The Near Impossibility of Credit Rationing

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Abstract

Equilibrium credit rationing in the sense of Stiglitz and Weiss (1981) implies the marginal cost of funds to the borrower is infinite. So borrowers have an overwhelming incentive to cut their loan by a dollar and thereby avoiding being rationed. Ways of doing this include scaling down the project, cutting consumption or infinitesimally delaying the project to accumulate more saving. All of these routes are normally feasible in which case credit rationing is impossible.

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1 Introduction

In their justly celebrated paper, Stiglitz and Weiss (SW) (1981) demonstrate that, in the presence of asymmetric information, interest rates cannot be counted on to clear credit markets. The claim is not that rationing always emerges, but that the conditions can plausibly be satisfied. There has naturally been discussion of just how restrictive are the requirements. This paper argues that if entrepreneurs can save or adjust the start date of their project it is almost impossible to generate credit rationing.

Bester (1986) was the first to question whether credit rationing is at all general. He shows that if borrowers can post collateral, a separating equilibrium emerges and credit rationing disappears. SW (1986) respond by showing that when collateral is limited there may be equilibria in which some or all borrowers post all of their assets as collateral (or provide maximum self finance) yet do not have enough assets to achieve separation. With no further scope for lowering fail-state income, the only way to combat moral hazard or influence the composition of borrowers is by adjusting the repayment in the event of solvency (the interest rate). The way is now open for credit rationing in the sense of banks randomly choosing which borrowers receive credit.[1] Or is it? At a credit rationing equilibrium, the marginal value of an additional dollar of internal funds is effectively infinite. Unless the cost of cutting consumption or the currrent dividend is also infinite, entrepreneurs will find some money. However, if this is not possible, the start date of the project can be delayed. Adopting this option allows entrepreneurs to earn interest on their assets and the extra self finance or collateral made possible alleviates moral hazard or allows extra signalling opportunities. To rule this out it must be assumed that postponement, rather than allowing for more effective planning, causes major deterioration in project prospects. Even this is not enough for credit rationing. Scaling down the project reduces borrowing requirements and so avoids the infinite marginal cost of funds in a rationing equilibrium. Whatever the asset endowment of the entrepreneurs there is almost no scope for random credit rationing.

To examine this conclusion more explicitly, note that SW proposed two routes by which higher interest rates may cause bank profit to deteriorate. The adverse selection effect works through changes in the composition

[1] Even if collateral is limited, credit rationing cannot arise if borrowers differ in ability rather than intrinsic risk (de Meza and Webb (1987)). There has been little formal testing of the existence of credit rationing. An exception is Berger and Udell (1992) which does not find evidence in favour.

of borrowers. When interest rates are high, entrepreneurs with relatively safe projects almost always default whereas those with equal expected returns but a riskier distribution sometimes perform sufficiently well to net the entrepreneur a jackpot. As rates rise, the safe types are the first to drop out. From the banks' perspective, there is therefore a disadvantageous change in the quality of the loan pool.

Incentive effects arise when entrepreneurs' project choice is not verifiable. For the reasons already established, an interest rate rise implies that debt financed entrepreneurs obtain a private benefit from switching to riskier strategies, causing the bank to lose out. A high interest rate, by diminishing the payoff to success, has the further moral-hazard effect of discouraging effort. This, too, implies that the bank's return function with respect to its loan rate may reach a turning point.

The final step in establishing credit rationing involves the assumption of an upward sloping supply curve of deposits. Suppose that at the loan rate that maximises the banks' gross return, the highest interest rate banks can offer depositors and still break even, does not attract enough funds for all loan applicants to proceed. Credit rationing then emerges.

This paper scrutinises these argument more closely. What we show is that if a bank is at the turning point of its return function, as is required for credit rationing, the borrower's marginal cost of funds is infinite. It is therefore worth the borrower incurring any finite cost to reduce the required loan size. There are a variety of ways to do this. The entrepreneur can increase self finance by reducing current consumption. Since in reality saving is almost always a feasible option, equilibrium credit-rationing in the sense of SW does not seem likely to be of practical relevance. That is, there is almost always some small personal expenditure an entrepreneur could eliminate without disastrous effect. Another possibility is delaying the start of the project, even infinitesimally. This allows interest on the borrower's savings to accumulate, thereby reducing the loan needed when the project eventually commences. Other escape routes from credit rationing with analytically similar properties include the entrepreneur scaling down the project, choosing less capital-intensive production techniques, and working harder to accumulate more wealth prior to starting the project. If any of these actions are possible, even minimally, credit rationing cannot occur.

