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PRE-CRISIS CREDIT STANDARDS: MONETARY POLICY OR

THE SAVINGS GLUT?

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ABSTRACT: This paper presents a theoretical model of how banks set their credit standards. It examines how a monopoly bank sets its monitoring intensity in order to manage credit risk when it makes long duration loans to borrowers who have private knowledge of their project's stochastic profitability. In contrast to standard models, it has a recursive structure and a general equilibrium. The bank loan contract considered specifies the interest rate, the monitoring intensity and a profitability covenant. Within this class of contract, the bank chooses the terms which maximise steady-state profits subject to the constraint that it must have as many deposits as loans. The model is then used to consider whether the reduction in credit standards and credit spreads observed before the financial crisis could have been caused by low official interest rates or a positive deposit shock. The model rejects a risk-taking channel of monetary policy and endorses the savings glut hypothesis.

KEYWORDS: credit standards, credit risk, monitoring, risk-taking channel, savings glut.

JEL CLASS.: G21

RÉSUMÉ: Cet article propose un modèle théorétique expliquant comment les banques fixent leurs normes de crédit. Il explore comment une banque en monopole choisit l'intensité de surveillance afin de gérer le risque de crédit quand elle fait des prêts de longue durée à des emprunteurs qui ont connaissance privé de la rentabilité stochastique de leurs projets. Contrairement à l'existant, le modèle possède une structure récursive et un équilibre général. Le contrat de prêt bancaire considéré définit le taux d'intérêt, l'intensité de surveillance et le niveau de rentabilité minimum. Dans cette classe de contrat, la banque choisit les termes qui maximisent les profits à l'état d'équilibre sous la contrainte d'un nombre égal de dépôts et de prêts. Le modèle est ensuite utilisé pour déterminer si la réduction des normes de crédit et des spreads de crédit observée avant la crise financière a été causée par la faiblesse des taux d'intérêts officiels ou par un choc positif sur les dépôts. Le modèle confirme l'hypothèse de la surabondance de l'épargne et rejette un canal de "risk-taking" de la politique monétaire.

MOTS-CLÉS: normes de crédit, risque de crédit, surveillance, canal de "risk-taking", surabondance de l'épargne.

CLASSIFICATION JEL: G21

NON TECHNICAL SUMMARY

The global financial crisis which began in the summer of 2007 and intensified in 2008 triggered the deepest economic downturn since the Great Depression. Why did it happen? There is, of course, no single or simple answer. But a crucial element was that in the years leading up to the crisis, major western banks were lending on easier terms to less creditworthy borrowers so their balance sheets were more vulnerable when the crisis struck. This was exemplified by the rise in sub-prime mortgages in the United States but was also evident in the residential real estate booms in Spain and Ireland and in the corporate sector.

There are two schools of thought about why this happened with different implications for the conduct of monetary policy and macroprudential policies. According to some, banks took more risk at lower spreads because of low official interest rates, a so-called risk-taking channel of monetary policy. According to others, it was not monetary policy but an increase in the supply of global savings. The increased demand for foreign exchange reserves, particularly in Asia, created a global savings glut. Central banks bought government bonds from private investors who then needed alternative uses for their funds.

To compare these hypotheses on a consistent basis, the paper builds a model of credit risk management. The model comprises a single (and thus monopoly) bank which intermediates funds between depositors and borrowers. Everybody in the economy has one unit of capital but to run a project, an individual requires two units. Those who do not have a worthwhile project at the market clearing interest rate are thus the depositors and those running projects are the borrowers. For the bank to have as many deposits as loans, half the population must be depositors and half borrowers. Projects can potentially last forever but are subject to persistent random shocks. This implies that there is some predictability in the path of future profits.

If there were no frictions to enter or exit from projects, then always the currently most profitable half of the possible projects would be in operation and this would be the safest possible portfolio of loans for the bank without it having to do anything. Instead, in this model it is assumed that it is costly to start up a project and costly to exit. When it is costly to exit and there is some possibility that a project will regain profitability, then a borrower will not quit immediately at the first loss but will gamble for resurrection, at least to a certain point. Likewise, with entry costs, marginally profitable projects are not worth starting. As a consequence of both costs, the threshold level of profitability to enter is above the threshold to exit and the distribution of projects which results from the private choices of actual and potential borrowers is no longer the most profitable possible.

If the profits, losses and switching costs were all absorbed by the borrowers, then the bank would have no interest in the distribution of profitability across projects because there would be no credit risk. Credit risk features in this model because one of the ways in which borrowers can exit is through bankruptcy. Borrowers will have an option to pay a bankruptcy cost and be excused of all current period payments, including bank interest. Moreover, it is assumed that if the bank has to liquidate the project, it is less efficient in doing so. The inefficiency assumption is important because it ensures that the value of the bankruptcy option to the borrower is less than the cost to the bank.

The borrowers who are in the gambling for resurrection region are the ones most likely to declare bankruptcy in subsequent periods and impose credit losses on the bank. The bank, therefore, has an interest in trying to influence the exit decision. One way it can do this is set an exit threshold of its own, through a covenant in the loan contract. If profitability falls below this covenant threshold, then the bank has the right to demand repayment. This would be highly effective if the bank was fully informed about the profitability of every loan in every period since it could costlessly enforce its covenant threshold. In the model it is assumed that is costly to monitor loans, although the bank will have a perfectly accurate signal of the profitability if it does. The frequency with which the bank monitors its portfolio is one of the key decision variables in the model.

To understand the central trade-off in the model, it is useful to focus on the project continuation decision. If the bank never monitors, the borrower alone chooses to continue or exit. If the bank always monitors, then the bank has the continuation or exit choice. The stochastic monitoring rate splits control over the continuation decision between the two parties. But the expected utility of the borrower is reduced, the greater the degree of control held by the bank and this influences the loan interest rate that the borrowers are willing to pay. The higher the monitoring rate (or the covenant threshold), the lower the equilibrium loan interest rate. So the central trade-off is that the more the bank monitors, the lower the credit risk but the lower the interest rate it can charge. A key feature of the solution of the model is that reducing credit risk dominates the loss of interest at low monitoring rates but reverses at high monitoring rates, implying that there is an intermediate value at which profit is maximized. The bank chooses the monitoring rate and loan interest rate that maximises its profits subject to the constraint that it must have the same value of deposits as loans.

The model is then used to consider whether a positive shock to deposits or a reduction in the deposit rate (a proxy for looser monetary policy) can explain a reduction in the monitoring rate and a reduction in the loan spread as observed in the years leading up to the crisis. This exercise shows that the savings glut can replicate these results but a monetary policy shock cannot.
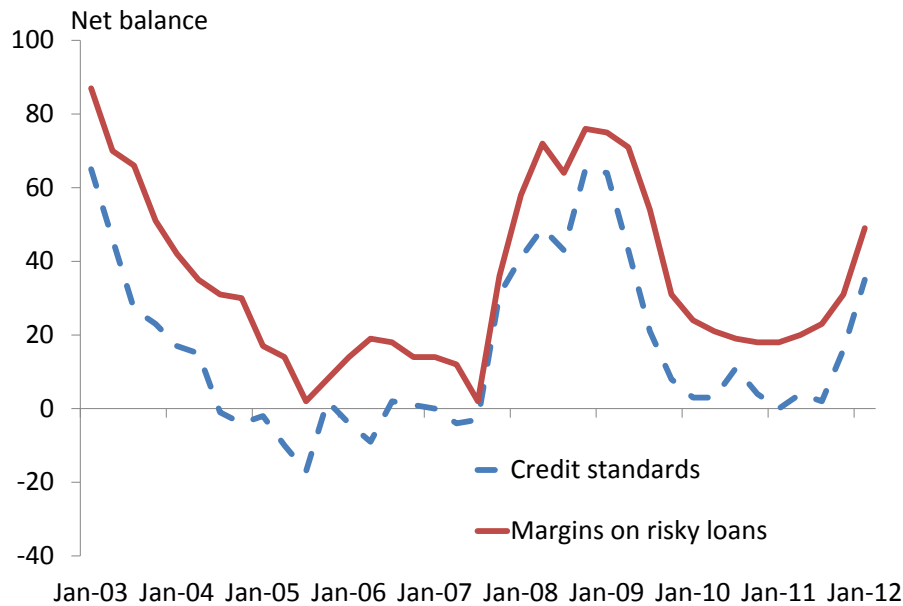
FIGURE 1. Bank Credit Standards and Credit Spreads

Note: Net balance of respondents reporting a tightening or loosening of credit standards and widening or narrowing of credit spreads on risky loans from the Bank Lending Survey of the European Central Bank.

1. INTRODUCTION

In the years preceding the financial crisis of 2007/2008, banks significantly relaxed their credit standards and, as a consequence, had loan portfolios of weaker credit quality when the crisis struck. Survey measures of credit standards fell in both the United States and the Euro-area from around 2003 and remained low right up until the crisis began. At the same time, however, margins on risky loans were falling. Banks were taking greater risk for less compensation.(Figure 1)[1]

There are two competing hypotheses for why this occurred. One hypothesis argues that banks took greater risks for less return because official interest rates were low. (The ECB target rate was set at 2% from June 2003 to December 2005 and the Federal Funds rate was at or below 2% from November 2001 to November 2004.) This 'risk-taking channel' of monetary policy (Borio and Zhu (2012), Gambacorta (2009)) operates through a number of inter-related effects. Lower risk-free interest rates boost asset prices and loan collateral values, thereby reducing expected loss given default. Stronger balance sheets and higher equity valuations also increase the estimated distance to default in credit risk models such as (Merton, 1974) and thereby reduce model-implied loan price volatility. Since models with these features, such as the Value-at-Risk framework, are commonly

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[1] The Senior Loan Officer Survey of the Federal Reserve Board exhibits a similar pattern.

used by rating agencies and regulators as a means to assess credit risk, credit ratings are upgraded and regulatory capital constraints are relaxed. So bank loans with less credit protections or to higher risk borrowers look better from a mean-variance perspective under low official interest rates. This type of channel is amplified if some investors have nominal return targets and are buying risky assets (and boosting their prices) in a 'search for yield' (Rajan (2005)).

