Crises and Capital Requirements in Banking*

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Abstract

We analyse a general equilibrium model in which there is both adverse selection of and moral hazard by banks. The regulator has several tools at her disposal to combat these problems. She can audit banks to learn their type prior to giving them a licence, she can audit them *ex post* to learn the success probability of their projects, and she can impose capital adequacy requirements. When the regulator has a strong reputation for *ex ante* auditing she uses capital requirements to combat moral hazard problems. For less competent regulators, capital requirements substitute for *ex ante* auditing ability. In this case the banking system exhibits multiple equilibria so that crises of confidence in the banking system can occur. Contrary to conventional wisdom, the appropriate response to a crisis of confidence may be to tighten capital requirements to improve the quality of surviving banks.

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1. Introduction

Despite more than a decade of enforcement of the Basle Capital Adequacy Accord, the precise mechanism through which capital regulation promotes banking system stability is still poorly understood. Moreover, the regulatory response to various different banking crises seem to be quite diverse. In turbulent times, should capital requirements be loosened to help struggling banks (as arguably happened in the S&L crisis), or should they be tightened to discourage desperate banks from undertaking further risky activities? In this paper we set up a general equilibrium model with which we attempt to explore these questions.

Two main theories predominate as to the role which capital requirements play. The first of these, which we may informally call the "moral hazard" theory, is most closely associated with economic theorists[1] as well as public choice economists. The idea is that if banks do not have equity "at stake" when they make their investment decisions then they may make decisions which, though optimal for equity-holders, are suboptimal from the point of view of society as a whole[2]. For example, banks may be tempted to make excessively risky and even negative net present value investments which maximise the returns to equity at the expense of debt holders.

The second theory, which we might call the "safety net" theory, is more associated with practioners, and, as far as we are aware, this intuitive idea has yet to be formally modelled[3]. It is the idea that a bank's capital forms a kind of cushion against losses for depositors. One might loosely capture this idea by saying that if the bank starts to lose money, equity value must fall to zero before debt-holders start to lose, so depositors cannot lose out if regulation ensures that the bank must be closed or recapitalised before this occurs.

Our theory incorporates both of these rationales for capital regulation, and also a third. Intuitively, capital regulation should have the desirable effect of discouraging unsound and unreliable institutions from setting up operations. We show that in fact this is a third rationale for capital regulation: capital requirements can be used to solve adverse selection problems. In doing so we paddress some interesting issues.

Firstly, we examine the role of the banking regulator. We show that the presence of moral hazard in the banking system means that competent bankers must receive a rent to reward them for investing and monitoring other agents' deposits. Depositors, however, do not fully take account of this rent when deciding whether to deposit in banks or not. Thus depositors are generally insufficiently willing to deposit from a social point of view, so any sound banking system will be smaller than is socially optimal. The regulator's role is therefore to take actions which maximise the size of the banking sector. This represents a rather broader view of the regulator's remit than that found in some of the existing literature (e.g. Dewatripont and Tirole, 1993, 1994), where the regulator simply represents the interests of depositors who are too dispersed and ill-informed to represent themselves.

Secondly, if a regulator wishes to use capital requirements select out bad banks from the system she will have to set capital requirements more tightly than if she desired simply to solve

[1] See for example, Bhattacharya (1982), Rochet (1992).

[2] In this literature, banks are generally assumed to act in the interest of shareholders; either because the models explicitly assume pure entrepreneurial banks, or (implicitly) because managers have shareholdings or options. For a rationale of this, see Dewatripont and Tirole (1994).

