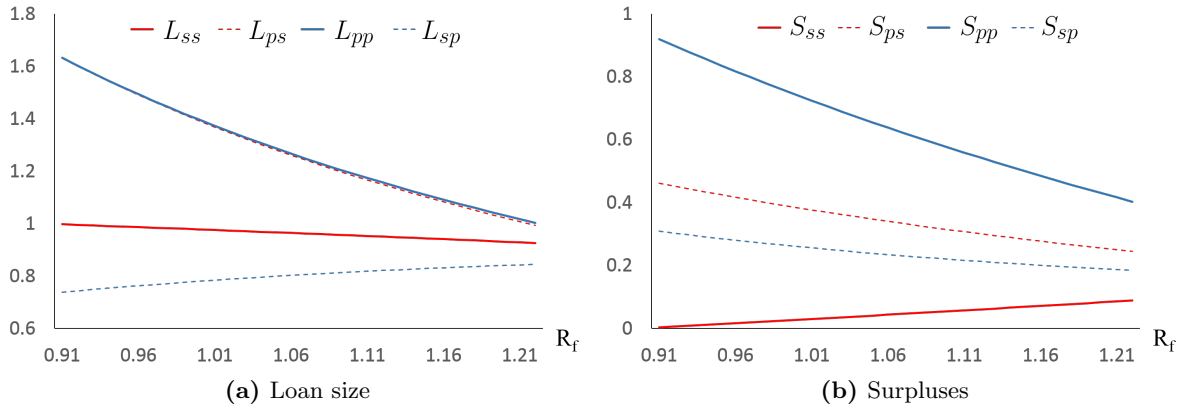

(a) Loan size

(b) Surpluses

Figure 5: Optimal contracts under parameterization 1

Optimal loan amount and surpluses as a function of R_f are depicted in Figure 5. In both symmetric equilibria, loan size decreases with interest rate R_f, as incentives to take risks decline. The sensitivity of optimal loan size to changes in R_f is lower under the credit-rationing equilibrium, because cutting back loans in this case entails giving a higher surplus to good firms, an expensive strategy that is made necessary by adverse selection constraint.[1] This is shown

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[1] Binding adverse selection constraint also implies that picking the cream must offer higher loan size as R_f increases. With surplus under credit boom declining with R_f, a deviating bank can counter offer with a

on the right panel of Figure 5, where the optimal surplus rises with R_f in the joint-separating equilibrium. In the joint-pooling case, the surplus shrinks with R_f as banks curtail loan supply.

5.2 'We're Still Dancing'

The existence of multiple equilibria highlights the potential instability of credit market equilibrium, and opens up the possibility of endogenous credit boom. For example, under parameterization 1 and for $R_f \in [1.00, 1.12]$, lending decision depends on the outcome of a coordination game, which can vary with synchronized shifts in banks' expectations. An equilibrium switch involves a jump in total lending as well as the average quality of banks' assets, with repercussion on total production and its volatility. The quantitative implications of such switch can be significant in the model, as Table 2 shows.

Table 2: Multiple Equilibria Comparison

	Total lending		Expected output		Output variance	
R_f	ss	pp	ss	pp	ss	pp
1.005	0.977	1.674	3.567	4.214	1.414	1.971
1.025	0.973	1.620	3.561	4.158	1.409	1.918
1.045	0.968	1.569	3.554	4.104	1.403	1.868
1.065	0.964	1.520	3.547	4.051	1.398	1.820
1.085	0.959	1.473	3.540	4.000	1.393	1.774
1.105	0.954	1.429	3.534	3.951	1.387	1.730

For example, when $R_f = 1.065$, there exist two equilibria with $L_{ss} = 0.964$ and $L_{pp} = 1.267$. Suppose the two banks somehow successfully coordinate their expectation shifts from joint separating to joint pooling. The resulting growth in total lending per bank is $(1 + \gamma)L_{pp}/L_{ss} = 1.520/0.964$, a 58 percent increase. The average default probability more than doubles from $1 - p = 10$ percent under credit-rationing equilibrium to $((1-p)+\gamma(1-q))/(1+\gamma) = 23$ percent under credit boom. The expected output produced by firms under the pooling equilibrium is 4.05, a 14 percent increase from the credit-rationing benchmark, but there is also a marked increase in average output volatility. Rapid credit acceleration accompanied by deterioration of asset quality and higher output volatility is a pattern consistent with actual credit boom phenomena.

It is clear from Figure 4 that both banks would prefer a credit-rationing equilibrium over a credit boom for any interest rate. But if the other bank is expected to offer a pooling contract, a bank's optimal response is to comply and contend with larger loan size and higher

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separating contract involving lower surplus and higher loan amount.

default probability, for fear of losing market share. The underlying coordination failure problem captures an essential aspect of the now famous quote:

> *"When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing."*

> Charles Prince

> Ex Citigroup CEO, interview with the Financial Times

In the model, both banks would prefer a quiet sit-down to dancing. But neither is willing to be the first to stop.

Even when the system starts off in a credit-rationing state, it takes only one bank's temporary deviation to upset the equilibrium. When one bank errs towards non-profit objectives, such as size or pursuit of socioeconomic policy, the implications for the credit market as a whole could be permanent and far-reaching. Even when that bank stops pursuing such objectives, the banking system does not automatically revert to the credit-rationing equilibrium. With coordination failure, once the credit market finds itself in a boom, there is no auto-correction mechanism.