An alternative hypothesis argues that banks took more risk for less return because of a relative increase in *ex ante* savings. The 'savings glut' hypothesis contends that the supply of funds to the western financial system increased strongly during the early 2000s, particularly from emerging market economies (Bernanke (2005), Bernanke (2010) and King (2010)). (World foreign exchange reserves tripled in US dollar terms in just six years between 2001 and 2007 (according to IMF International Statistics)). Emerging market central banks bought government bonds from private investors who then needed alternative uses for their funds. Private savings were also strong in Japan and Germany at that time. This set up a 'search for the marginal borrower' by western banks. Other emerging markets were reluctant to borrow given their recent experience of crises. Instead, willing borrowers were found in real estate markets, particularly those who had previously been denied credit because of high default risk. With lower borrowing rates and rising asset prices, these look like better credit risk than previously.

These hypotheses have quite similar mechanisms but very different policy implications. The first implies that expansionary monetary policy comes at the risk of greater financial sector vulnerability and central banks with inflation, output and financial stability objectives face a trade-off in their conduct of monetary policy. If monetary policy and financial stability policies are operated separately, then there is a risk of operating at cross-purposes. At a minimum, central banks would have to scale back their expectations of their ability to deliver stable inflation if this hypothesis is true.

If the second hypothesis is true, then monetary policy and financial stability policy are more independent and can have separate targets. Financial stability policy, however, should be concerned about cross-border capital flows. For example, there might be an argument for using capital restrictions in the interest of financial stability.

The issue for identifying the primitive source of the shock empirically is that reserves were growing at the same time as official interest rates were low. Indeed, it is plausible that monetary policy was counteracting the disinflationary effects of the global savings shock. So empirical work such as Jimenez, Ongena, Peydro, and Saurina (2009), which finds significant statistical support for the risk-taking channel of monetary policy, cannot distinguish between original and proximate causes. As noted by Merrouche and Nier

(2014), it is impossible to assess the effect of monetary policy on risk taking without a counterfactual path for monetary policy.

In this paper, I develop a theoretical model of bank credit risk management in a general equilibrium setting. There is a monopoly bank intermediating capital between heterogeneous agents. At any point in time, some of the agents are running projects subject to persistent stochastic shocks which are privately observable. These "entrepreneurs" decide every period whether to continue with their projects or exit. The remaining agents, "inventors" are searching for projects which are sufficiently profitable to enter. All agents have one unit of capital but projects require two units so the inventors are the depositors and the entrepreneurs are the borrowers. With a single bank, market clearing for capital is equivalent to the bank having the same measure of depositors as borrowers. Four crucial assumptions create the incentive for the bank to actively manage the composition of its balance sheet.

The first assumption is that borrowers are protected by limited liability. This caps downside risk to the entrepreneurs and creates default risk for the bank. (Limited liability is not an option the bank would voluntarily offer but is imposed exogenously.)

The second assumption is that the bank is inefficient in liquidating projects if entrepreneurs declare bankruptcy. This drives a wedge between the value of the bankruptcy option to the borrower and the cost of the option to the bank.

The third assumption is that there are entry and exit costs (as in Dixit and Pindyck (1994)). Without these switching frictions, competition for capital would ensure that only the most profitable projects would be in operation. This would also be the lowest credit risk distribution so there would be no need for the bank to act. With switching frictions, the entry threshold is above the exit thresholds. Naturally, projects at the lower end of the distribution are the ones with the highest subsequent default probability. These three assumptions ensure that the bank has an interest in the profitability distribution and thus the turnover rate of projects.

The fourth assumption is that it is costly for the bank to observe the profitability state of individual projects. With costly monitoring, the bank will generally choose to be less than fully informed about the state of its loan portfolio and will unknowingly roll over some loans that it would not if it knew the true state.

It is the interaction between these four assumptions that motivates the bank to manage credit risk. Without monitoring, borrowers will make individually rational continuation choices which expose the bank to under-compensated credit losses. Exit costs and limited liability give borrowers an incentive to gamble for resurrection. But the cost to the bank of a failed gamble by the borrower is greater than the value of bankruptcy to the borrower.

A higher monitoring frequency can reduce credit risk but the loan contract is less valuable to the borrower and thus commands a lower loan interest rate in equilibrium. At the core of the model, therefore, is a trade-off between credit risk, the loan interest margin and monitoring costs. Equilibrium in the model is a loan interest rate, a monitoring intensity and a profitability distribution where the equilibrium choice is constrained by the need to have the same measure of depositors as borrowers.

This equilibrium can then be shocked to consider the effect on monitoring intensity (credit standards) and loan interest rates of the savings glut (an external deposit supply shock) or a cut in monetary policy (through a lower deposit rate). The savings glut shock delivers lower monitoring intensity and low credit spreads. The monetary policy shock does not.

This model itself has a number of novel features relative to the existing microeconomics of banking literature. The first is that the model focuses on credit policies which operate *during* an ongoing credit relationship. The standard literature considers either *ex ante* credit screening (for example Broecker (1990), Ruckes (2004), and Dell'Ariccia, Marquez, and Laeven (2010), *ex post* auditing (such as Diamond (1984), Gale and Hellwig (1985) and Williamson (1986) or monitoring to prevent resource diversion (Holmstrom and Tirole (1997)).[2] A common feature of these models is that the borrower and lender only make one decision with respect to one exogenous shock, with the difference being the order in which the decisions are taken. In this model, credit risk management takes place in a recursive setting with repeated rounds of actions and shocks. Credit standards, in this case the monitoring frequency and a covenant threshold, specify the actions the bank can take. The optimal policies for the bank take into account the dynamically optimizing behavior of the agents given the bank's actions.

A second feature of the model is that it integrates a bank into a firm dynamics framework (based on Hopenhayn (1992)). This is a very natural setting within which to analyse continuation choices. Taking a firm life-cycle approach makes clear that what matters for credit losses is the manner and circumstances in which firms depart. This is important when one considers that the majority of firms exit in an orderly way and only a minority of firms (or households) end lending arrangements through default. Thus what is important is not that firms experience adverse shocks but why they choose one exit method over another. Using a firm dynamics framework also helps understand how credit policies shape the endogenous distribution of firms. Since in the model, all firms have loans of the same size, the distribution of firms in the economy maps directly into the shape and size of the distribution of loans on the bank's balance sheet. So the policies the bank uses to influence its balance sheet affect the distribution of firms.

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[2] Acharya and Naqvi (2012) contains screening of borrowers and auditing of bankers.

A third feature of the model is that it is set in general rather than partial equilibrium. All the agents in the economy interact with the bank, either as depositors or borrowers. To achieve balance sheet equilibrium, the bank must offer a contract which induces half the agents to choose to be on each side. Thus loan contract terms affect the supply of savings as well as the demand for loans. If one believes that credit standards are a macroeconomic phenomenon, then one ought to examine them in an aggregate setting.

The bank in this model will be choosing parameter values for a particular contract form. The loan contract specifies a loan interest rate, a monitoring intensity rate and a minimum profitability threshold (or covenant). The bank has the option to monitor the loan after the borrower has made a continuation decision. If the bank monitors and finds the profitability of the loan is below the minimum threshold, then it has the right to demand immediate repayment of the loan. If the loan is not monitored or is monitored and is above the threshold, then the loan continues. All borrowers are offered the same contract and the contract terms do not vary over time. This is not, therefore, an optimal contracting approach. Much more sophisticated dynamic contracts could be envisaged using time and message-contingent payments and monitoring (along the lines of Monnet and Quintin (2005)). [3] Such contracts would be tremendously complicated and involve features such as repeated debt forgiveness that are never observed in reality. Moreover, Boyd and Smith (1994) show that the theoretical gains from using optimal contracts relative to simpler standard debt contracts are extremely small and could easily be wiped out by implementation costs. The spirit of the model presented here is that banks make decisions with only partial information and use only blunt instruments because circumstances change faster than contracts do (or can).

The remainder of the paper is organized into four sections as follows. Section 2 sets out the assumptions and Section 3 solves for the optimal behavior of individual agents for any given contract terms. To assist in understanding the subsequent choice of the bank, an illustrative numerical example is presented. Section 4 explains equilibrium bank behavior and the profit-maximising choice of credit standards and loan interest rate. Section 5 discusses the equilibrium properties of the model and Section 6 uses the model to consider whether the global savings glut or the risk-taking channel of monetary policy are possible culprits for explaining the loosening of credit standards in the lead up to the crisis. The results show that in this model only the savings glut hypothesis is consistent with lower credit standards and falling credit spreads. Section 7 concludes.

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[3] For example, dynamic contracts have been used to consider how credit constraints affect the size and growth rates of firms (Clementi and Hopenhayn (2006) and Albuquerque and Hopenhayn (2004)).

2. MODEL

2.1. **Space.** The model takes place in an economy comprising a measure 1 of infinitely small, *ex ante* identical and infinitely living risk-neutral agents and a bank. Time is discrete and future payoffs are discounted at rate β. In each period every agent chooses whether or not to run a "project" (or "firm"). Existing or potential projects are agent specific and are indexed by an idiosyncratic "profitability" state, a, which can be thought of as including technical productivity, consumer preferences, degree of market power and managerial talent. a is drawn stochastically every period from the compact set $\{A \in \mathbb{R} : 0 \le a \le 1\}$ and completely defines the circumstances of each agent (and thus *ex post* heterogeneity). Profitability levels are private information and can only be verified by the bank by paying a monitoring cost m per loan. All agents are endowed with a unit of capital which they cannot add to or lose. The purpose of this assumption will be explained once more of the structure of the model is in place.

2.2. **Agents and production.** At any point in time the agents in this economy are partitioned endogenously into two situations.

One group of agents is considering whether to enter production. During each period these "inventors" receive an "idea" for a project with a profitability state drawn from the continuous i.i.d distribution $G(a)$.[4] Inventors weigh up paying start-up costs S to enter production next period based on this profitability draw or waiting for a better idea in the future.[5] Inventors are of measure I (which in equilibrium will equal a $\frac{1}{2}$) and while they wait, they deposit their capital at the bank on which they receive an exogenously fixed deposit rate, r_d.

The other group of agents is currently in production for which they will have borrowed capital from the bank at an *endogenously* determined loan interest rate, r. These agents are called "entrepreneurs" and their per period payoffs ("profits" and "losses"), $q(a) - r$, are a function of their idiosyncratic profitability states and the loan interest rate. These profitability states evolve according to a first-order Markov process $F(a', a)$. The following assumptions on the transition process and profit function are made:

A: (i) $F(a', a)$ is continuous in a and a'; (ii) Profitability shocks are persistent and so $F(a', a)$ is strictly decreasing in a. (iii) But profitability shocks eventually die out and the monotone mixing condition is satisfied: $F^n(\epsilon, a) > 0 \; \forall \epsilon$ for some n where $F^n(\epsilon, a)$ is the conditional probability distribution of profitability in n periods time

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[4] This is similar to the way wage offers are received in labour search models such as McCall (1970).