Three papers have examined the interaction of saving opportunities, capital market imperfections and the timing of investment. Parker (2000) utilizes a continuous time model to examine the impact of exogenous borrowing constraints on the decision of whether and when to become an entrepreneur. Inability to borrow more than a pre-specified amount may lead to the postponement of a business start up rather than its abandonment. The origin of the borrowing constraint and whether a credit-rationing equilibrium is consistent with endogenous timing is not considered. Lensink and Sterken (2001,2002) analyze a model in which entrepreneurs are endowed with projects that have returns that differ by mean-preserving spreads. A project's risk characteristic is the private information of the entrepreneur. The novel ingredient is that by deferring the start date by a period, the entrepreneur finds out whether the project will succeed or fail. Thus projects which wait never default, whilst those that start immediately do. To determine whether credit rationing is possible LS examine what happens to overall default rates if all banks raise their current and future interest rates. They argue that if the riskier projects are the first to be delayed as the interest rate rises, the impact effect of rises in interest rates is to drive bad firms out of the loan market and not good firms as in the SW model. This reduces the empirical relevance of credit rationing in the sense of Stiglitz and Weiss. In the current paper, with much weaker and more general assumptions, in models with both moral hazard and hidden type we show the generic implausibility of equilibrium credit rationing .

Our model is more conventional in assuming that the mere passage of time is not informative. Entrepreneurs only find out the properties of the project (or their own abilities, or the state of the world) by the experience of running the project. Delay does though allow financial assets to accumulate and so reduce the size of the required loan. Banks do condition the interest rate on this information which allows full separation to emerge and hence credit rationing is precluded.

The remainder of this paper makes explicit the incompatibility of saving and credit rationing. In the next section we examine the case of moral hazard. After setting up a benchmark static model we consider the impact of saving rates,varying the project scale and endogenising the project start date. In Section 3 we look at hidden types. When the nature of heterogeneity is that entrepreneurs' returns differ by mean preserving shifts, a separating equilibrium emerges, in which safe entrepreneurs delay their projects but there is no random rationing. When entrepreneurs' return distributions can be ranked by first-order stochastic dominance, there is a pooling equilibrium with no delay. Once again, random rationing does not feature; in fact too many projects are funded.

In the interest of transparency the assumptions are not as general as they might be and, as with much of the literature, we do not embed the analysis in a full general equilibrium model.

2 A Basic Static Moral-Hazard Model

To set the scene we examine the possibility of credit rationing in the standard model. Some fraction of a risk-neutral population are endowed with a project with fixed capital requirement K, which when activated, with probability $p(E)$ instantaneously yields S, or else gross revenue is zero, where E is the effort of the entrepreneur. We assume that $p' > 0$ and $p'' < 0$.[2] Although entrepreneurs have some initial financial resources of their own, these are insufficient to self-finance the project. Debt finance is available from competitive banks. The most straightforward justification for debt as the equilibrium financial contract is that it is costly to verify project revenue but cheap to verify whether a contracted payment is made. Incentive compatibility is achieved by allowing the bank to seize project revenue if the payment is missed.[3]

The entrepreneur has initial wealth $\overline{W} = \overline{W_L} + \overline{W_I}$, where $\overline{W_L}$ denotes the liquid wealth endowment and $\overline{W_I}$ denotes the value to the entrepreneur of their illiquid wealth endowment. Illiquid wealth can only be transformed into investment capital at a cost.[4] Since wealth may involve costly liquidation, in a competitive financial market it is never worse for the entrepreneur to pledge wealth as collateral that is returned in the event of success, rather than invest directly in the project. This follows because in the latter case liquidation costs are only incurred in the event of failure. Granted that debt is risky, project failure loses the entrepreneur $W = W_L + W_I$, where the value of each asset posted as collateral is $W_L \leq \overline{W_L}$ and $W_I \leq \overline{W_I}$. The entrepreneur's expected utility is therefore

$$V = p(E)[S - D] + p(E)\overline{W} - E + (1 - p(E))(\overline{W} - W) \tag{1}$$

[2]These assumptions on the shape of the $p(E)$ function are equivalent to assuming a cost of effort function $E(p)$ that is convex with $E' > 0$ and $E'' > 0$.

[3]We assume that borrowers cannot very effectively expropiate returns prior to seizure.

[4]Proportional liquidation costs raise the possibility of corner solutions where entrepreneurs commit only liquid wealth to their project deciding not to incur any (expected) costs of liquidation. Fixed costs have a similar threshold effect but have no efffect beyond the threshold at which they are incurred

where D is the contracted repayment on debt. The FOC with respect to effort is

$$p'[(S-D)+W]-1=0 \tag{2}$$

Project lending is risky, so competitive banks must charge a premium to cover the chance of default. The safe rate of interest is denoted by r but for simplicity we keep this equal to zero .[5] The debt contract returns D to the bank in the event of success and the pledged collateral is recovered by the bank in the event of default. The equilibrium repayment satisfies the break even condition

$$pD+(1-p)W=K \tag{3}$$

From (2),

$$p''[(S-D)+W]dE-p'dD=0 \tag{4}$$

and from (3)

$$\left(p+p'\frac{dE}{dD}(D-W)\right)dD=-(1-p)dW \tag{5}$$

Then (4) and (5) imply

$$\frac{dD}{dW}=\frac{-(1-p)}{p+p'\frac{dE}{dD}(D-W)}=\frac{-(1-p)}{p+\frac{(D-W)p'^2}{p''(S-D+W)}} \tag{6}$$