These results suggest that distortions at individual bank levels could have systemic effects even if there are no direct financial linkages between the banks. For example, a large presence of specialized financial institutions (SFIs) could have implications for the stability of the banking sector when they operate in the same credit market as other private banks. Policymakers must strike a balance between the need to implement public policies and the need to safeguard financial stability. (Section 6 below discusses the role of SFIs in the recent run-up in credit cycle in Thailand.) More generally, the regulatory regime should refrain from asymmetric treatments, and mitigate any distortions to the credit market from any sources.

5.3 Finance-neutral Rates of Interest

After the global financial crisis, there is much debate about the extent to which monetary policy should play a more active role in safeguarding financial stability (for a recent review, see Yellen (2014) and Bank for International Settlements (2014)). The linkage between monetary policy and financial stability remains vague, however, when compared to macroeconomic stability. The standard 'gaps' approach to macroeconomic stabilization dictates that optimal monetary policy be tied to the output and inflation gaps, the deviations of output from its potential and inflation

from its target. In the long run when all gaps close, the policy interest rate converges to its natural rate of interest, namely the neutral stance. It is less clear what the resting stance for monetary policy should be, that will be consistent with maintaining financial stability in the long run.

There have been recent attempts to introduce analogous 'financial gaps', based for example on a deviation of credit-to-GDP ratio from its trend, to define an augmented policy rule. Such reduced-form approach may prove to be a useful and robust characterization of how to respond to financial stability risks. What the approach lacks is a more explicit theoretical underpinning, casting doubt on its validity. The model proposed here is one attempt to fill this theoretical gap, and articulate the scope as well as the limits to using conventional monetary policy to secure financial stability. Among other things, the notion of 'finance-neutral' rate of interest can be meaningfully defined.

Financial instability in this model can be equated to the likelihood of the credit-boom equilibrium obtaining. Let R_f represent the interest rate policy set by the central bank, which has an impact on financial stability via the risk-taking channel.[2] The finance-neutral rates of interest can be defined as the levels of R_f consistent with financial stability, namely the interest rates such that the credit-rationing equilibrium is obtained rather than the credit boom.

Consider again the model's baseline solution under parameterization 1 in Table 1. To guard against financial instability in this instance, R_f must necessarily be higher than 1.00 to at least rule out the case of credit boom being a unique equilibrium. But this may not be sufficient if the two banks choose to coordinate on the pooling equilibrium, which remains a possibility as long as $R_f \in [1.00, 1.12]$. To secure financial stability for certain, R_f needs to be above 1.12 to enforce a unique credit-rationing equilibrium.

The indeterminacy of the finance-neutral rate of interest suggest that there may be practical limits to using conventional monetary policy as the only policy instrument to target financial stability. The rate of interest should certainly not be as low as to result in a unique equilibrium of credit boom. But setting R_f high enough to guarantee a unique equilibrium of credit rationing could potentially cause a material conflict with the broader macroeconomic considerations.[3] An additional policy tool, such as macroprudential, can be useful here, not only as a

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[2] In a general equilibrium model, it would be the government that pays R_f on its short-term debt, financed through tax revenue. The risk-free technology, in the long run, is therefore pinned down by the taxable national income. To focus purely on the financial stability issue, it is assumed here that the central bank can set R_f freely without worrying about fiscal budget constraint.

[3] Yellen (2014): *"But such risk-taking can go too far, thereby contributing to fragility in the financial system. This*

non-intrusive brake to credit expansion, but also to the extent that it strengthens banks' belief in the credit-rationing equilibrium, and thereby facilitates a coordination on it.

The range of finance-neutral R_f varies with the structural factors determining bank competition. Financial innovation, for instance, could lower firms' switching costs d, thus intensifying competition among banks. Changes in d could also serve as a rough proxy for the exogenous shifts in banks' preferences for size, or their degree of risk appetite.[4] In a paper presaging the global financial crisis, Rajan (2005) suggests that the two may even interact, as financial innovation may contribute to a surge in the degree of risk-taking. By taking these developments into account, it is argued, monetary policy could play a greater role in securing financial stability. Figure 6 sheds light on how monetary policy should be conducted in this manner, by showing the range of R_f corresponding to each type of equilibrium, as a function of d.
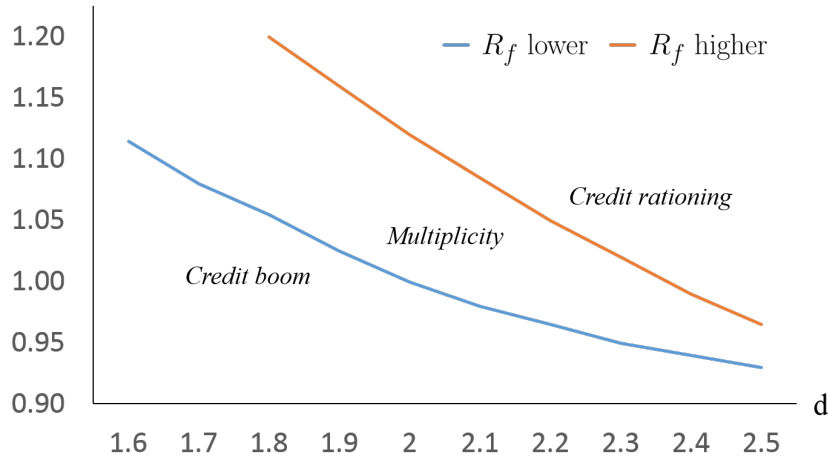

Figure 6: Finance-neutral rates as a function of d

A credit-rationing equilibrium is guaranteed for R_f in the region above the upper line. Meanwhile, multiplicity results when R_f falls between the two lines, and a unique equilibrium of credit boom emerges when R_f is below the lower line. As d declines as a result of either financial innovation or higher banks' risk appetite, the range of interest rates that can guarantee financial stability narrows, and eventually vanishes. This effectively places a limit on how much risk-free rate can do to prevent financial instability.[5] The range of interest rates over which there is

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possibility does not obviate the need for monetary policy to focus primarily on price stability and full employment– the costs to society in terms of deviations from price stability and full employment that would arise would likely be significant."