[3] Closely related to this intuitive idea is the literature arguing that capital requirements can be used to prevent destructive bank runs (Diamond and Dybvig, 1983 ; Diamond and Rajan, 2000). Probably the closest formal model to the 'safety net' theory is Dewatripont and Tirole (1993b). Their story is however much more focussed on providing incentives for those running banks.

the moral hazard problem of "gambling" by under-capitalised banks. Thus solving adverse selection problems has a cost in terms of a banking system which is smaller (though on average more productive) than it otherwise would be. Regulators with a good ability to audit banks *ex ante* should therefore prefer the alternative of following a looser capital policy which merely solves the moral hazard problem, while relying on their own auditing skill to avoid chartering unsound banks. Regulators without a good reputation, on the other hand, should follow a tight regulatory policy, because by doing so they will gain in average bank quality more than they lose in bank size. Thus, in contrast to the Basle Accord's emphasis on a "level playing field" across nations, we suggest that capital regulation should be tighter in countries where regulator reputation is worse, since it is in effect a substitute for regulator auditing ability.

Thirdly, the regulator's ability to audit *ex post* and determine in advance of realisation the likely outcome of banks' investments has an interesting interaction with the above policy prescription. In general, the more transparent banks' investments (i.e. the easier it is for a regulator to determine early that investments are unprofitable), the looser capital requirements can be set. In our model, if the regulator recognises bad investments early, then she can step in and redistribute all of their returns to depositors before bank equity holders benefit from them. A high probability of such regulatory intervention will reduce the likelihood that bad banks will benefit from bad investments and will thus alleviate both moral hazard and adverse selection problems. It will also render depositing more attractive. This feature of the model therefore incorporates the "safety net" theory of capital regulation, because a diminished equity base reduces the amount of capital which can be redistributed from equity holders to depositors in the event of bad behaviour.

Fourthly, we show that when capital requirements are used to solve adverse selection problems, the economy exhibits multiple equilibria. This is because in any economy agents with capital can choose whether to use it to set up and manage a bank, to use it to run their own project, or to deposit it with another agent who may be able to invest it more productively than they can. The equilibrium therefore depends on agents' expectations about the quality of applicants for banking licences. If agents are *pessimistic* about the quality of applicants then the average quality of the financial system will be low and agents will be unwilling to deposit their capital with banks, preferring instead to use it to set up their own banks. Thus in equilibrium all agents with capital apply for licences, the average quality of successful applicants is low, and the pessimistic expectations are confirmed. On the other hand, if agents are *optimistic* about the quality of licence applicants they will anticipate a high quality banking system. They will therefore choose to deposit their capital in a bank rather than to set up a bank, thus confirming the high quality of the banking sector.

Notice that the solution of the adverse selection problem in a pessimistic economy requires setting capital requirements more tightly than the solution of the adverse selection problem in an optimistic economy, since pessimistic beliefs about the banking sector make unsound agents more inclined to apply for a banking licence. We interpret a switch between optimistic and pessimistic beliefs as a *crisis of confidence*. Notice that such crises of confidence will arise only in economies where regulation solves adverse selection problems: that is, crises occur only in economies where the regulator's reputation is poor. However, the crises themselves may occur independently of changes to the poor regulator's reputation. A regulator with a very good reputation will use capital requirements only to solve moral hazard problems and hence will not be vulnerable to such crises.

Finally, we show that the optimal response to crises of confidence depends on how bad the regulator's reputation is, but may be to *tighten* capital requirements. If agents switch from optimistic to pessimistic beliefs, then existing capital regulation is no longer tight enough to prevent unsound agents from applying for banking licences. The regulator has two possible reactions to this. If he has some auditing ability, he could simply accept the deterioration in banking sector, fall back upon his auditing ability to keep some of the worst applicants, and use capital regulation only to solve moral hazard problems. Thus regulators of medium ability may respond to a crisis of confidence with a loosening of capital requirements, allowing a reduction in the average quality of the banking system because this is preferable to the alternative of a reduction in size of the banking system. Regulators with very little auditing skill may however prefer to respond to the crisis by tightening capital requirements. Although the banking sector will shrink in size they will continue to solve the adverse selection problem and thus maintain a highly productive banking sector despite their poor reputation.

The remainder of this paper is organised as follows. Section 2 describes the agents in the economy and describes the circumstances in which regulation of the banking sector is necessary. Section 3 describes the regulator and derives her optimal policy as a function of both her regulation and the beliefs which obtain in the economy. Section 4 contains concluding remarks.