[5] Start up costs are large in many countries. In Djankov, Porta, Lopez-De-Silanes, and Shleifer (2002) just the official costs of entry range from 0.5% of per capita GDP in the US to 460% of per capita GDP in the Dominican Republic.

given a. So from any given level of profitability, it is possible to transit to any other profitability level in a finite number of periods. Since there are exit thresholds, this assumption implies that all projects will almost surely close at some future point.

B: (i) $q(a)$ is continuous and; (ii) strictly increasing in a.

In each period, entrepreneurs decide whether to continue in production next period or to exit. If they do not wish to continue, there are two exit options.

- "Orderly" exit occurs if the entrepreneur absorbs current period payoffs - naturally losses - and pays a liquidation cost L to close the project. These liquidation costs might be pecuniary such as termination pay, liquidating stock at below cost and administrative costs or non-pecuniary such as lost human capital and reputation.[6]

- "Default" occurs if the entrepreneur pays an exogenous cost B to file for bankruptcy protection in which case current period losses are excused (including repayment of loan interest). If the entrepreneur defaults, the bank has to pay the liquidation costs instead. (For notational convenience it is assumed that S, L and B are paid in the following period.)

These options for the entrepreneur will partition the set A into three regions - continuation, orderly exit and default - delineated by threshold values a_X and a_δ (exit and default, respectively) and the value of B is calibrated for the sensible ordering $a_X > a_\delta$. If the model had a continuous time shock process, then agents experiencing negative profitability shocks would always enter the voluntary exit region first and default would never arise. In discrete time, there is default because some projects jump over the orderly exit region $[a_\delta, a_X]$ (which could be considered as a proxy for discontinuous shocks). By assumption A(iii), project profitability will almost surely pass below one of these thresholds and the project is terminated on the first occasion. When entrepreneurs exit, they become inventors again so the value of an entrepreneur's outside option is the expected value of being an inventor. Defaulting entrepreneurs are indistinguishable from other inventors.[7]

To keep the model as simple as possible and to focus on the main mechanism of interest, all decisions take place at the extensive margin. Aggregate variables, which are used for market clearing, are thus the sums over measures of agents entering, exiting or continuing. Likewise, expectations of payoffs are simple integrals over profitability states only. It was to turn off the intensive margin that agents were assumed to be unable to

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[6] Ramey and Shapiro (2001) describe the heavy discounts on machinery sold during the closure of aircraft manufacturing plants.

[7] It is just convenient to recycle defaulters in this way. Nothing of any substance would change by assuming defaulters are excluded forever but new inventors are born at the same steady-state rate.

change their capital holdings.[8] Relatedly, it will be assumed that projects require 2 units of capital. Entrepreneurs do not borrow directly from inventors (perhaps for the reasons described by Diamond (1984)) and must get a loan of 1 unit from the bank.[9] These simplifications ensure that the only decisions that agents are making are how to allocate their units of capital between bank deposits and production, that borrowing and lending take place and that the loan size remains fixed over the lifetime of the project. More technically, it means that the only endogenous distribution involved in the model is the measure of entrepreneurs over the set of profitability states.

Finally, since this is a model based on incentives, it will be (implicitly) assumed that all agents have an exogenous endowment of income every period regardless of their circumstances sufficient to cover any expenses or losses. This simply rules out having to consider situations in which agents want to pay but cannot. Decisions are determined by the profitability state alone.

2.3. **Banking.** Capital in this model is intermediated between inventors and entrepreneurs by a monopoly bank. As a consequence of the assumption of infinitely small agents and the law of large numbers, *ex ante* probability distributions over the bank's loan portfolio are identical to the distribution of *ex post* outcomes. Since this is a model of purely idiosyncratic risk, the distributions faced by the bank are deterministic.

The bank offers the following deposit and loan contracts:

- Deposits earn an interest rate r_d set exogenously by the monetary authority. Deposits can be withdrawn at the end of any period.
- The loan contract specifies an interest rate r, a monitoring intensity φ (where $0 \leq \varphi \leq 1$) and a covenant specifying a minimum profitability level ξ. For notational simplicity, the parameters of the bank contract are summarised by $\psi = \{r, \varphi, \xi\}$. The loan is nominally indefinite but both parties have an option to terminate it each period. The borrower has the option to repay the loan if she decides to exit production. And the bank can demand repayment if it discovers that the covenant condition has been breached. The covenant condition, ξ, will correspond to a threshold value, $\xi = q(a_T) - r$, at which the bank exercises its right to terminate the loan. Since the bank uses the covenant to protect its interests, it follows that ξ must imply a trigger value of a at least as high as that at which entrepreneurs voluntarily exit or else the covenant would be redundant.

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[8] For a similar model with entrepreneurial wealth accumulation which is used to explain firm size dynamics, see Arellano, Bai, and Zhang (2012).

[9] This implied leverage ratio could be set to any constant without loss of generality with an appropriate adjustment to the market clearing condition.

3. Equilibrium behaviour of the agents

This is a recursive model and in each period the move order is the following:

(1) Agents enter the period in their previously chosen situation (inventor or entrepreneur) and then draw their idiosyncratic shocks. The inventors get a new idea from $G(a)$ and entrepreneurs get an update of their profitability according to $F(a', a)$.

(2) Entrepreneurs decide whether to continue with production next period or to exit either voluntarily or by defaulting. Payoffs are received and loan interest paid by non-defaulting entrepreneurs. Entrepreneurs who exit voluntarily inform the bank that they will repay their loan. Inventors receive deposit interest and decide whether to enter production next period based on their profitability draw.

(3) The bank monitors continuing loans at the stochastic rate φ and recalls the loans of all entrepreneurs found below the covenant profitability threshold state a_T.

(4) The bank receives deposits from waiting and new inventors and makes additional loans to entering producers.

The following two sections formalise the analysis of the choices of the productive and inventors.

3.1. Entrepreneurs.

Depending on the idiosyncratic profitability state, a, an entrepreneur chooses between default, orderly exit and continuation. If she decides to default to escape $q(a) - r$, she pays B next period and switches to being an inventor. The discounted value of defaulting is thus

$$V_B = \beta\{E\left[V_I(a';.)\right] - B\} \tag{1}$$

where the value function of an inventor is denoted $V_I(a; V_E)$ and $E\left[V_I(a';.)\right] = \int_A V_I(a';.)G(da')$.

If she chooses orderly exit from production, she absorbs current losses, pays liquidation costs L next period and also enters next period as an inventor. The value of orderly exit in state a is

$$V_X(a) = q(a) - r + \beta\{E\left[V_I(a';.)\right] - L\} \tag{2}$$

The remaining option is to continue in production next period. Naturally the conditional value of continuing in production is to receive current payoffs and the discounted expected value of being an entrepreneur in the next period.

$$V_C(a) = q(a) - r + \beta\{E\left[V_E(a'; \psi, V_I) \mid a\right]\} \tag{3}$$

where the value function of an entrepreneur is denoted $V_E(a; \psi, V_I)$.

Given the options available, the value of being an entrepreneur at the moment the shock is revealed is:

$$V_E(a; \psi, V_I) = \max\{V_B, V_X(a), V_C(a)\} \tag{4}$$

There is a natural ordering of the choices facing an entrepreneur. Bankruptcy costs will be assumed to be sufficiently large that entrepreneurs only choose this form of exit when facing a very bad profitability state. So the default threshold will be determined by a comparison of the value of default and the value of orderly exit. It is straightforward to see from equations (1) and (2) that entrepreneurs will default for all values of $a < a_\delta$ where

$$q(a_\delta) = \beta(L - B) + r \tag{5}$$

The threshold for orderly exit, a_X, results from the comparison of $V_X(a)$ and $V_C(a)$. The only challenging aspect of this problem is the conditional expected value of being an entrepreneur next period at the time the decision is made: $E\left[V_E(a';.) \mid a\right]$. Consider first an entrepreneur with profitability above the loan covenant threshold, $a \geq a_T$. In this case the entrepreneur faces no risk if the bank chooses to monitor, so she can ignore the monitoring probability of the bank and

$$E\left[V_E(a';.) \mid a \geq a_T\right] = \int_A V_E(a\prime;.)F(da',a)$$

The calculation is more complex for an entrepreneur with $a_\delta < a < a_T$. In this case, if the entrepreneur decides to continue and escapes monitoring (with probability $1 - \varphi$) then the entrepreneur gets the conditional expected value of being an entrepreneur in the next period. If the entrepreneur tries to continue but is monitored then the loan is recalled by the bank, the project is shut down and the agent involuntarily reverts to being an inventor. Therefore for $a_\delta \leq a < a_T$

$$E\left[V_E(a';.) \mid a_\delta \leq a < a_T\right] = (1 - \varphi)\int_A V_E(a\prime;.)F(da',a) + \varphi\left(\int_A V_I(a';.)G(da') - L\right)$$

The voluntary exit threshold a_X is the value of current period profitability at which an entrepreneur is indifferent between continuing or exiting voluntarily.[10] Some simple cancelling defines the voluntary exit threshold as:

$$\int_A V_E(a\prime;.)F(da\prime,a_X) = \int_A V_I(a';.)G(da') - L \tag{6}$$

3.2. **Inventors.** We turn now to the decision by inventors whether or not to enter production. Unlike in Hopenhayn (1992), inventors are assumed to draw a profitability level *before* they decide whether or not to enter although they cannot begin production until the *following* period. Each period, an inventor gets one idea with a profitability level drawn from $G(a)$. The agent can either decide to pay the cost of starting up a project, S, and enter production next period or keep his capital on deposit at rate r_d for another period.

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[10] Since the bank only monitors continuing loans, these are always above the default threshold and so any agent forced to repay the loan will prefer to exit in an orderly fashion rather than default.