[4]Although banks are assumed to be risk-neutral in this model, a lower d indirectly decreases the cost of taking on additional risky loans.

[5]While there is no strictly upperbound on interest rate, recall the assumption that $R_f < \overline{R_f}$, which is needed for

multiplicity also expands as d declines. Thus, finance-neutral interest rates are not constant, but are inversely related to d. As financial innovation deepens or risk appetite intensifies, the level of risk-free rate required to maintain financial stability must grow, and could worsen the macro-financial stability tradeoffs facing the policymaker.

5.4 Financial Stability as a Welfare Criterion

The preceding discussion takes as given that, to pursue financial stability, the policymaker should try to steer the economy clear of the credit-boom equilibrium. In this section, the relationship between financial stability objective and social welfare will be more carefully examined.

From the society's viewpoint, multiple equilibria are not Pareto rankable, since the bad firms always enjoy positive surplus under the pooling equilibrium regardless of banks' preferences. A pooling equilibrium could in fact be preferred by a social planner if, despite not observing firms' types a priori, she can still verify realized output and redistribute ex post. In such case, the social planner is effectively an equity investor with access to both technologies, and may want to gamble more than a bank does. In particular, when $G(L)$ is sufficiently larger than $F(L)$ for $L > 1$, the social planner may well want to finance both types of firms even when a single bank would not. After production, the planner can then tax the successful bad firms in order to redistribute. Banks as a seller of debt contracts, on the other hand, do not enjoy such privilege because it cannot extract any surplus from the bad firms without giving up the good customers.

The social welfare case against the pooling equilibrium would therefore stand on shaky ground if it were to hinge only on productive efficiency argument. However, financial stability as an objective is quite orthogonal to the need to channel finance to its most productive use. The primary welfare consequence of financial stability has to do with the special intermediary function of banks, and the notion that their viability is critical for a well-functioning economy.[6] A simple way to introduce financial stability to welfare calculations in the current setting is to assume that, in spite of banks' risk neutrality, the society assigns some positive weight to the viability of banks, and trades off the risk of bank insolvency against the productive efficiency.

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the pooling contract to be nondegenerate.

[6]There are well-known reasons why a decentralized allocation may be suboptimal according to this criterion. Banks that know they are 'too big to fail', for example, could undertake projects that pose risks to their viability, at social costs that far exceed private ramifications. A separation of origination and distribution of debt securities is another instance where moral hazard is made worse by increased product sophistication and diluted accountability, leading to allocative inefficiencies. In this model, the assumption that the society may want banks to be more risk-averse could be motivated by reasons similar to these.

As an example, consider a social welfare function of the form

$$W = \pi + S - \lambda \sigma_\pi^2 \qquad (5.1)$$

where π is the aggregate banks' profits, S is the total firms' surplus, σ_π^2 is the variance of π, and λ is the weight that the society places on financial stability. The variance of banks' payoff captures the probability of bank insolvency or its value-at-risk, in the events that banks lose too much capital from risky investment going bad.

Using equation 5.1, social welfare with and without financial stability objective can be compared under the two symmetric equilibria. The parameters used for this exercise are given in Table 3, where the technological parameters are modified slightly from Table 1 (in order to illustrate a case where the social planner indeed wishes to take more risks than banks do). It is also temporarily assumed here that risks are perfectly correlated across firms of the same type, so that default risks are aggregate shocks. The assumption is needed so that banks cannot rely on the law of large number to avoid insolvency risks (equivalently, one could assume that banks only lend to a finite number of firms).

Table 3: Parameterization 2

a_1	b_1	a_2	b_2	p	q	γ	C	d
0.3	4	0.9	4	0.9	0.1	0.2	10	2

Under these parameters, $\left[\underline{R}, \overline{R}\right] = [0.695, 0.915]$. Over this interval, there exists three subsets of interest rates as before: (1) for $R_f < 0.805$, there exists a unique credit-boom equilibrium; (2) for $R_f > 0.895$, a unique credit-rationing equilibrium obtains; and (3) there are multiple equilibria in the intermediate range. Banks strictly prefer the joint separating equilibrium of credit rationing when there is a multiplicity.