2. An Unregulated Banking Sector

In this section we consider a one-period economy without a banking regulator which contains N risk neutral agents. Each agent has an initial endowment of \$1 which may be invested, with any returns being consumed at the end of the period. Each individual agent also has their own 'project' in which they may choose to invest. All projects return either 0 (failure) or R (success). If a project is not monitored then it is less likely to succeed and returns R with probability $p_L > 0$. But it is possible by spending $C > 0$ per unit invested upon monitoring the activities of the (exogenous) project management to increase the probability of the high return R to p_H, where $p_H > p_L$. Only $\mu < N$ agents are able to monitor: we call these agents *sound*; the other $(N - \mu)$ agents are said to be *unsound*. An agent's type is his private information. We assume the costs of monitoring are sufficiently low that it is efficient for agents to monitor if they are able to do so:

$$\Delta p R > C, \tag{1}$$

where $\Delta p \equiv p_H - p_L$. The basic model follows Holmström and Tirole (1997), extended to allow for adverse selection of agents.

There are constant returns to investment in projects, so that instead of managing his own project, an agent can deposit his endowment with another agent, who will use it to augment the size of his own project. We call an intermediary which is established to accept such deposits a *bank*: the managing agent accepting the deposits is a *banker*. We will denote by $k - 1$ the dollar amount of other agents' capital which a bank receives to invest on their behalf. The total amount of investment by a banker will therefore be k, equal to the sum of his own dollar and the other agents' capital. Investment by banks and the return on investments are verifiable so that bankers cannot steal project returns and cannot invest deposited funds with other banks.

Our accounting convention is as follows. When investors deposit their money with the bank, they sign a *deposit contract* stipulating the sum Q which the banker will receive if his project succeeds. If the bank's investment succeeds the investor therefore receives a "deposit rate" of $R-Q$ and the banker receives a payment of $R+(k-1)\,Q$. Neither the banker nor the investor receives anything if the project fails[4]. Only a banker can observe the size of the bank which he manages; this information is not available to outside investors and hence it is impossible for any agent to make a credible commitment to limit the size of the bank which he manages.

Every agent can therefore take one of three actions: he can manage his own project; he can augment his own investment with those of other agents and run a bank; or he can invest his funds in a bank. An equilibrium comprises an action for each agent which maximises his expected income, given the actions of other agents.

Notice that since sound agents' investments (when monitored) are more productive than those of unsound agents, the welfare optimum for this economy will be attained when all funds are managed by sound agents. However, matters are complicated in that an agent's type is his private information and cannot be credibly communicated. When no agent is able to control entry into the banking system we say that the economy is *unregulated*. An equilibrium in which every sound agent runs a bank and performs monitoring is *(constrained) efficient*[5].

There are two conditions for an equilibrium with bank size k to be efficient. Firstly, monitoring must be incentive compatible for sound agents: $(Q\,(k-1)+R)\,p_H - Ck \geq (Q\,(k-1)+R)\,p_L$, or

$$Q \geq MIC\,(k) \equiv \frac{Ck - R\Delta p}{\Delta p\,(k-1)}. \tag{MIC}$$

Note that because monitoring is efficient, sound agents will always monitor if they have no outside capital ($k=1$). But because monitoring is costly and not contractible, sound agents will not monitor if they have too much outside capital to manage (k large) and the reward for success is insufficiently high (Q low).

Secondly, banking (as opposed to sole trading) must be incentive compatible for sound agents: $(Q\,(k-1)+R)\,p_H - kC \geq Rp_H - C$, or

$$Q \geq BIC \equiv \frac{C}{p_H.} \tag{BIC}$$

That is, sound agents will be just indifferent to running a bank if in expectation they receive exactly the cost of monitoring on their outside deposits, independently of the volume of deposits which they manage. The monitoring and banking incentive constraints for sound types - MIC and BIC, respectively - are illustrated in figure 1. The feasible parameter constellations for rational unregulated economies are those above both MIC and BIC.