From (1), using (2)

$$\begin{aligned}\frac{dV}{dW} &= (1-\frac{dD}{dW})p-1+[p'((S-D)+W)-1]\frac{dE}{dW} \\ &= (1-\frac{dD}{dW})p-1\end{aligned} \tag{7}$$

Consider the possibility of a credit rationing equilibrium.The bank's expected gross return is $R=pD+(1-p)W$ so

$$\frac{dR}{dD}=p+p'\frac{dE}{dD}(D-W)=p+\frac{(D-W)p'^2}{p''(S-D+W)} \tag{8}$$

[5] A full general equilibrium analysis would endogenise r, the safe rate of interest. This though would be a distraction in the present context since our demonstration that borrowers reject all loans offered at the rationing interest rate is independent of the level of r. Note though that in a closed economy, at any moment the aggregate supply of lending is totally inelastic, so were it not for the point made in this paper, credit rationing would be a possibility.

From (7), when the bank is close to the turning point of its returns function (so $\frac{dR}{dD}$ is close to zero and $\frac{dD}{dW}$ tends to minus infinity) $\frac{dV}{dW}$ is certainly positive and tends to plus infinity. Hence, the only possible rationing equilibrium is in the corner with $W = \overline{W}$ and $\frac{dV}{dW} > 0$, with entrepreneur totally destitute in the event of failure.

Were entrepreneurs risk averse (as analysed in the Appendix) finding a credit rationing equilibrium is even more problematic. Now entrepreneurs limit their commitment of collateral to the project, thereby trading-off risk-bearing against the reduction of moral hazard. Corner solutions must satisfy more restrictive conditions and are impossible if the Inada condition holds. The proof that an interior solution is inconsistent with credit rationing stands though. In such an equilibrium posting an extra dollar of collateral has a finite expected utility cost, even when the extra risk is accounted for but at the bank's turning point the marginal saving in interest payments is infinite. So, by making it less likely that entrepreneurs would willingly pledge all their assets as collateral, risk aversion further limits the possibility of rationing.

2.1 The Static Model with Divisible Projects

Changing project scale is an alternative to self finance or pledging collateral. Consider a static model that allows for the possibility that the firm has a divisible technology that must be implemented immediately. In particular let gross success revenue be $S(K)$ with $S' > 0$ and $S'' < 0$. With maximum self-finance the entrepreneur's expected utility is

$$V = p(E)\left[S(K) - D\right] - E \tag{9}$$

The FOC with respect to effort is

$$p'\left[S - D\right] - 1 = 0 \tag{10}$$

The equilibrium repayment must satisfy the bank's break even condition

$$pD = K - W \tag{11}$$

From (11)

$$pdD + p'dE = dK \tag{12}$$

and from (10),

$$p''\left(S - D\right)dE + p'[dS - dD] = 0 \tag{13}$$

so from (12) and (13)

$$\frac{dD}{dK} = \frac{\frac{Dp'^2 S'}{p''(S-D)} + 1}{p + \frac{Dp'^2}{p''(S-D)}} \tag{14}$$

Making use of (14) and (12), from (9), at an interior optimum,

$$\begin{aligned} \frac{dV}{dK} &= p(S' - \frac{dD}{dK}) + [p'(S-D) - 1]\frac{dE}{dK} = \\ & \quad p[S' - \frac{\frac{Dp'^2 S'}{p''(S-D)} + 1}{p + \frac{Dp'^2}{p''(S-D)}}] = 0 \end{aligned} \tag{15}$$

From the bank's return function

$$\frac{dR}{dD} = p + p'\frac{dE}{dD}D = p + \frac{p'^2 D}{p''(S-D)} \tag{16}$$

$\frac{dR}{dD}$approaches zero in a credit-rationing equilibrium, but if S' is finite, as must surely be true at any positive project scale, from (15) this is inconsistent with $\frac{dV}{dK} = 0$. The firm will cut back the scale of investment rather that face the prospect of being rationed.

3 Intertemporal Models

Though the prospects of equilibrium rationing emerging seem bleak, further considerations appear to restore the possibility. First, liquidating some assets may involve a fixed cost. The absolute saving in interest payments from lowering borrowing may not be enough to cover this cost, so there could be rationing even if not all assets are surrendered in the event of default. Second, for good or ill the government typically exempts some assets from seizure. If this threshold is sufficiently high (and in some US states even the family home is immune) credit rationing may result. The next section shows that when intertemporal considerations are introduced even these cases of rationing are eliminated endogenise savings we consider two simple extensions of our model.