Figure 7 depicts social welfare under the two equilibria, when the society does not care about financial stability ($\lambda = 0$) and when it does ($\lambda = 0.1$). When $\lambda = 0$, the social planner would prefer lending to both firms as in the credit-boom equilibrium as long as $R_f < 0.865$ (thus, including when there are multiple equilibria in the decentralized allocation). This is an instance where the social planner would prefer to take more risks than banks. But as the society places a larger penalty on the variability of banks' profits, the credit-rationing equilibrium becomes socially optimal for a wider range of interest rates. In Figure 7, when $\lambda = 0.1$, it is socially desirable to attain the joint separating equilibrium for the entire relevant range of interest rates.
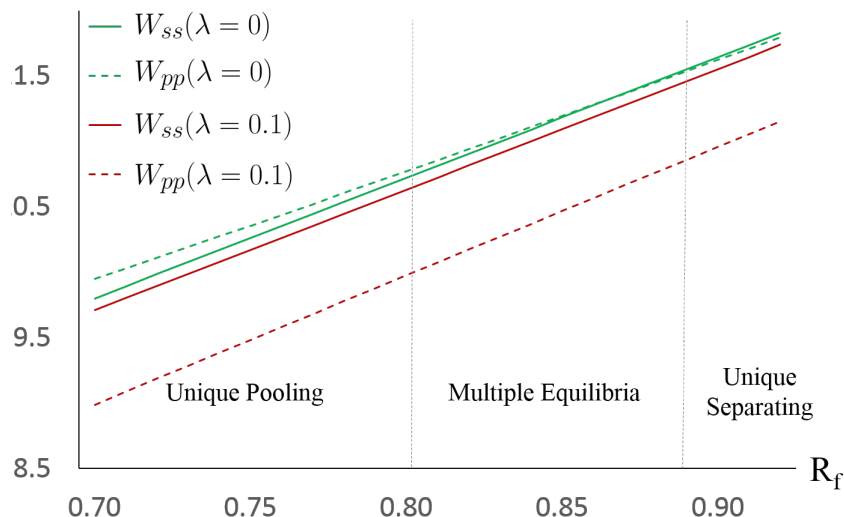
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Figure 7: Social welfare with and without financial stability objective

6 Some Empirical Observations

6.1 Credit Booms and Crises: Global Experience

The connections between financial development and economic growth have been widely examined in the literature, both theoretically and empirically (for a review, see Freixas and Rochet (2008) and Degryse et al. (2009)). Levine (2005) concludes that financial development can foster economic growth by producing ex ante information, monitoring investments after providing finance, facilitating risk management, mobilizing savings, and easing goods and services exchanges. Thriving and efficient financial sector, thus, seems imperative for the real sector growth.

However, financial development does not always correlate with the size of the financial sector or the general availability of credits. The relationship between finance and growth, in fact, tends to be negative at the top-end of the distribution. Figure 8 plots the frequency of credit booms of various sizes, sorted according to whether the country is in a financial crisis.[7] Far from always supporting growth and development, 64 percent of credit booms co-exist with financial crises. Larger credit booms tend to have a stronger association with financial crises, with z-scores of credit booms averaging about 1.5 when the sample is restricted to crisis events (compared with 1.2 for non-crisis). In addition, the distribution for z-score has a thicker right

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[7]The samples are entirely credit booms episodes, defined as the top ten data points with the highest credit growth as a deviation from trend (measured as z-scores) for each country, out of about 50 data points from an annual data base covering 1960-2010 from the World Development Indicators (WDI). The crisis definition follows that of Reinhart and Rogoff (2009). See Reinhart and Rogoff (2011) for additional discussion.
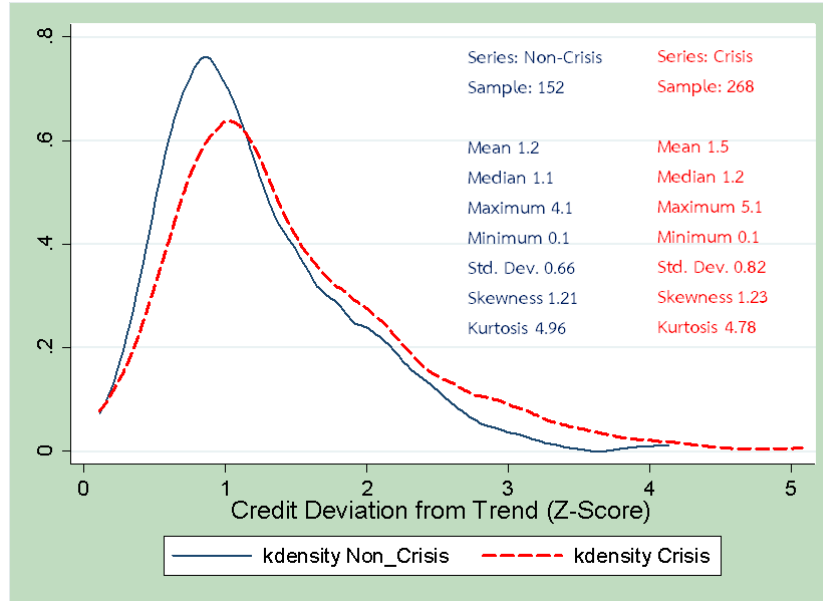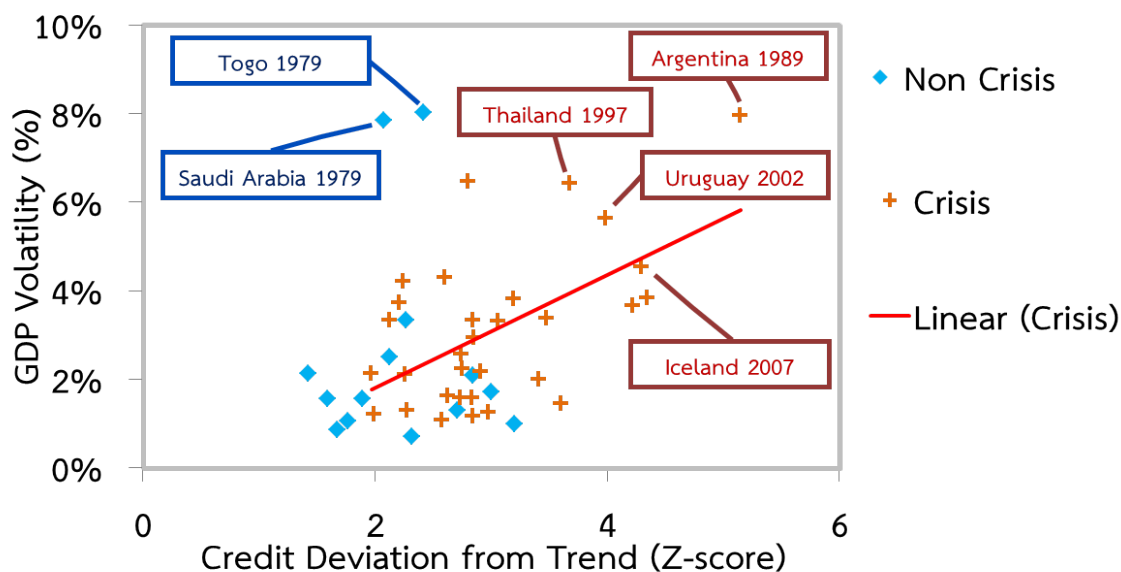
Source: WDI and Reinhart and Rogoff (2011). Calculations by authors.
Note: The distribution depicts each country's 10 year data with the highest
credit growth z-score during 1960-2010.