Profitability next period will be subject to an idiosyncratic shock according to the same function F as existing projects. So the expected value of entering production is equal to the expected value of being an existing entrepreneur at the same level of profitability net of S. An inventor this period receives the interest on his deposit for this period and the discounted expected value of the maximum of the choice between entering or remaining as an inventor the following period. The value function for an inventor with an initial draw of a is therefore:

$$V_I(a; V_E) = r_d + \beta \max \left\{ \int_A V_E(a'; ,)F(da\prime, a) - S, \int_A V_I(a'; ,)G(da') \right\} \tag{7}$$

The threshold level of profitability at which inventors will choose to enter is where the expected value of being an entrepreneur at that level of profitability net of start up costs matches the expected value of waiting. a_E is thus determined by:

$$\int_A V_E(a'; ,)F(da\prime, a_E) - S = \int_A V_I(a'; ,)G(da') \tag{8}$$

The right hand side is not contingent on the current state and in equilibrium will be a known constant.

The equilibrium behaviour of entrepreneurs and inventors is described in the following proposition:

PROPOSITION 1– *Given Assumptions A and B and a banking contract ψ, unique, bounded and mutually consistent functions $V_E(a; \psi, V_I)$ and $V_I(a; \psi, V_E)$ exist. These value functions yield unique and continuous functions in ψ for a_E and a_X. $a_E(\psi)$ and $a_X(\psi)$ are strictly increasing in r.*

Proof. See Appendix.   □

Proposition 1 states that there are unique values of the entry and exit thresholds, a_E, a_δ and a_X which, along with the profitability threshold implied by the loan covenant, a_T, completely summarise the equilibrium behaviour of agents for a given loan contract ψ and deposit rate r_d. So from here on we can dispense with the value functions.

3.3. **Steady state.** Define $H([0, a); \psi)$ as the measure of entrepreneurs at the *end* of each period with profitability levels in the interval $[0, a)$ given loan contract ψ. Define $FH(a'; \psi) = \int_A F(a\prime, a)H(da; \psi)$ as the distribution of firms evolving into productivity state a' from the distribution $H(A; \psi)$.

With the behavioural assumptions of the model and recalling that I is the measure of inventors, then the transition function for the distribution of entrepreneurs is:

$$H'([0,a');\psi) = I \int_{a_E}^{a'} G(a) + \int_{a_X}^{a'} FH(da';\psi) - \varphi \int_{a_X}^{\min(a_T,a')} FH(da';\psi) \qquad (9)$$

The first term on the right hand side measures the volume of agents entering at profitability levels below a'. The middle term measures the volume of continuing entrepreneurs evolving into the profitability interval $[a_X, a')$ - ie above the voluntary exit threshold, a_X. The third term eliminates those entrepreneurs in the interval $[a_X, a_T)$ forced to close down because the loan is recalled by the bank. (Defaulting entrepreneurs are implicitly removed by the lower truncation of the distribution at a_X.) An invariant steady state distribution occurs if

$$H'([0,a);\psi) = H([0,a);\psi) = \bar{H}([0,a);\psi) \quad \forall a \in A$$

PROPOSITION 2– *For each ψ there is a unique invariant distribution, $\bar{H}([0,a);\psi) \quad \forall a \in A$.*

3.4. **Illustrative numerical example.** Before turning to the decision of the bank, it is useful to illustrate an example of an invariant distribution derived from the model and decompose the transition equation (9). The parameterisation in Figure 2 is entirely illustrative but was chosen to give roughly sensible credit spreads and entry, exit and default rates.[11] The monitoring intensity, which will be endogenised later, is here assumed to be strictly positive but less than 1.

It is easy to see the influence of the three behavioural thresholds on the distribution. Below a_X, there are no entrepreneurs in the distribution at the end of each period because they have either defaulted or exited voluntarily. Between a_X and a_T we have entrepreneurs that are in breach of the loan covenant but have escaped monitoring. There is a concentration of entrepreneurs just above the entry threshold, a_E.

There is a long right tail to this distribution. These are entrepreneurs who have either entered with a very high initial profitability level or entered and subsequently experienced predominantly positive profitability shocks. Those at the far right are well beyond the initial profitability draws so only exist because of the persistence of shocks and the luck of drawing positive shocks.

Figure 2 also helps draw out the importance of start-up and liquidation costs in driving the results of the model. If we combine equations (6) and (8) which determine the entry and exit thresholds then we obtain

$$\int_A V_E(a\prime,r,V_I)F(da\prime,a_X) = \int_A V_E(a',r,V_I)F(da\prime,a_E) - S - L \qquad (10)$$

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[11] The example uses a normal distribution for $G(a)$ and an AR(1) process for $F(a,a')$ using a Tauchen matrix approximation (see Tauchen (1986)).
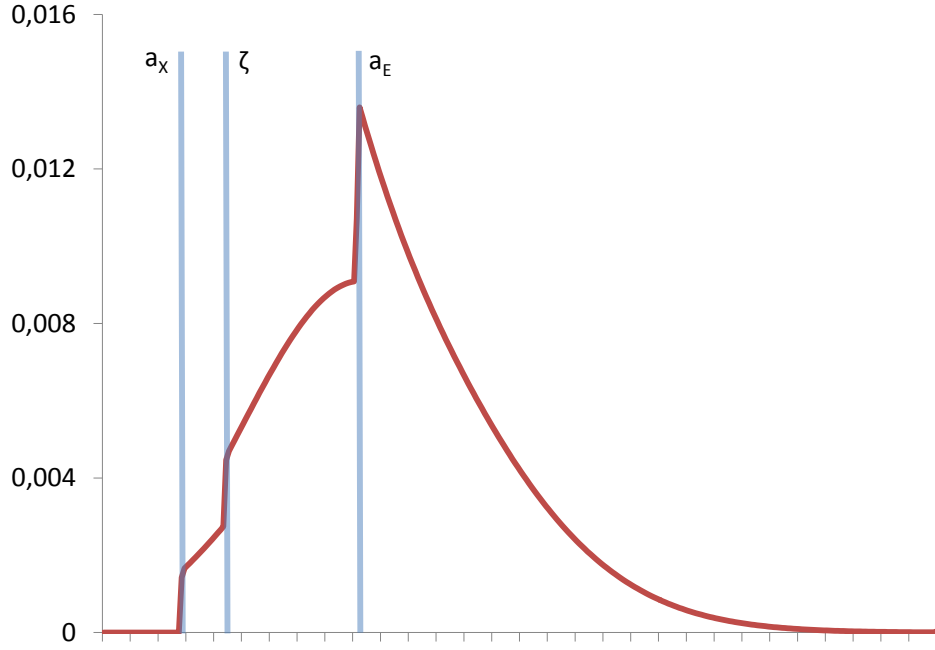
FIGURE 2. Illustrative Invariant Distribution

Note: The figure presents the distribution function across idiosyncratic profitability states a.

from which it can be easily seen that if $S = L = 0$, then $a_E = a_X$. Since a covenant threshold is only relevant in the interval $[a_X, a_E]$, if we have $S = L = 0$ and $a_E = a_X$, then a_T is redundant and so is bank monitoring. In this case, even though there is a positive probability that profitability falls below the default threshold, a_δ, there is no incentive for bank monitoring. This occurs because in the frictionless entry and exit case, borrower behaviour is completely aligned with the interests of the bank. Borrowers only continue in situations in which they would also wish to enter. Frictionless entry and exit always selects the most profitable firms given the profitability processes and thus the lowest possible credit risk. So asymmetry of information has no bite when exit and entry is costless.[12] This ability to rely on borrower behaviour breaks down when there are entry and exit costs because private choice by borrowers no longer selects the lowest credit risk portfolio. By setting a covenant threshold and monitoring stochastically, the bank can alter the distribution of credit risk.

Figure 3 illustrates the one period transition of the distribution in Figure 2 with the invariant distribution overlaid. Looking from right to left, one can see that the upper tail of the distribution is entirely driven by the presence of a small number of existing entrepreneurs experiencing positive shocks. Since on average entrepreneurs with positive profitability experience a reversion towards the mean (of zero), there is a noticeable

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[12] With a single F process and bankruptcy costs, the bank does not need to engage in *ex ante* screening or *ex post* monitoring in this setting.
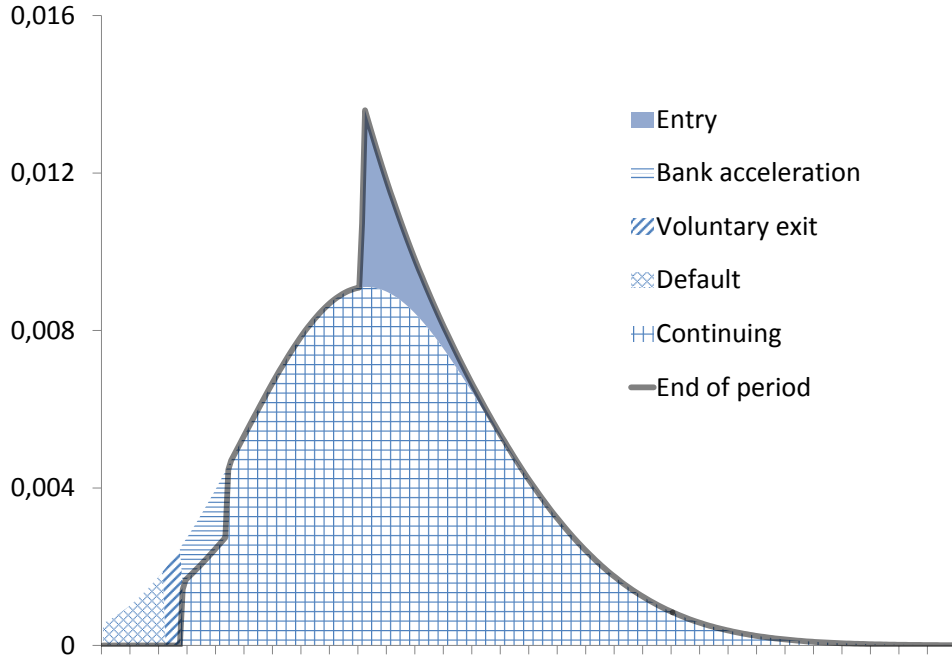
FIGURE 3. One Period Transition of the Invariant Distribution

deterioration in the average quality of continuing entrepreneurs. The distribution is re-freshed by the entry of new entrepreneurs clustered above the entry threshold. Moving further to the left, a number of entrepreneurs fall below the threshold a_T but above a_X. These are the entrepreneurs who want to continue but are in breach of the loan covenant. φ proportion of these entrepreneurs are monitored, have their loans revoked and exit and $1 - \varphi$ are able to continue. Moving further to the left, there are entrepreneurs who fall below a_X but above a_δ and exit voluntarily. Finally, there is a portion of the distribution who falls below a_δ and defaults.