It transpires that in pure strategy equilibria either all or none of the unsound agents will wish to run banks. The intuition for this is that it is not possible for some unsound agents to be content to run a bank while other unsound agents are content to invest in banks. For then an unsound agent who currently manages a bank could leave the banking system. This would increase the average quality of the banking system, so that the defecting agent would be strictly better off depositing than managing a bank. The converse is true if an unsound agent decides

[4] An alternative accounting procedure under which the banker received a fee in direct proportion to the size of his bank would be possible and would not have a substantive effect upon our results. We use this method in order to maximise the transparency of the algebra.

[5] Constrained efficiency might theoretically be achieved by having all sound agents manage banks, and some unsound agents manage banks too. However, we will see below that having a fraction of unsound agents manage banks is not feasible.

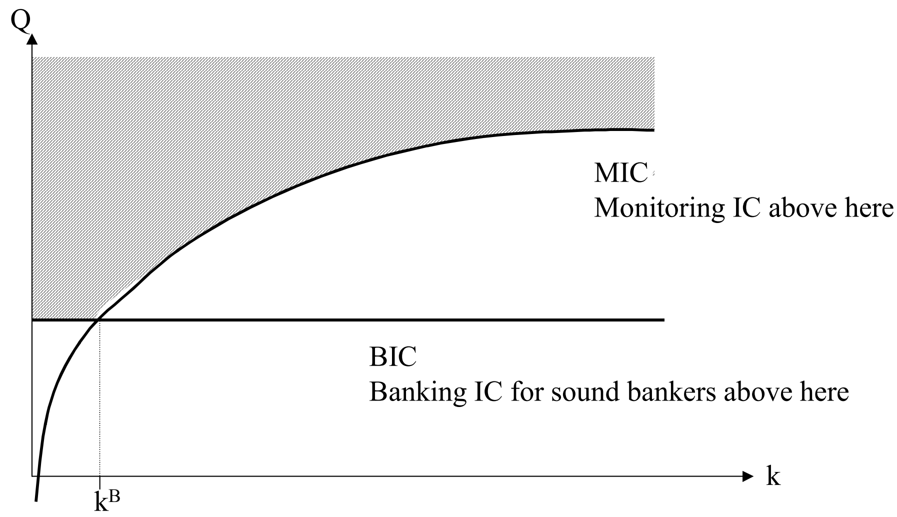

Figure 1: Sound banker participation region.

to manage a bank, so the banking system must either grow until it contains all agents, or shrink until it contains only sound agents. This is stated formally proposition 1 below.

PROPOSITION 1 *There are no asymmetric pure strategy efficient equilibria in the unregulated economy.*

Proof. Consider a rational unregulated economy in which b banks exist and assume that an equilibrium exists for $N > b > \mu$. Let $\beta_U(b) \equiv \left(Q\left(\frac{N}{b}-1\right)+R\right)p_L$ be the expected income which an unsound banker earns in a b bank economy and let $\eta_b \equiv \frac{\mu}{b}p_H + \left(1-\frac{\mu}{b}\right)p_L$ be the unconditional probability that a bank in such an economy earns R on its investments.

Unsound bankers must prefer bank management to investment in a bank, so that $\beta_U(b) \geq (R-Q)\,\eta_{b-1}$. Equivalently,

$$Q \geq \frac{R\mu b\Delta p}{N(b-1)\,p_L + \mu b\Delta p}. \tag{2}$$

Depositors must prefer bank investment to establishing another bank: $(R-Q)\,\eta_b \geq \beta_U(b+1)$, or

$$Q \leq \frac{R\mu(b+1)\,\Delta p}{Nbp_L + \mu(b+1)\,\Delta p}. \tag{3}$$

Equations 2 and 3 can be satisfied simultaneously provided

$$\frac{R\mu b\Delta p}{N(b-1)\,p_L + \mu b\Delta p} \leq \frac{R\mu(b+1)\,\Delta p}{Nbp_L + \mu(b+1)\,\Delta p}.$$

This reduces to $b^2 - 1 \geq b^2$ which is a contradiction. It follows that any efficient equilibrium must have $b = \mu$ or $b = N$, as required. □