Figure 8: Credit booms and financial crises

tail for crisis sample. The figure suggests that an excessive amount of credits could harm the
economy by making the financial sector more fragile, consistent with the pooling equilibrium's
property in the model.

Credit booms also have negative consequences on economic growth volatility, as illustrated
in Figure 9. Each observation on the scatter plot represents the episode with the biggest
deviation of credit growth from trend since 1960 of 46 countries (the strongest candidate for a
'bad credit boom'), shown in the horizontal axis measured as a z-score. The vertical axis depicts
GDP volatility during the subsequent 5 years including the boom year, measured as the standard
deviation of differences between GDP growth and the pre-boom trend. Obviously, a 'bad credit
boom', to the extent that it increases risks of a financial crisis, is positively correlated with
the future growth volatility. In particular, the definition picks up the Latin America Financial
Crisis in 1980s, the Uruguay Banking Crisis in 2002, the Asian Financial Crisis in 1997, and
the Global Financial Crisis in 2007-2008. For the non-crisis boom, there is no clear relationship
between a booms size and growth volatility. The only two cases of non-crisis boom followed by
volatile economic growth can be explained by the rises in commodity prices, oil shock in 1979
for Saudi Arabia, as well as the phosphate boom of 1974-1975 and coffee price rises in 1977 for
Togo.

Source: WDI, and Reinhart and Rogoff (2011). Calculations by authors.
Note: Each observation represents the episode with highest deviation of credit growth from trend since 1960 of 46 countries. Y-Axis depicts GDP volatility during the subsequent 5 years (including the boom year), measured as the standard deviation of differences between GDP growth and the pre-boom trend. X-Axis shows the biggest deviation from trend of domestic credit provided by financial sector (% of GDP) during 1960-2012, measured as a z-score.

Figure 9: Credit booms and growth volatility

6.2   Should Monetary Policy Do More? Fed and the Housing Bubble

Some have proposed that the prolonged monetary easing in the US following the dot-com bubble burst, may have contributed to the subsequent housing bubble and sowed the seed for the global financial crisis. By placing too much weight on growth during 2000-2004 in its policy deliberations, the argument goes, the Federal Reserve inadvertently encouraged speculation which was further fueled by proliferated exotic financial innovations amid light-handed regulations. Taylor (2009) argues that during this period, the Federal Reserve deviated from its past behaviour that has served it well since the early 1980s, namely the Taylor rule. Had there been no deviation, Taylor (2009) estimates that the amplitude of the housing bubble would have been only half as big. The empirical link between pre-crisis US monetary policy and the housing bubble is not without contention, however. Dokko et al. (2011), for example, acknowledged that the US monetary policy did deviate from the Taylor rule, but found that the departure was too small to explain the subsequent boom in the housing market. They suggest that lax regulations had a larger role to play.

The model here offers an alternative and somewhat stronger proposition in this debate.

Even if monetary policy was consistent with the Taylor rule, there is no guarantee that financial stability would have been ensured. The critical issue is less about the cost of departing from the policy rule, and more about the basic conflict between the two policy objectives. Figure 10 plots the 3-month Treasury bill yield (risk-free rate) against the output gap (estimated by the Congressional Budget Office) and the corporate bond options-adjusted spread (a measure of risk premium). From macro stability angle, a negative output gap in 2003-2004 may lend justifications for keeping interest rate low to return the economy to full employment. However, falling risk premium over the same period to its decade low also hints at emerging risks to financial stability. The compressed risk premium persists throughout 2004-2007 despite gradual policy normalization, right up until the subprime blowup. This experience is consistent with a property of multiple equilibria predicted by the model, that the loan market can be trapped in an excessively cheap finance equilibrium even as risk-free interest rate moves up.
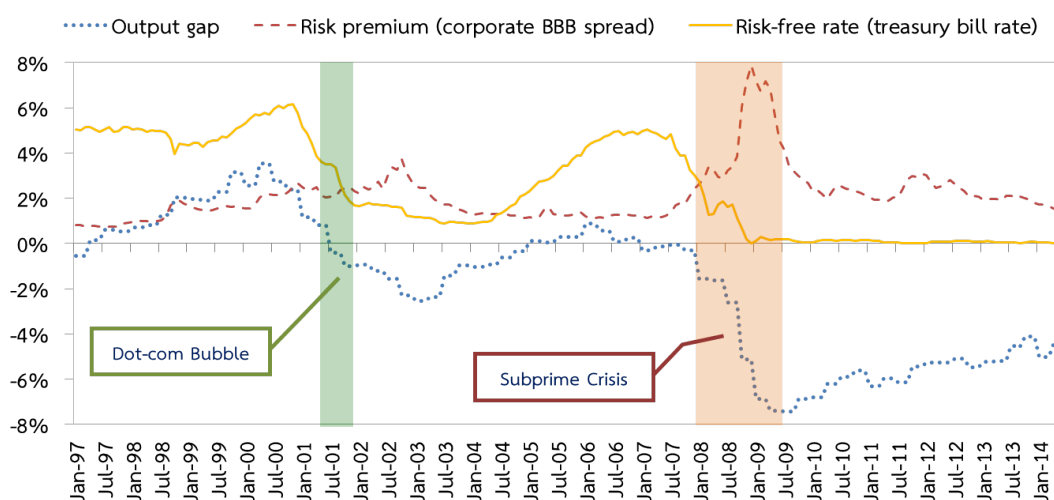
Source: Congressional Budget Office, Board of Governors of the Federal Reserve System, and BofA Merrill Lynch. Calculations by authors.