The model structure and Figures 2 and 3 are broadly consistent with the empirical evidence. Studies using US data, for example Bartelsman and Doms (2000), Baily, Bartelsman, and Haltiwanger (2001) and Foster, Haltiwanger, and Krizan (2006), show that there are wide distributions of profitability and productivity within industry classifications and that firm-level shocks are highly persistent. Farinas and Ruano (2005) use Spanish manufacturing data and show that the productivity distribution of exiting firms is stochastically dominated by the distribution of continuing firms and that the productivity of entering firms is stochastically dominated by continuing firms.

4. EQUILIBRIUM BANK BEHAVIOUR

We can now turn to the bank's choices of parameters in the loan contract $\psi = \{r, \varphi, \xi\}$. In this framework, the effects of φ and ξ are almost identical. The bank can protect itself against default risk by raising the monitoring rate (equivalent to a cut in the expected duration or maturity of the loan) or tightening the covenant. But it is simpler to present

the equilibrium by fixing the value of one parameter and making the other an endogenous choice variable. In what follows, the covenant value is fixed and the monitoring rate is endogenous but making the alternative choice changes nothing substantive about the results.[13] This leaves pairs of r and φ. Proposition 2 asserted that there is a unique invariant distribution for any loan contract and thus (r, φ) pair. The bank, however, is constrained in its choice of loan contract by the need to finance its loans by deposits.[14] Using the simplifying assumption made earlier that all agents have a fixed unit of capital but projects require 2 units, it follows that there must be as many borrowers as depositors. With measure 1 of agents, the funding constraint faced by banks in equilibrium is:

$$\bar{H}(A; r, \varphi) = \frac{1}{2} \tag{11}$$

Although choosing an optimal (r, φ) pair is a joint decision, for ease of explanation (and proof) it will be assumed that the bank uses the loan rate to equilibrate its balance sheet and then uses the monitoring rate to maximise profits.

PROPOSITION 3– *There is a unique value $\tilde{r}$ that ensures that satisfies the balance sheet constraint, equation* (11), *for given values of φ and ξ.*

This is a very intuitive proposition. If the bank faces an excess demand for loans, then raising the borrowing rate simultaneously reduces the demand for new loans (by increasing a_E), increases the incentive for existing borrowers to repay and exit production voluntarily (an increase in a_X) and effectively tightens the loan covenants (by increasing a_T).[15] These effects work on both sides of the balance sheet by reducing loans and increasing deposits. Uniqueness follows from continuity and monotonicity of the behavioural functions. With r a function of φ, we can denote the subset of invariant balance sheets, $\bar{H}$, which satisfy the balance sheet constraint as $\tilde{H}(A, r(\varphi), \varphi)$.

Crucially, not all invariant distributions that satisfy the balance sheet constraint are equivalent. To illustrate what is at stake, Figure 4 compares the distributions arising from two different pairs of r and φ which satisfy the balance sheet constraint. When the monitoring rate is lower ($\varphi = 0.2$), it is intuitive that there are more projects in the left tail of the distribution because more borrowers are able to continue in breach of the covenant than otherwise. But more lenient contract terms are more favourable for the borrower

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[13] In a companion version of this paper, Penalver (2014) I endogenise both simultaneously and obtain a unique solution.

[14] The level of equity funding is not relevant in this model.

[15] It also increases the default rate by increasing a_δ. Since those going bankrupt are assumed to reappear as depositors in the next period, within the logic of the model, this also reduces the excess demand for loans.
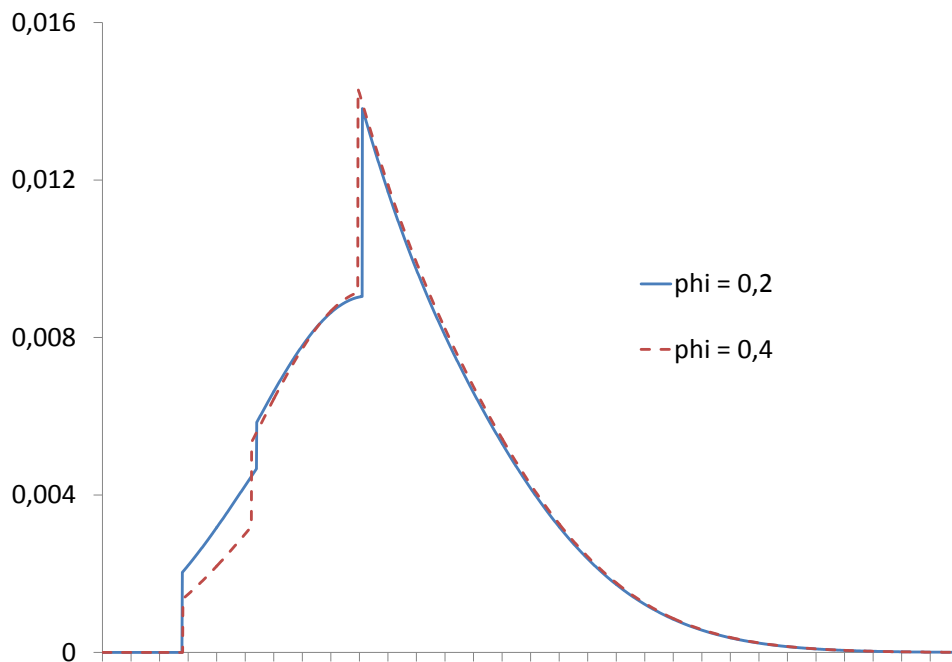
FIGURE 4. Equilibrium Effect of Higher or Lower Monitoring

so satisfying the bank balance sheet constraint requires a higher loan rate, r. The higher loan rate explains the other differences in the distribution. With a higher loan rate, the covenant threshold bites at a higher value of a (a_T is further to the right for $\varphi = 0.2$). A higher loan rate is also a disincentive to enter, so the entry threshold a_E is also higher, with the knock-on effect that there are marginally fewer projects with high profitability. Overall, the invariant profitability distribution for a higher monitoring rate stochastically dominates a distribution with a lower monitoring rate and has a lower default rate. In this sense, a lower monitoring rate results in a loan portfolio of lower "credit quality".

Another way to think about the effect of an increase in φ is to consider how this affects the way entrepreneurs exit. Given the process for $F(a', a)$, entrepreneurs almost surely find themselves in the interval $[a_X, a_T]$ at some point and thus are vulnerable to having their loan recalled by the bank. Since this is above the voluntary threshold, there is a utility loss for entrepreneurs ejected in this way. From the perspective of the individual agent, the recall of the loan results in premature and inefficient liquidation of the project. The parameter φ is thus effectively a distribution of control rights over the decision to exit production - the lower φ is, the higher the control rights allocated to the entrepreneur. Anticipating this, an entrepreneur will be willing to pay more for a loan with a lower monitoring rate because it gives the entrepreneur higher control rights over the exit decision and reduces the risk of premature liquidation. If earnings are volatile, this is potentially a very important consideration for a borrower. An entrepreneur required to reveal her profitability state to the bank every period will not have her loan rolled over and will be forced to pay the liquidation costs as soon as she fails to meet

the covenant condition. A less monitored loan is thus a form of insurance against profit volatility and premature liquidation which an entrepreneur is willing to pay through a higher average interest rate.

Having clarified these issues about the influence of r and φ, we can now state the decision problem of the bank more formally. Again to simplify notation, define $F\tilde{H}(a'; \varphi) = \int_A F(a\prime, a)\tilde{H}(da; r(\varphi), \varphi)$ which is the distribution of firms evolving into state a' from the balance-sheet-consistent invariant distribution at the end of the previous period for a given value of φ. ($F\tilde{H}(a'; \varphi)$ is the distribution depicted in Figure 3.) The bank's objective is to:

$$\max_{\{\varphi\}} \Pi = r(\varphi) \int_{a_\delta}^1 F\tilde{H}(da'; \varphi) - r_d \frac{1}{2} \tag{12}$$
$$- \int_0^{a_\delta} \lambda(a') F\tilde{H}(da'; \varphi) - \varphi m \int_{a_X}^1 F\tilde{H}(da'; \varphi)$$

where m is the per unit cost of monitoring and $\lambda(a)$ is a parameter measuring loss given default which is decreasing in a. Equation (12) measures steady state bank profits. Since the bank is assumed to be sufficiently large that a law of large numbers applies, the variables in this problem are completely deterministic. The first term in equation (12) measures the interest income received on non-defaulting loans. The second term deducts the payment of interest on all deposits. The third term measures expected loss given default. The final term measures the cost of monitoring those entrepreneurs who choose to continue. Since different values of the monitoring intensity imply different invariant distributions, steady state bank profits vary in φ.

Figure 5 illustrates the general case of an interior solution to the model based on a constant per unit cost of monitoring m and loss given default $\lambda(a) = L - 2q(a)$. Discussion of the importance of the latter assumption is deferred to the following section on the general equilibrium properties of the model. The crucial point is that the bank is less efficient than the entrepreneur in running the project until it can be closed down.[16] In this case, credit quality improves as monitoring increases but at a decreasing rate. This decreasing marginal effectiveness of monitoring occurs because as the credit quality of the portfolio improves, there are fewer and fewer loans at risk of jumping to default and so monitoring is influencing a smaller proportion of borrowers. The equilibrium loan interest rate is falling because more highly monitored loans are less attractive to borrowers. And, of course, monitoring is costly. For an interior solution, the reduction in loss given default dominates initially but is eventually outweighed by the reduction in monitoring effectiveness, the higher monitoring costs and the lower equilibrium credit spread.