3.1 Model 1

Assume that there are two periods. Current assets are W_0 of which C_0 is consumed. Next period a project costing K is to be run. Some of the entrepreneur's savings are put towards project finance and the rest, C_1, is consumed in the second period (the risk free rate of interest is zero). Banks provide the remainder of the finance, $K - W + C_0 + C_1$. The entrepreneurs expected utility is

$$V = U(C_0) + p(E)U\left(C_1 + S - D\right) + \left(1 - p(E)\right)U\left(C_1\right) - E \tag{17}$$

The second period choice of E satisfies

$$p'(E)[U\left(C_1 + S - D\right) - U\left(C_1\right)] = 1 \tag{18}$$

so

$$\frac{dE}{dD} = -\frac{U'\left(C_1 + S - D\right)}{p''} < 0 \tag{19}$$

Then,

$$\frac{dV}{dC_0} = U'\left(C_0\right) - PU'\left(C_1 + S - D\right)\frac{dD}{dC_0} \tag{20}$$

The competitive banks break even so

$$pD = K - W + C_0 + C_1 \tag{21}$$

from which, using (19), we have

$$\frac{dD}{dC_0} = \frac{1}{p - \frac{Dp'U'(C_1+S-D)}{p''}} \tag{22}$$

and substituting into (20) yields

$$\frac{dV}{dC_0} = U'\left(C_0\right) - \frac{pU'\left(C_1 + S - D\right)}{p - \frac{Dp'U'(C_1+S-D)}{p''}} \tag{23}$$

However, from (21), using (19), we have

$$\frac{dR}{dD} = p - \frac{Dp'U'(C_1 + S - D)}{p''} \tag{24}$$

Approaching the turning point of the revenue function $\frac{dV}{dC_0}$ tends to minus infinity, at least if $U'(C_0)$ is finite, as is surely true in any practical case, since entrepreneurs can always find an extra dollar from current consumption without too much strain. If credit rationing prevails, the cost of the last unit of consumption is infinite.

3.2 Model 2

Even if entrepreneurs have exhausted the possibilities for curtailing current consumption there are still escape routes from credit rationing. Lets assume risk neutrality, so there is no loss to the entrepreneur in concentrating consumption at a single instant. Now there is still the escape route from rationing of postponing the project's start date. For simplicity, assume that all wealth is liquid and is invested directly in the project. [6] Project returns are delivered instantaneously. The discount rate is constant and positive.[7] The project can be activated just once, but this can be at any time in the entrepreneur's long life.[8] With maximum self-finance, if the project is operated at time τ, the entrepreneur's expected utility is

$$V = e^{-r\tau}\{p(E)[S(\tau) - D] - E\} \tag{25}$$

where the dependency of S on τ reflects the possibility that the project deteriorates if postponed, $S'(\tau) < 0$. The FOC with respect to effort is

$$p'[S - D] - 1 = 0 \tag{26}$$

The entrepreneur has initial wealth W_0, so by time τ this has grown to $W_0e^{r\tau}$, all of which is invested in the project. Project lending is risky, so competitive banks must charge a premium to cover the chance of default. The equilibrium repayment must satisfy the break even condition

[6]The alternative of pledging this wealth as collateral makes no difference in this case and this formulation leads to slightly simpler algebra.

[7]As we show that for credit rationing projects must be activated instantaneously or not at all, this assumption is consistent with the flow of fundable projects being constant.

[8]Though S or p may decline with τ, as later noted, this does not affect the results.

$$pD = K - W_o e^{r\tau} \tag{27}$$

Substituting (27) into (25)

$$V = e^{-r\tau}\left\{\left[S - \frac{K - W_0 e^{r\tau}}{p}\right] p(E) - E\right\} \tag{28}$$

From (27)

$$pdD + p'dE = -rW_0 e^{r\tau} d\tau \tag{29}$$

and from (26),

$$p''\left(S - D\right) dE + p'[dS - dD] = 0 \tag{30}$$

so

$$\frac{dD}{d\tau} = \frac{\frac{Dp'^2 \frac{dS}{d\tau}}{p''(S-D)} - rW_0 e^{r\tau}}{p + \frac{Dp'^2}{p''(S-D)}} \tag{31}$$

which for an interior optimum starting time must be negative. Making use of (31) and (26), form (25)

$$\frac{dV}{d\tau} = e^{-r\tau}\{p\left(E\right)\frac{dS}{d\tau} - r\left[p(E)(S-D) - E\right)] - p(E)[\frac{\frac{Dp'^2 \frac{dS}{d\tau}}{p''(S-D)} - rW_0 e^{r\tau}}{p + \frac{Dp'^2}{p''(S-D)}}]\}$$

Moreover from the bank's return function

$$\frac{dR}{dD} = p + p'\frac{dE}{dD}D = p + \frac{p'^2 D}{p''(S-D)} \tag{33}$$

The first thing to note is that credit rationing is inconsistent with an an interior solution. From (33), if $\frac{dS}{d\tau} \leq 0$, then $\frac{dV}{d\tau} = 0$ requires that the final square bracket must be negative and finite but under credit rationing $\left(\frac{dR}{dD} = 0\right)$this term is plus or minus infinity. If $\frac{dS}{d\tau} \geq 0$ the final square bracketed term is negative so under credit rationing must be minus infinity. The only possibility for credit rationing is thus the corner solution $\tau = 0$.This is not easily achieved though. Suppose $\frac{dS(0)}{d\tau} \geq 0$ which is to say that some level of planning is valuable, then from (33) credit rationing at $\tau = 0$. That is, even if the entrepreneur is offered a loan at the credit-rationing interest rate, it is optimal to reject it and postpone starting the project. Doing so allows extra wealth to be accumulated, shrinking the required loan and, due to the moral hazard, more than proportionately lowering the debt repayment. It follows that there cannot be a credit-rationing equilibrium.