Figure 10: Macro versus Financial Stability Objectives

Developments after the global financial crisis share a few similarities with the previous episode, despite the latest recession being much more pronounced in scale. The legacy of the crisis left a large negative output gap in its wake, justifying an extended period of extraordinary policy accommodation. Indeed, the zero rate policy is now in its sixth year. At the same time, risk premium remains higher than the previous decade, and the broader credit creation continues to be somewhat subdued. Nonetheless, there are pockets of financial vulnerabilities developing in various guises, reflected in non-price indicators in particular. Stein (2013) highlighted the

return to pre-crisis highs of the payment-in-kind bond and covenant-lite loan issuance by the final quarter of 2012, for example. This pattern suggests that at least parts of the credit markets may have slided back into the 'pooling' equilibrium. It would be a mistake to ignore the repercussion of monetary policy on the degree of risk-taking, especially in areas of credit markets that yield less growth dividends.

6.3 Bank Competition and Risk-taking: Thailand 2011-2013

Thailand recently witnessed a mini episode of credit boom of her own. The 12-month growth of credits going to the private sector accelerated from below 5 percent at the beginning of 2010, to peak above 17 percent by the third quarter of 2011. Credit growth consistently hovered at double digit figure throughout 2011-2013, during which nominal GDP growth averaged about 6 percent. As a result, the ratio of credit to GDP, a popular measure of threat to financial stability, shot up during the period (Figure 11, left panel). Weakening economic activity since 2013 eventually led to a soft-landing of credit growth to about 6 percent by mid-2014, though still somewhat higher than the nominal GDP growth of 4.7 percent over the same period.

A number of real and financial factors may have been responsible for driving up both credit demand and supply during 2011-2013. On the demand side, the economic recovery after the global financial crisis and investment recovery from the 2011 flood may have played some part in spurring loan applications, especially from corporations. Government measures aimed at stimulating consumption in 2012 (especially the first-car buyer program) also provided a boost to consumer loan demand, whose rapid growth averaged 16 percent over 2011-2013.