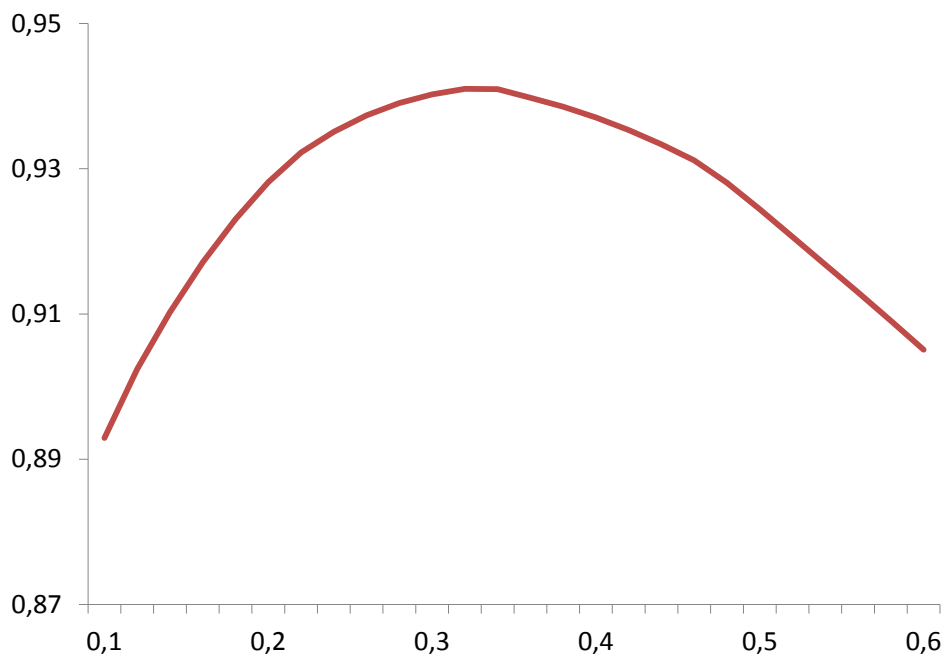[16] $q(a)$ is negative (ie gross losses) whenever default takes places.

FIGURE 5. Equilibrium Profits for Different Choices of Monitoring Intensity

5. GENERAL EQUILIBRIUM PROPERTIES

The previous two sections have described the optimal choices of agents and the decision by the bank. This section analyses the properties of equilibrium, explains the importance of several assumptions in deriving the results and hopefully provides economic intuition about how the various features of the model interact.

The bank makes a profit in this model because there is a positive loan spread. This margin can be divided into three components.

First, there is an intermediation rent received by the bank because of the assumptions that inventors cannot lend directly to entrepreneurs, that the project size is fixed, that there is a monopoly bank and that the deposit rate is exogenously determined.[17] This rent occurs because there is a utility gain in switching from being an inventor to being an entrepreneur because only the marginal entrant is indifferent between the two situations. In order to meet the balance sheet constraint, the bank has to change the relative attractiveness of being a depositor or borrower. With a fixed deposit rate, the bank changes the loan rate to equilibrate the balance sheet and earns the difference. If the rate of return received by lenders was variable because of banking competition or borrowers could lend directly, then this rent would disappear. In reality, of course, deposit rates do vary and

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[17] Standard assumptions like positive and continuously decreasing returns to capital, flexible capital adjustment and direct lending (or perfect banking competition) would together give all borrowers and lenders the same expected utility.

there is competition in banking markets but monetary policy also exerts a powerful influence over what depositors receive. For a bank, borrowing funds from the central bank at around the policy rate is a close substitute for retail deposits. Lending to the central bank (increasing remunerated reserves) is not a close substitute for commercial lending.

Second, borrowers pay for the option to declare bankruptcy. They do not do this explicitly but the fact that downside losses are capped increases the attractiveness of borrowing and must be constrained by a higher loan interest rate (than if bankruptcy were not available). If there was no efficiency loss when the bank liquidates the project - ie if $\lambda(a) = L - q(a)$ - then this bankruptcy option would be equally valued by both parties and the bank would be fairly compensated for the transfer of losses during bankruptcy. If loss given default is fully compensated, then the bank has no incentive to reduce equilibrium default risk in which case, since monitoring is costly and paid for by the bank, it would be optimal to set the monitoring rate to zero. Turning this around, only if bankruptcy is inefficient can there be an incentive to monitor. But inefficiency implies that the cost of the bankruptcy option to the bank is greater than the benefit to the borrower and therefore what the borrower is willing to pay will not compensate the bank for credit risk. This, of course, would seem to imply that risky lending loses money and that a competitive banking market could not fund risky projects.

This explains the importance of the third component of the loan spread which is the insurance borrowers are willing to pay to avoid 'premature' liquidation. To understand this premium, consider the situation in which entry and exit from production is costless ($L = S = 0$). From (10) if $S = L = 0$, then $a_E = a_X$. Firms would simply start up when there is an expected profit for at least one period and shut down again whenever there is an expected loss the following period. Production would be completely opportunistic. But in the model, as in reality, firms cannot jump in and out of production like this. Start-up costs are a barrier to entry and liquidation costs provide an incentive to absorb mild losses if there is sufficient prospect of a future return to profitability. The voluntary exit threshold, a_X, is the point at which the prospect of recovery becomes too low. Exiting above that point entails a utility loss. Yet, as explained in the previous section, if the bank is to protect itself against credit risk with a loan covenant, then this has to bite at above the voluntary exit threshold and a more monitored loan is less attractive to the borrower. Or put another way, the borrower is willing to pay an insurance premium against premature liquidation through a higher interest rate for a lower monitoring rate.

There is an important relationship between this premature liquidation insurance premium and the bankruptcy premium. The insurance premium, *per se,* does not involve any additional risk to the bank. It would exist even if bankruptcy was efficient and credit risk was fully compensated. But the more insurance the bank offers, through a lower monitoring rate, the lower the credit quality of the distribution (recall Figure 4). So the

insurance premium can only be earned by taking on default risk at the same time. It was explained above that if bankruptcy is inefficient, then the bankruptcy premium does not cover the credit risk. So it is the fact that the bank also earns the insurance premium that explains the willingness to offer risky loan contracts.

Joining up the threads of this discussion, monitoring and covenants are only relevant when bankruptcy is inefficient and when there are entry and exit frictions from production. It is the interplay between these two effects that determines equilibrium credit standards.

6. MONETARY POLICY V THE SAVINGS GLUT

It is now time to put the model to work.

Since the start of the financial crisis there has been a lively debate about whether the low credit standards and narrow credit spreads observed in the years before it erupted were in part caused by accommodative monetary policy. On one side are those who charge monetary policy makers with having ignored or misunderstood the effects of a prolonged period of low official interest rates on the willingness of banks to take financial risks (Borio and Zhu (2012), Borio and Disyatat (2011), Taylor (2009), Adrian and Shin (2008), Gambacorta (2009)). The other side, including major monetary policy makers, counter that credit standards deteriorated because of the strong inflows into the western banking system coming from a sharp increase in *ex ante* savings in emerging market countries (Bernanke (2005), Bernanke (2010), King (2010) and Portes (2009)). The two hypotheses are illustrated in Figure 6. The joint effect of each channel is analysed in Merrouche and Nier (2014), albeit with a slightly different measure of financial sector risk, who conclude that global imbalances in conjunction with supervisory policies was the root cause of financial stability with not role for monetary policy.

The model developed in this paper can be used to compare the effect of two shocks on equilibrium credit standards and credit spreads.

- The risk-taking channel is introduced through a reduction in the deposit rate r_d. Monetary policy is assumed to directly affect the funding costs of banks and we look for the endogenous equilibrium responses of the loan interest rate and the monitoring intensity, all other things equal.
- The savings glut hypothesis is introduced as an exogenous supply of deposits from outside the economy. This alters the balance sheet constraint in equation (11). The deposit rate is kept unchanged and again we look for the endogenous equilibrium responses of the loan interest rate and the monitoring intensity.
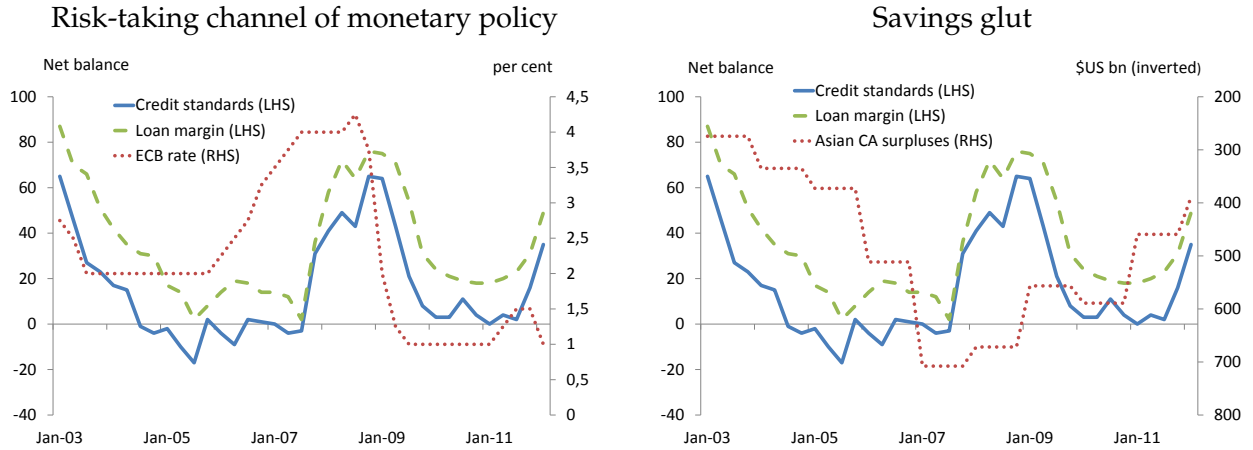
Risk-taking channel of monetary policy

Net balance   per cent

- Credit standards (LHS)
- Loan margin (LHS)
- ECB rate (RHS)

Savings glut

Net balance $US bn (inverted)

- Credit standards (LHS)
- Loan margin (LHS)
- Asian CA surpluses (RHS)

FIGURE 6. Competing Hypotheses of Looser Credit Standards and Lower Credit Spreads

Monitoring Intensity

- Baseline (LHS)
- Deposit shock (RHS)
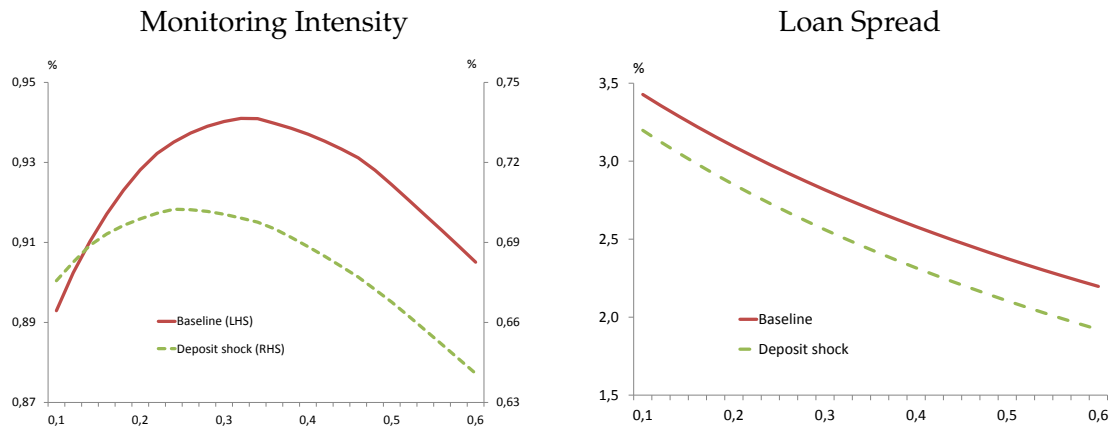
Loan Spread

- Baseline
- Deposit shock

FIGURE 7. Savings Glut Shock

The test of these hypotheses is whether these shocks deliver a reduction in monitoring intensity (or equivalently an extension in loan maturity or a weakening in covenants) and a reduction in the spread between the loan and the deposit rate for a given degree of risk. The equilibria being compared in each case are the associated invariant distributions so the implicit assumption is that these shocks are permanent.[18] It is also being assumed that we are comparing interior solutions of the model. The results presented below are general and not parameter-specific.