For credit rationing it is thus necessary that there is no delay in project commencement which in turn requires that any planning delay is unproductive (and therefore that an unlucky credit applicant will never be served in the future). Even should all these conditions be satisfied, as already shown, credit rationing cannot survive the possibility of varying project scale.

To summarise the main implications of our analysis for credit rationing;

Proposition 1 *When start-date is the only choice variable, a credit-rationing equilibrium implies that projects commence without delay and unsuccessful applicants for funds never reapply. This is inconsistent with postponement having a neutral or beneficial effect on project performance through better planning. If in addition project scale is smoothly variable, credit rationing is inconsistent with an equilibrium in which projects are of finite size.*

Even when credit rationing is avoided, note that the value of initial assets may determine whether an entrepreneur ever proceeds with the project. Suppose that a project is positive NPV if undertaken by a self-financed entrepreneur. Were the same project available to an entrepreneur with insufficient assets to self-finance, the loan required to allow immediate commencement involves a repayment so high that the deadweight cost renders it negative NPV. Delay brings down the deadweight cost involved, but causes the intrinsic value of the project to decline even more rapidly. Hence, the poor entrepreneur does not proceed and is, in effect, red-lined.

3.3 A Multi-Project Intertemporal Model

Now suppose that our entrepreneur is faced with a sequence of projects each with a given capital outlay and each yielding an instantaneous return once initiated. However, a new project can only be commenced once the previous project is completed. The order of projects in this sequence is taken as given, but could be generated as part of an optimisation exercise that we currently abstract from. The entrepreneur has available the return from his previous project if it was successful, together with any collateralisable wealth, plus borrowings to finance the next project. The entrepreneur's objective is to maximise the present value of his wealth, which is a conventionally discounted sum of net returns from his projects. The problem has a recursive structure. At any date in the sequence the entrepreneur makes a decision in accordance with the "principle of optimality". The problem can therefore be decomposed into a sequence of instantaneous optimisation problems.

To be more explicit, suppose there are just two projects. The expected value function for the second project is $G(A)$ where A is the assets owned by the entrepreneur. Due to moral hazard $G'(A) \geq 1, G''(A) \leq 0$. The value of the payoff to the first project (plus any unused assets) is evaluated by means of the value function. In effect, the first project can be analysed as a one-off with the future collapsed into the V function, but it is as if the entrepreneur were risk averse. So there will not be maximum self finance in the first project and when it is completed the delay until the second is begun will depend on the success of the first (as well as its technical characteristics). The earlier analysis is thus enough to ensure that neither project is credit rationed. Generalisation to more than two projects is routine.

4 Hidden Types

Saving opportunities also preclude the emergence of credit rationing in the presence of hidden types. In their formulation, SW assume that all projects have the same expected return but differ in risk (a mean-preserving spread). The return to the project of entrepreneur i is S_i in the event of success, which occurs with probability p_i, or else the return is zero. If entrepreneurs differ by mean-preserving spreads

$$S_i = \frac{Z}{p_i} \tag{34}$$

High p_i low S_i projects are riskier. To proceed, a project requires input of funds $K < Z$. Were type public information, the repayment would be project specific but all projects would be undertaken and would be implemented immediately. What we investigate is whether this occurs when project risk is the private information of the entrepreneur.[9]

[9] The Lensink and Sterken (LS) analysis is closest to the analysis in this section. It is primarily concerned at showing that if project delay adds most value to the poorest projects, interest rate rises improve rather than reduce the average default probability of loan applicants so that the SW rationing equilibrium will not obtain. In the LS formulation the interest rate is though independent of delay. At first sight this is legitimate if banks cannot observe gestation period. However, entrepreneurs that delay invest their wealth at the safe rate so if they then choose to proceed provide more self finance. Loan size is certainly observable by the bank. Moreover, there is no obvious reason why the banks cannot offer finance that is made available one period ahead on different terms to loans that are provided immediately. LS also assume that the firms discount cash flows at the same rate at which the banks lend to them. The lending rate must incorporate a default premium which is not appropriate for entrepreneurs to apply since their payoffs explicitly take into account failure probabilities. This necessary divergence is itself a mechanism giving rise to separation. Because

The game is that the uninformed banks move first, specifying the size of the loan, the interest rate and the start date.[10] Then entrepreneurs decide whether to proceed and if so, choose the contract they prefer. If an entrepreneur decides to postpone the project, during the interval they save at the safe interest rate to reduce the necessary loan. The contrast with SW is that they construct a pooling equilibrium assuming that there is no discretion over starting date. Our contribution is to show that once the start date is endogenised, pooling is impossible but a separating equilibrium can arise.