An increase in credit supply also played an important part in triggering and sustaining the latest episode of a credit boom. Partly to meet the government's policy, some Specialized Financial Institutions (SFIs) stepped up their lending activities since 2009, pushing up their outstanding credits to GDP by almost 10 percent over 5 years (Figure 11, right panel). This upward trend is matched by private commercial banks' credit-to-GDP. To explain the correlation in the context of the model, a shift in SFIs' lending strategy may have triggered a transition away from a 'credit rationing' type of equilibrium to one of 'credit boom', as discussed in Section 5.2. Growth strategy by some private banks may have contributed to the overall expansion in credit supply over this period too. Strategic interactions among banks then transmit these initial shocks across the entire banking system. The credit boom could then be made persistent by the existence of multiple equilibria, given an environment of low interest rates.
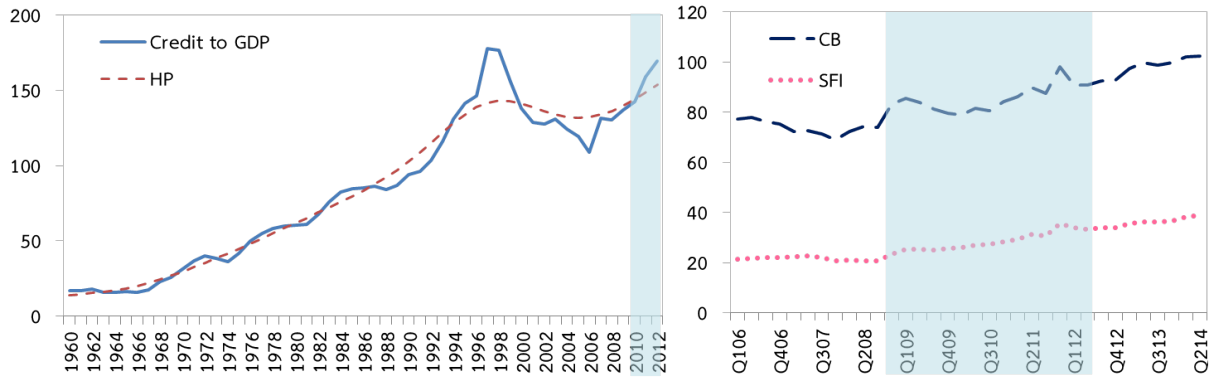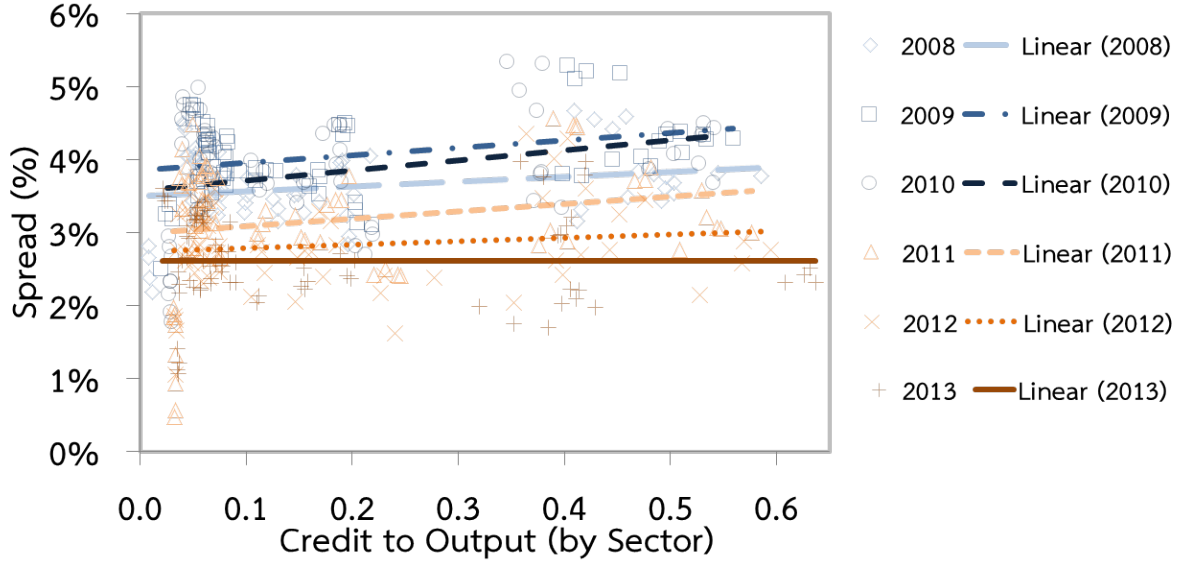
Source: BOT and WDI. Calculations by authors.

Figure 11: Thailand credit cycles

A simple identification strategy to disentangle demand versus supply shocks is to evaluate the effects on the pricing of loans. A positive credit supply shock brought about by banks' greater risk-taking would push down the terms of the loans, holding fixed the borrowers' characteristics. In the model, such easing in the loan terms corresponds to a higher surplus given to firms.

To explore banks' risk-taking behaviour in more details, the Loan Arrangements database at the Bank of Thailand is examined. This database contains more than 700,000 commercial banks loan contracts, including lending amount as well as the corresponding interest rates. Figure 12 shows the relationship between interest rate spreads and loan amount. Each data point represents to a unique economic sector (classified by a one digit ISIC) at the specified year. The loan amount is measured by credit-to-GDP, with both the numerator and the denominator corresponding to the sector concerned. Measuring loan amount as a ratio of GDP serves as a partial control for loan demand.

Cross-sectionally, a higher loan amount is generally associated with more expensive loan terms. While consistent with an upward slope of the loan supply curve, this could also be due to several reasons outside the model. More leveraged sectors such as real estate or hotels and restaurants could be assigned higher credit risks, justifying higher spreads than other sectors. At the same time, these sectors could enjoy higher profit margins than, say, public administration and agriculture, thus are able to service debt at a higher spread.

What the model predicts is that these spreads should compress across the sectors as competition and risk-taking intensify. The price-quantity relationship indeed began to shift downwards starting in 2010. During 2011-2013, the spreads became progressively tighter, coin-

Source: BOT. Calculations by authors.
Note: Each observation represents the spread between the weighted average lending rate and deposit rate of each industry in each quarter.

Figure 12: Bank risk-taking by sector: 2008-2013

ciding with the period of overall credit boom. This pattern is robust to segregating the data into different loan types, and there was a compression of spreads since 2009 across all categories.

To establish that this broad-based spread compression is due to higher risk-taking by banks and not other factors that could prompt an increase in loan supply, a more careful empirical assessment is required. The exercise needs to control for expectations of future growth which could prompt banks to extend more loans (due to lower perceived credit risks and higher future loan demand), despite no change in their risk appetite and stable degree of bank competition. Bank characteristics, such as liquidity and deposit availability, could also prompt banks to adjust their lending policies even if there is no change in the degree of bank competition.

To control for these factors, a dynamic panel specification following Brissimis and Delis (2009) is estimated to identify the loan supply function[8]:

$$R_{j,t} = \beta_1 R_{j,t-1} + \beta_2 L_{ij,t} + \beta_3 L_{ij,t-1} + \beta_4 D_{i,t} + \beta_5 D_{i,t-1}$$

$$+ \beta_6 D_{i,t} Z_{i,t} + \beta_7 D_{i,t-1} Z_{i,t-1} + \beta_8 CON_t + \eta_t + \epsilon_{ij,t} \qquad (6.1)$$

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[8]The data used for estimation are the panel of sectoral loans (at one digit ISIC), aggregated over monthly loan contracts in each sector. They cover 24 Thai commercial banks during 2008-2013. After aggregation, approximately 450 cross-sectional observations ($j \times i$) are available each month for estimation.