Figure 7 illustrates the effect of the deposit shock. The left panel shows different profit levels for each value of the monitoring intensity. The baseline is the same as depicted in Figure 5. The right panel shows the equilibrium loan spread for each value of the

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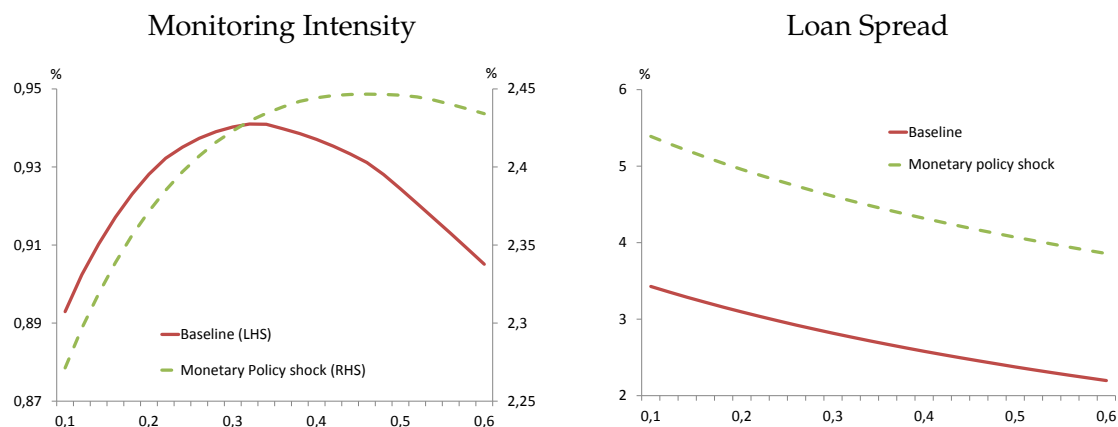[18] Dynamic versions of the model are currently under development.

FIGURE 8. Risk-taking channel

monitoring intensity. The profit-maximising monitoring intensity is clearly to the left of the baseline case and the loan spread is lower for any given monitoring rate.[19]

By contrast, the left hand panel of Figure 8 shows that in contradiction of the hypothesis of a risk-taking channel, the profit-maximising monitoring intensity moves to the right in response to a cut in monetary policy. The right hand panel illustrates that credit spreads are higher too.

To understand the intuition behind these results it is useful to introduce an alternative graphic for how to understand the equilibrium (Figure 9). The credit management line (CM) has a positive relationship between the monitoring rate and the loan interest rate. When interest rates are higher, the default rate is higher so for any given cost of monitoring, the bank will want to monitor more. The balance sheet line (BS) has a negative relationship between the monitoring rate and the loan interest rate. The higher the monitoring rate, the less attractive the loan for a potential borrower and thus the lower interest rate that can be charged to match the volume of borrowers with the volume of depositors. The equilibrium is at the intersection of the two lines.

The monetary policy shock and the savings glut shock shift the BS curve in opposite directions whilst leaving the CM curve unchanged. The CM line is unchanged because neither shock affects the incentive to monitor for a given loan interest rate (the monitoring costs and loss given default rates are not affected). The savings glut shock causes an inward shift in the BS curve. The exogenous inflow of deposits disequilibrates the balance sheet with the bank having to induce more borrowing. To do so, it must offer less onerous credit terms than before. It could do so by offering a much lower loan interest rate for the same monitoring rate. But with a lower loan interest rate, the default

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[19] The profit maximising loan spread might be higher overall because the monitoring intensity is lower. The spread conditional on monitoring intensity gives the best measure of risk-adjusted spreads.
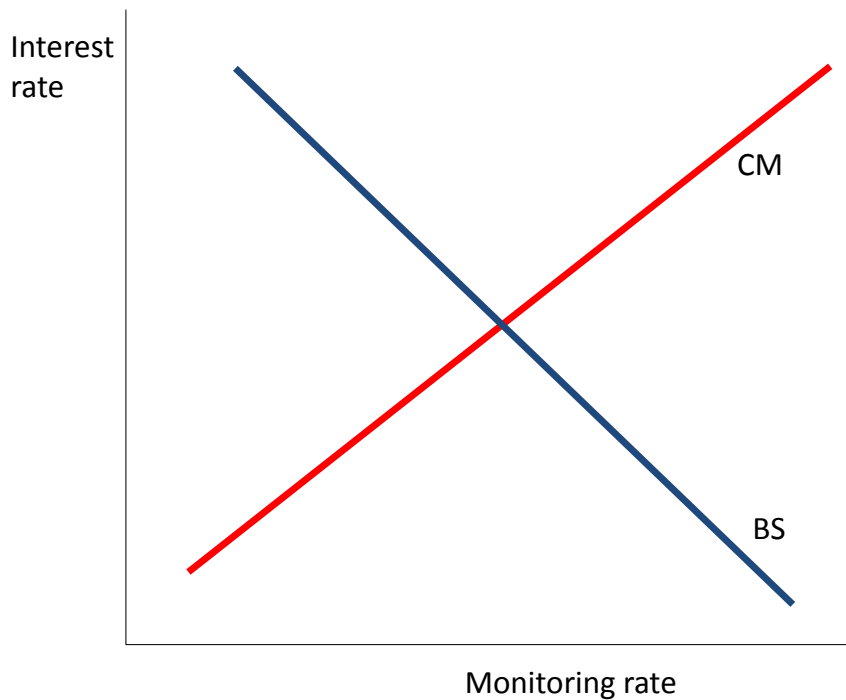
FIGURE 9. Equilibrium Monitoring and Interest Rates

rate is lower and the bank can economise on monitoring costs, the trade-off represented by the CM curve. Moreover, by monitoring less, the bank can preserve some of its credit spread. Thus the savings glut shock delivers a relaxation of credit standards, lower credit margins, higher lending and a riskier loan portfolio.

By contrast, a monetary policy shock alone shifts the BS curve outwards, which seems counterintuitive. The cut in the deposit rate, as with the deposit shock, destabilises the balance sheet. At existing loan interest rates and monitoring, there is less incentive to be a depositor. There is also less incentive as an existing borrower to exit. Moreover, the bank is earning a higher margin per loan and so would like to lend more. The problem is the balance sheet condition. The bank faces excess demand for loans and can only re-establish equilibrium by making credit terms more onerous than before. In a reverse of the previous mechanism, the best combination is a higher interest rate and a higher monitoring intensity.

Overall, therefore, the comparison of the two shocks shows that, at least as far as the model presented in this paper is concerned, the global savings glut is a more likely explanation for the reduction in credit standards and lending spreads observed in the run-up to the crisis than the risk-taking channel of monetary policy.[20]

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[20] It thus agrees completely with the empirical results of Merrouche and Nier (2014).

7. CONCLUSION

The model developed in this paper provides a theory of how banks manage credit risk when they make multi-period loans to entrepreneurs who have private information on firm profits and future prospects. If entry and exit were frictionless, then the individually rational choices of entrepreneurs and inventors would select the distribution of firms with the lowest credit risk and the asymmetry of information would have no bite. This is not the case with entry and exit costs since there will now be a segment of firms who choose to continue in circumstances in which they would not decide to start. Such firms are at the highest risk of defaulting in the near future and the bank has an interest in trying to reduce this portion of the distribution through its credit standards. The bank monitors continuing loans stochastically to discover breaches of loan covenants. But credit controls are costly, directly due to the cost of monitoring and indirectly through the interest rate the bank can charge on loans. Credit standards are a form of control right over the decision to continue a firm - the tighter the standards, the less control exercised by the borrower. Borrowers, therefore, are willing to pay an interest rate premium for greater control rights. So in deciding how to set its credit standards, a bank needs to take into consideration the cost of monitoring and enforcing its covenants, the effect of credit standards on default risk and the loan interest rate it can charge for different contract terms. The model shows how these competing considerations can be equilibrated whilst ensuring that the bank has sufficient deposits to fund its lending.

In the model there was only one bank and it had complete flexibility to set its terms and conditions subject to the balance sheet constraint. As the only actor capable of influencing aggregate outcomes, the bank effectively determines the distribution of firms in the economy and thus the allocation of resources. Banking is a socially useful activity since lending with no monitoring leads to the highest credit risk distribution which is not welfare maximising except under extreme conditions. However, since there is an externality from higher monitoring,the bank's choice of monitoring intensity will be below that of a social planner.

In the final section, the paper examined the effects of a cut in monetary policy and a deposit shock on equilibrium credit standards and credit spreads. In a closed economy, a cut in the monetary policy interest rate led to a tightening of credit standards and an increase in credit spreads in contradiction to the hypothesis of the risk-taking channel of monetary policy. By contrast, an exogenous increase in deposits reduced credit standards and credit spreads, consistent with what was observed prior to the financial crisis. Therefore the model rejects the risk-taking channel in favour of the savings glut hypothesis. Macroprudential regulators should clearly take account of both types of shocks but

the model suggests that they should be particularly wary of lending practices when there are large capital inflows into the economy.

APPENDIX A. APPENDIX

A.1. **Proofs of Propositions.** **Proposition 1** *Given Assumptions A and B and a banking con-*
tract ψ, unique, bounded and mutually consistent functions $V_E(a; \psi, V_I)$ and $V_I(a; \psi, V_E)$ exist.
These value functions yield unique and continuous functions in ψ for the entry and exit thresholds
a_E and a_X respectively. $a_E(\psi)$ and $a_X(\psi)$ are both strictly increasing in r.