In outline, the model implies that entrepreneur's' indifference curves in (D, τ) space satisfy the single-crossing property. The expected return to an entrepreneur borrowing $K - W_0 e^{r\tau}$ at time τ and promising to repay D if solvent is given by

$$V = e^{-r\tau} [S_i - D] p_i \tag{35}$$

In this formulation there is no decay but as there is no moral hazard its introduction would not change the conclusion. Holding utility fixed, it follows that

$$\frac{dD}{d\tau} = -r(S_i - D) \tag{36}$$

Indifference curves are thus convex and are steeper for high-risk types than for low-risk types, labelled respectively I_H, I_L in the Figure. In equilibrium, loans satisfy the banks zero-profit constraint

$$\widehat{p} D = K - W_o e^{r\tau}, \tag{37}$$

where $\widehat{p}$ is the expected default rate on the particular offer made. From (21), the slope of the bank's offer curve is

$$\frac{dD}{d\tau} = -\frac{r W_0 e^{r\tau}}{\widehat{p}} \tag{38}$$

In the Figure, the broken convex curves B_H , B_L and B_P denote the offer curves for high risks, low risks and full-pooling offers respectively. Since the indifference curves cross, an interior pooling equilibrium is impossible

interest rates are not conditioned on loan size full separation does not arise. To determine whether credit rationing is possible LS examine what happens to overall default rates if all banks raise their current and future interest rates. In an intertemporal model this is not the right question to determine the consequences of a single bank deviating since its loan applicants have the opportunity to patronise non deviant lower interest rate banks in the future.

[10] Because of competition, it makes no substantial difference if banks cannot commit to future terms.

for standard reasons. Even a corner pooling equilibrium, in which all types of entrepreneur start at the first possible moment, is ruled out. This is because a slightly smaller loan, which requires a short delay before the project commences, could be charged an interest rate at which only low-risk types apply.

The Figure shows a separating equilibrium in which high-risk types take immediate finance, whilst low-risk entrepreneurs delay to get a lower rate of interest. The mechanics of such an equilibrium are well known and it exists whenever high risks are sufficiently numerous in the population so that, for the low-risk types, pooling with $\tau = 0$ does not dominate the least-cost separating payoff.[11] Note that as the uninformed types move first in this model, the issue of out-of-equilibrium beliefs is not relevant.

Figure 1

In the adverse selection context, credit rationing requires that there is a pooling equilibrium from which the safest types exit as interest rates rise. By showing that there is no pooling equilibrium when start date is endogenised, it follows that credit rationing can be precluded.

If a separating equilibrium emerges in which entrepreneurs differ by mean-preserving spreads, even though credit rationing is avoided, under-investment is present in that the low-risk types delay entry relative to the full-information case.

Under different assumptions, hidden types give rise to overinvestment rather than to under-investment. If entrepreneurs differ in intrinsic quality rather than risk, then, when the other assumptions of SW are retained and start date is endogenous, de Meza ad Webb (1987) showed that more entrepreneurs are financed than under public information. The presence in a pooling equilibrium of high-quality entrepreneurs with low default probabilities provides a cross subsidy to low-quality types in the form of interest rates lower than would be actuarially fair for their characteristics. The consequence is that some low-quality types are induced to borrow, though were they to pay the interest rate appropriate to their type, they would choose to be inactive.

When saving opportunities are introduced to this model, the overinvestment equilibrium continues to apply. A simple formulation is to suppose that all entrepreneurs have the same payoff, S, in the event of success but can

[11] Here, start date plays a similar role to collateral in Bester (1987). In Bester low-risk types must be endowed with enough collateral to achieve separation. However, in our model entrepreneurs can always accumulate enough capital to achieve separation.

be ranked by the probability of success, p_i. The expected utility of an entrepreneur is thus

$$V = p_i(S - D)e^{-r\tau} \tag{39}$$

so, as before, the slope of the entrepreneur's indifference curve is

$$\frac{dD}{d\tau} = -r(S - D) \tag{40}$$

As the indifference curves of all entrepreneurs have the same slope, pooling is sustainable. All entrepreneurs commencing without delay, including some with negative present value projects, is an equilibrium. A bank deviating by offering a loan starting later on terms that attract any entrepreneur, would attract all entrepreneurs. Since delay is inefficient, a bank deviating from a zero expected profit offer can only attract custom by violating the break-even constraint.[12] Similarly, pooling with a delayed start is always broken by a deviant offering immediate finance, so the equilibrium is unique.