The key identifying strategy of the above specification is the assumption that each bank i has a limited influence on industry j's interest rate spread $R_{j,t}$ (and must take it as given), so that the slope of banks' loan supply schedule can be approximated by β_2. The coefficient captures the relationship between the spread in sector j and the amount of loan supplied by bank i, measured again as a ratio to sectoral GDP, $L_{ij,t}$, after controlling for a number of factors. Bank liquidity is measured by the logarithm of deposit level of bank i, $D_{i,t}$, and is allowed to interact with a vector $Z_{i,t}$ which stacks together the logarithm of total assets, the ratio of liquid assets to total assets and the ratio of capital to total assets. As in Brissimis and Delis (2009), all bank characteristics are measured as deviations from their cross-sectional means or overall means. To control for expected future economic growth, the consensus forecast of next year global growth CON_t is added, which is exogenous to the extent that Thailand can be regarded as a small economy. The dynamic panel estimators allow independent variables to be correlated with past and current realizations of the error (or system GMM; see Roodman (2009) for the procedure implemented here). The regression results are expressed in Table 4.

Table 4: Dynamic Panel Regression of Loan Supply Function

Year	Obs.	$R_{i,t-1}$	$L_{i,t}$	$L_{i,t-1}$	Hansen	AR(1)	AR(2)	Wald
2008	3,594	0.946	0.013	-0.016	0.514	0.000	0.036	0.000
		(0.04)**	(0.02)	(0.02)				
2009	3,946	0.718	0.015	-0.016	0.519	0.000	0.000	0.000
		(0.03)**	(0.01)	(0.01)				
2010	3,863	0.824	0.017	-0.017	1.000	0.000	0.263	0.000
		(0.07)**	(0.00)**	(0.01)**				
2011	3,809	0.936	-0.067	0.067	0.978	0.001	0.058	0.000
		(0.02)**	(0.07)	(0.07)				
2012	3,541	0.898	-0.066	0.068	0.979	0.000	0.232	0.000
		(0.02)**	(0.03)*	(0.03)**				
2013	2,995	0.956	-0.149	0.151	0.582	0.001	0.271	0.000
		(0.01)**	(0.05)**	(0.05)**				

Source: BOT, NESDB and Consensus Forecasts. Calculations by authors.
Note: $R_{i,t}$ is the dependent variable, with S.E. in parentheses; * significant at 5%, ** significant at 1%
Each observation represents credit-to-GDP and lending-deposit spread from bank i to sector j in period t. Other coefficients' estimates, such as those of banks' covariates and forecasts of global growth, are not shown.

If the 2011-2013 boom was driven by greater bank competition as described by the model, there should be an equilibrium switch from a joint pooling with credit rationing, to credit-boom equilibrium. The switch would involve an upward jump in loans and lower interest rate, since there would be a sharp downward shift of the loan supply function. Thus, empirically the estimate for β_2 should undergo a structural break, indicating a shift of loan supply rather than reflecting the slope of a stable supply curve.

The regression results in Table 4 support the hypothesis that banks have taken on more risks since 2011, leading to a credit boom as described by the theory.[9] Over 2008-2009 in the immediate aftermath of the global financial crisis, β_2 shows no discernable slope. A fall in loan supply amid heightened risk aversion, coinciding with a decrease in loan demand, could have led to little sensitivity of spreads to changes in credits. During 2010, however, the estimates for β_2 are positive and significant, suggesting that there may be a stable upward-sloping loan supply curve during the period. The slope then becomes insignificant in 2011, before turning significantly negative in 2012 and 2013, at the same time when the credit cycle was reaching its peak. The negative coefficient suggests that the loan supply schedule may have shifted to the right over the period, corresponding to the switching of equilibrium to credit boom.

7   Conclusion

This paper offers a theory of credit booms based on the idea that bank competition increases the screening cost. Despite its simplicity, the model offers several insights into the nature of financial stability risks and role of preventive policy. In particular, because banks' strategic interactions involve a coordination failure problem, the resulting credit-boom equilibrium can be persistent. For the same reason, small adjustments in monetary policy may have relatively little effects in preventing a credit boom. Policy instrument that does not on marginal incentives, such as macroprudential policy, could play a useful role in this case (a similar argument is made in Nakornthab and Rungcharoenkitkul (2010), in a model with highly nonlinear risk taking). The theoretical result also argues in favour of promoting a level playing field in the regulatory policy. It can take only a small number of banks to incur greater risks, for the entire system to be shifted to a high-risk equilibrium.

Since the model makes minimal institutional assumptions, it can be readily applied to understand risk-taking behaviour in financial markets more generally. For example, the US high-risk private debt market underwent a period of excessive exuberance in the run up to the global financial crisis, not dissimilar to banking credit booms. In this instance, 'banks' could include international investors who chase after risky assets in the presence of low interest rates, and low availability of risk-free assets.

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[9]The Hansen J test statistics confirms the valid degree of overidentification with the null hypothesis that the lagged levels and lagged first differences are sound instrumental variables. Correlation between the first difference of the current and the first lagged period error terms is significant (AR(1)). The null hypothesis of overall insignificance is strongly rejected by the Wald test for every period.

A natural extension is to take the model to a general equilibrium macroeconomic setting. Doing so would enable an optimal policy assessment in the presence of a trade-off between macroeconomic and financial stability. The main point of adding the banking model here is not to create a propagation mechanism, however. Low interest rate raises financial fragilities, which is negative for growth. The policy maker can recognize these implications by incorporating subsequent realization of output losses into its objective, or penalizes ex ante financial stability risks as proposed in Section 5.4.

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