Proof. It greatly simplifies the presentation of the proof (and with no loss of generality)
to ignore the presence of the default option and focus on the choices of voluntary exit or
continuation.

We work in $\mathcal{B}(A)$, the set of all bounded functions on the set A. By completely stan-
dard dynamic programming arguments, for any $V_I \in \mathcal{B}(A)$, the operator

$$T_1(V_E, V_I)(a) = q(a) - r + \beta \max \left\{ \begin{array}{c} \varphi I_{a_T}(a) \left(E\left[V_I(a';.)\right] - L \right) + \left(1 - \varphi I_{a_T}(a)\right) \int\limits_A V_E(a\prime;,)F(da\prime,a), \\ E\left[V_I(a';.)\right] - L \end{array} \right\}$$

is a contraction on $\mathcal{B}(A)$ with modulus β and a unique V_E exists for a given V_I with

$$V_E = T_1(V_E, V_I) \tag{13}$$

And for any $V_E \in \mathcal{B}(A)$, the operator

$$T_2(V_E, V_I)(a) = r_d + \max \beta \left\{ \int\limits_A V_E(a';,)F(da\prime,a) - S, E\left[V_I(a';.)\right] \right\}$$

is a contraction on $\mathcal{B}(A)$ with modulus β and a unique V_I exists for a given V_E with

$$V_I = T_2(V_E, V_I) \tag{14}$$

The existence of each value function individually does not, however, imply the existence
or uniqueness of any pair of functions (V_E, V_I) satisfying both conditions (13) and (14)
simultaneously. For any $V_I, V_I', V_E, V_E' \in \mathcal{B}(A)$

$$\left| \int\limits_A \left[V_I(a';.) - V_I'(a';.)\right] G(da') \right| \leq \left\| V_I - V_I' \right\|$$

$$\left| \int\limits_A \left[V_E(a\prime;,) - V_E'(a\prime;,)\right] F(da\prime,a) \right| \leq \left\| V_E - V_E' \right\|$$

and

$$\left| \begin{array}{c} \varphi I_{a_T}(a) \left[\int\limits_A \left[V_I(a';.) - V_I'(a';.)\right] G(da') \right] \\ + \left(1 - \varphi I_{a_T}(a)\right) \left[\int\limits_A \left[V_E(a\prime;,) - V_E'(a\prime;,)\right] F(da\prime,a) \right] \end{array} \right| \leq \max \left(\left\| V_E - V_E' \right\|, \left\| V_I - V_I' \right\| \right)$$

where $\|v\| = \sup_a |v(a)|$ is the usual sup norm. Let $\mathcal{M}$ be the set of ordered pairs (V_E, V_I) such that both V_E and V_I are in $\mathcal{B}(A)$ and impose the following metric d on $\mathcal{M}$:

$$d((V_E, V_I), (V_E', V_I')) = \beta \max \left\{ \|V_E - V_E'\|, \|V_I - V_I'\| \right\}$$

Now consider the operator $T : \mathcal{M} \to \mathcal{M}$ defined by

$$T(V_E, V_I) = (T_1(V_E, V_I), T_2(V_E, V_I))$$

Fix $a \in A$ and observe that

$$
\left| \begin{array}{c} T_1(V_E, V_I)(a) \\ -T_1(V_E', V_I')(a) \end{array} \right| = \beta \left| \begin{array}{c} \max \left\{ \begin{array}{c} \varphi I_{a_T}(a)\left(E[V_I(a';.)] - L\right) + (1 - \varphi I_{a_T}(a)) \int_A V_E(a\prime;,)F(da\prime, a), \\ E[V_I(a';.)] - L \end{array} \right\} \\ \max \left\{ \begin{array}{c} \varphi I_{a_T}(a)\left(E[V_I'(a';.)] - L\right) + (1 - \varphi I_{a_T}(a)) \int_A V_E'(a\prime;,)F(da\prime, a), \\ E[V_I'(a';.)] - L \end{array} \right\} \end{array} \right|
$$

$$
\leq \beta \left| \begin{array}{c} \max \left\{ \begin{array}{c} \varphi I_{a_T}(a)\left(E[V_I(a';.)] - L\right) + (1 - \varphi I_{a_T}(a)) \int_A V_E(a\prime;,)F(da\prime, a), \\ \varphi I_{a_T}(a)\left(E[V_I'(a';.)] - L\right) + (1 - \varphi I_{a_T}(a)) \int_A V_E'(a\prime;,)F(da\prime, a), \end{array} \right\} \\ \max \left\{ \begin{array}{c} E[V_I(a';.)] - L \\ E[V_I'(a';.)] - L \end{array} \right\} \end{array} \right|
$$

$$\leq \beta \max \left\{ \|V_E - V_E'\|, \|V_I - V_I'\| \right\}$$

where the first inequality follows from the fact that $|\max(a, b) - \max(c, d)| \leq \max(|a - c|, |b - d|)$ for any $a, b, c, d \in \mathbb{R}$. Taking the supremum over both sides:

$$\|T_1(V_E, V_I)(a) - T_1(V_E', V_I')(a)\| \leq \beta \max \left\{ \|V_E - V_E'\|, \|V_I - V_I'\| \right\}$$

Exactly the same arguments give

$$\|T_2(V_E, V_I)(a) - T_2(V_E', V_I')(a)\| \leq \beta \max \left\{ \|V_E - V_E'\|, \|V_I - V_I'\| \right\}$$

and thus

$$d(T(V_E, V_I), T(V_E', V_I')) \leq \beta d((V_E, V_I), (V_E', V_I'))$$

Hence T is a contraction mapping on the complete metric space $(\mathcal{M}, d)$ establishing a unique fixed point exists. $V_E(a)$ and $V_I(a)$ are unique continuous functions.

The entry threshold a_E is determined by:

$$\int_A V_E(a';,)F(da\prime, a_E) - S = \int_A V_I(a';,)G(da') \tag{15}$$

To show uniqueness, note that $\int_A V_I(a';,)G(da')$ is constant and independent of a. Since $q(a) - r$ is increasing in a and $F(da\prime, a)$ is stochastically increasing in a, $V_E(a)$ is increasing in a from Lemma 3.9.4 in Topkis (1998). Therefore $\int_A V_E(a';,)F(da\prime, a_E)$ is strictly increasing in a because $V_E(a\prime;,)$ is an increasing function and $F(da\prime, a)$ is strictly stochastically

increasing in a. By the intermediate value theorem there is a unique value of a_E. By analogous reasoning, there is a unique value of a_X.

The explanation why a_E and a_X are increasing functions of r is intuitive but the formal proof is long and available on request. The following sketches the argument. Consider equation (15) that determines the entry threshold and fix the value of a_E. The left hand side is the expected value of being an entrepreneur conditional on a_E. There is clearly a direct increase in $V_E(a';,)$ from a decrease in r through the rise in $q(a) - r$. If the right hand side were unchanged, then a_E would have to fall to re-establish equality. Unfortunately the right hand side is not fixed because $V_I(a';,)$ is a function of $V_E(a\prime;.)$ so the right hand side also rises. And $V_E(a\prime;.)$ is a function of $V_I(a';,)$ which increases the left hand side etc. Since only a fraction of inventors receive a profitability draw high enough to warrant entry, most inventors have to wait to take advantage of a lower interest rate so the expected value of being an inventor is less sensitive to the interest rate than the expected value of being an entrepreneur. (Likewise, only a fraction of entrepreneurs have a profitability shock so adverse as to warrant exiting, so the expected value of being an entrepreneur is not very sensitive to the change in value of the outside option of becoming an inventor.) Intuitively, therefore, the direct effect dominates the subsequent chain of indirect effects and the left hand side rises by more than the right, requiring a fall in a_E. □

Proposition 2 *For each ψ there is a unique invariant distribution, $\bar{H}([0,a);\psi)\ \forall a \in A$.*

Proof. The transition equation for the end of period distribution of entrepreneurs can be re-written as an operator on probability measures:

$$(T^*H)(A,\psi) = I\int_{a_E}^{1} G(a) + \int_{a_X}^{1} F(a',a)H(da;\psi) - \varphi\int_{a_X}^{a_T} F(a',a)H(da;\psi) \qquad (16)$$

Since $\int_{a_E}^{1} G(a)$ and $F(a',a)$ are continuous probability measures and H is continuous by assumption, T^* maps a continuous function into another continuous function and thus has the Feller property. A is compact and therefore the operator function (16) satisfies the requirements for Theorem 12.10 in Stokey and Lucas (1989) and an invariant distribution exists. $F(a',a)$ is stochastically increasing and, since $0 \leq \varphi \leq 1$, the third term never dominates the second. Monotonicity plus the monotone mixing condition, Assumption A (iii), ensure that Theorem 2 of Hopenhayn and Prescott (1992) is satisfied and the invariant distribution is unique. □

Proposition 3 *There is a unique value $\tilde{r}$ that ensures that the balance sheet of the bank is equal on both sides for given values of φ and ξ.*

Proof. Two conditions must be satisfied at equilibrium for any loan terms : For the bank to be able to match deposits with liabilities we require:

$$\frac{1}{2} = \tilde{H}(A, \tilde{r}) = I \tag{17}$$

And at the invariant distribution for any loan terms ψ, the volume of entrants must equal the volume of exits. The volume of entrants is determined by $I \int_{a_E(\psi)}^{1} G(a)$. For an assumed process of G and a given value of I, this is a strictly negative and continuous function of $a_E(\psi)$. For a given φ and ζ, $a_E(\psi)$ is a strictly positive and continuous function of r, hence the volume of entrants is a strictly negative and continuous function of r. The volume of exits is determined by $\int_0^{a_X(\psi)} F(a', a) H(da; \psi) + \varphi \int_{a_X(\psi)}^{a_T(\psi)} F(a', a) H(da; \psi)$. For an assumed process for F and a given distribution of H, this is a strictly positive and continuous function of $a_T(\psi)$ and $a_X(\psi)$. For a given φ and ζ, $a_T(\psi)$ and $a_X(\psi)$ are strictly positive and continuous functions of r, hence the volume of exits is a strictly positive continuous function of r. By the intermediate value theorem, there is unique value for r (given φ and ζ) which matches the volume of entrants with exits and satisfies (17) given (16). $\qquad \square$

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