5 Empirical implications

The analysis in the paper has some strong empirical implications deriving from credit rationing equilibria necessitating corner solutions. A sharp test of rationing is whether the safe interest rate is sensitive to the supply of deposits. Credit rationing requires that the rate of interest at which banks must attract funds is increasing in the volume of lending. First consider the static model with divisible projects. In this model credit rationing only occurs at the minimum feasible project scale. A small rightward shift in the supply curve of funds then makes the banks' current portfolios of loans profitable. To restore equilibrium, banks will deny fewer projects finance until the market real interest rate is restored to the original level. In the predicted interior market-clearing equilibrium, scale is above the minimum feasible level, so that the same rightward shift in the supply curve of loans will result in positive profits for banks on the original portfolio of loans and, other things being equal, D will decline, leading to a fall in agency costs and hence an increase in project scale. This increase in borrowing

[12] Note that this result is strengthened if there are three or more states. Were there two solvent states with the distribution of the better entrepreneur bearing a relation of first-order stochastic dominance to that of the worse, then the better entrepreneur is strictly more willing than worse to pay a higher D to advance the start date. This augments the force making for a pooling equilibrium in which all proceed to borrower as soon as possible.

will lead to upward pressure on interest rates but the new equilibrium must involve lower interest rates than in the original equilibrium.

In the model with delay we get similar results. Credit rationing can only occur at a corner equilibrium in which projects start immediately. In this case, rightward shifts in the supply curve for funds will again lead to a decline in rationing and a restoration of the original level of interest rate. This is not the case in the market clearing equilibrium. Interest rate declines now lead to project starts being brought forward, adding to the demand for finance. This will mitigate some of the potential decline in interest rates as market clearing equilibrium is restored.

Credit rationing therefore implies that safe interest rates are unresponsive to fluctuations in the supply of funds. So the existence of rationing is empirically testable and seems obviously rejected by the data. Our analysis also highlights the features of the market clearing equilibria, in which agency costs (due to moral hazard and adverse selection) play an important role in determining the interaction between investment and financing. Our analysis of these equilibria is consistent with the empirical work reviewed by Hubbard (1998) that shows the importance of agency costs and not rationing in determining the preference by firms for internal over external funds and the impact on investment decisions.

6 Conclusion

We have shown that the SW credit-rationing result is undermined to the extent that entrepreneurs can save or postpone commencement of their projects or vary their scale. This is true whether the origin of rationing is hidden action or hidden types. Credit rationing requires that the delay severely damages project efficiency, that project scale cannot be smoothly adjusted, that there are significant fixed costs of liquidating assets, that the entrepreneur has no earning opportunities outside of the project and can find no way to cut current consumption by a dollar except at infinite utility cost. Since these are very restrictive conditions, there is little reason to think that random rationing will be observed in practice and, as far as we know, it never has been. Under both hidden action and hidden types, it is though quite possible that entrepreneurs with low net worth begin their projects later than if they had greater wealth endowment, and possibly never undertake them at all. There is plenty of empirical evidence along these lines (e.g. Blanchflower and Oswald (1998)), Holz-Eakin and Rosen (1994)). Delays can be regarded as a form of credit rationing and to that extent, our results are not destructive of the underlying concept. It is the pure form involving random rationing that is so difficult to accomplish.

Although credit rationing is all but precluded, the dynamic considerations are consistent with overinvestment. If entrepreneurs' return distributions are private information, but can be ranked by first-order stochastic dominance, there is no commencement delay and excessive participation.

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Appendix

7 The case of risk aversion

7.1 Assumptions

(i) A population of identical entrepreneurs is competed for by identical risk-neutral banks.

(ii) Project success yields gross revenue S whilst failure yields $F < S$. To run a project requires capital input K.

(iii) An entrepreneur can increase the chance of success, $p(E)$, by exerting unverifiable effort with $.p' > 0$ and $p'' < 0$.

(iv) Entrepreneurs are risk averse with utility function $U(Y)$, $U' > 0$, $U'' < 0$.

(v) Entrepreneurs have initial wealth W. They can borrow the project cost of K by means of a standard limited-liability debt contract with stipulated repayment is D and pledged collateral of W. Then, in the event of success, the entrepreneur receives $\overline{W} + S - D$. If the project fails the entrepreneur receives $\overline{W} - W$.

7.2 Analysis

The entrepreneur's expected utility is

$$V = p(E)U(\overline{W} + S - D) + (1-p)\,U\left(\overline{W} - W\right) - E \tag{A1}$$

so the choice of success probability satisfies

$$p'(E)[U(\overline{W} + S - D) - U\left(\overline{W} - W\right)\} = 1 \tag{A2}$$

In competitive equilibrium D and W are set to maximise expected utility subject to the bank breaking even in expected terms, which requires

$$pD + (1-p)\,W = K \tag{A3}$$

From (A3)

$$p'(D-W)dE + pdD + (1-p)dW \tag{A4}$$

From (A2)

$$p''[U(\overline{W}+S-D) - U\left(\overline{W}-W\right)]dE - p'U'(\overline{W}+S-D)dD \tag{A5}$$

$$+p'U'(\overline{W}-W)dW = 0$$

From (A4) and (A5)

$$\frac{dD}{dW} = \frac{-(1-p) + \frac{p'^2[U'(\overline{W}+S-D)+U'(\overline{W}-W)]}{p''[U(\overline{W}+S-D)-U\left(\overline{W}-W\right)]}(D-W)}{\left(p + \frac{p'^2U'(\overline{W}+S-D)}{p''[U(\overline{W}+S-D)-U\left(\overline{W}-W\right)]}(D-W)\right)} \tag{A6}$$

Then from (A1)

$$\frac{dV}{dW} = pU'(\overline{W}+S-D)(-\frac{dD}{dW}) - (1-p)U'\left(\overline{W}-W\right) \tag{A7}$$

From the bank's return function we have

$$\frac{dR}{dD} = p + p'\frac{dE}{dD}(D-W) \tag{A8}$$

Substituting $\frac{dE}{dD}$ from (A5) we have

$$\frac{dR}{dD} = p + \frac{p'^2U'(\overline{W}+S-D)}{p''[U(\overline{W}+S-D) - U\left(\overline{W}-W\right)]}(D-W) \tag{A9}$$

Credit rationing requires $\frac{dR}{dr} = 0$ which implies that in (A7) $\frac{dV}{dW} > 0$ and tends to infinity, unless $U'(\overline{W}-W)$ tends to infinity . That is, credit rationing is impossible if the entrepreneur has positive wealth in the fail state as must certainly be true if the Inada condition applies.

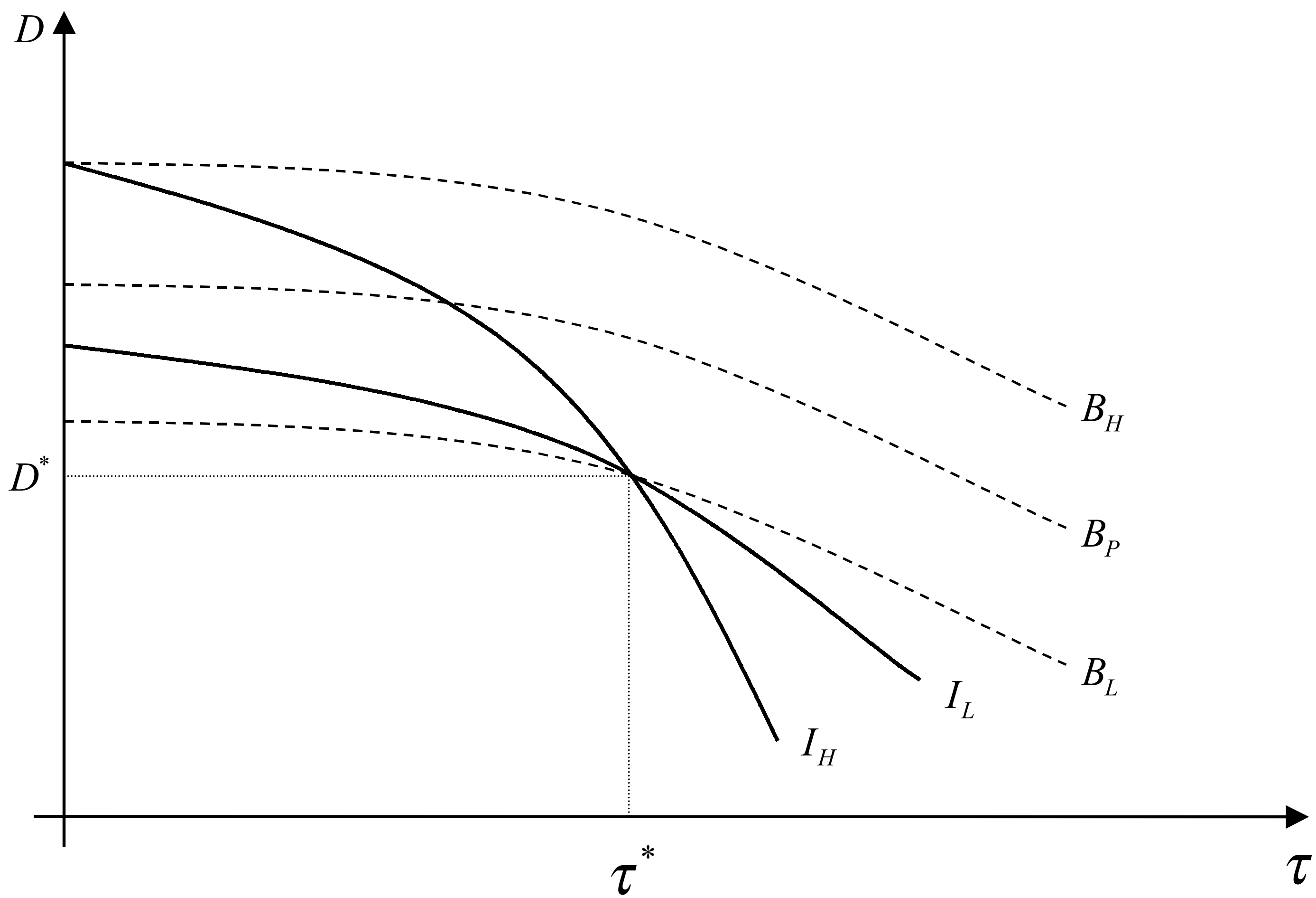

Fig. 1