Proposition 1 tells us that there will be μ or N banks in any efficient unregulated economy. The case with N banks corresponds to autarky and we disregard it. In an efficient unregulated economy, banks therefore return R with probability p_H. In a symmetric equilibrium when the size of a bank is k there are $\frac{N}{k}$ banks: if a new bank enters the market then the size of every bank will therefore shrink from k to $\frac{N}{N/k+1}$. The IC constraint for unsound agents to prefer investment to running a bank is therefore $\left(Q\left(\frac{N}{N/k+1}-1\right)+R\right)p_L \leq (R-Q)\,p_H$. This can be re-expressed as:

$$Q \leq B^U(k) \equiv \frac{R\Delta p}{\left(\frac{N}{N+k}\right)kp_L+\Delta p}. \tag{UIC}$$

Finally, in efficient unregulated economies, to avoid autarky bank investment must be individually rational for unsound agents, which implies:

$$Q \leq UIR \equiv R\frac{\Delta p}{p_H}. \tag{UIR}$$

In other words, unsound agents would prefer to manage their own projects unless the amount Qp_H which they must pay to bankers in expectation is less than the incremental value $R\Delta p$ which the latter add. This constraint is illustrated in figure 2.

Proposition 2 establishes the conditions which must obtain for an efficient unregulated economy to be feasible.

Proposition 2 *Define*

$$C^U \equiv \frac{R\Delta p\,(\mu p_H+\Delta p)}{Np_L+\Delta p\,(1+\mu)}.$$

Then efficient unregulated equilibria exist if and only if $C \leq C^U$.

Proof. An efficient equilibrium can exist provided there exists Q which satisfies conditions MIC, BIC, UIC and UIR. Note firstly that $MIC\,(1) = -\infty$, $MIC'\,(k) > 0$ and $MIC\,(k) \to \frac{C}{\Delta p} > BIC$ as $k \to \infty$ and secondly that $B^U\,(1) = \frac{R\Delta p}{\left(\frac{N}{N+1}\right)p_L+\Delta p} < UIR$, $\frac{d}{dk}B^U\,(k) < 0$ and $B^U\,(k) \to \frac{R\Delta p}{Np_L+\Delta p}$ as $k \to \infty$. A rational unregulated equilibrium is guaranteed to exist provided MIC is always below UIR and below B^U. Since B^U lies below UIR this is equivalent to the requirement that $\frac{C}{\Delta p} \leq \frac{R\Delta p}{Np_L+\Delta p}$, or $C \leq \frac{R\Delta p^2}{Np_L+\Delta p}$. If $C > \frac{R\Delta p^2}{Np_L+\Delta p}$ then MIC and B^U cross at $k^U \equiv \frac{N\Delta p(Rp_H-C)}{C(Np_L+\Delta p)-R\Delta p^2}$. A rational unregulated equilibrium can exist provided $k < k^U$. In such an equilibrium, $k = \frac{N}{\mu}$ so the existence requirement is $\frac{N}{\mu} \leq k^U$, which reduces to $C \leq C^U$, as required. □

The intuition for this result is as follows. When no one controls entry to the banking sector, an equilibrium with non-trivial financial intermediaries can exist only if unsound agents do not wish to run a bank. If the cost of monitoring is very low then the sound agents can squeeze out the unsound agents by charging a sufficiently low intermediation cost Q. Another way of putting this is that the sound agents' monitoring technology is so much more efficient than the unsound agents' investments that the former can offer a return on deposits which is so attractive to depositors that the latter are never tempted to run a bank themselves, no matter how large the bank: margins are too low.

When the monitoring cost is higher, however, unsound agents will wish to run banks which are sufficiently large. Recall from inspection of UIC that the reason why unsound agents only want to run large banks is that bankers receive fees per unit of deposits managed, while the opportunity cost of forgoing the opportunity to deposit is fixed. Therefore, it might be possible by limiting bank size to prevent unsound agents from setting up and running banks. We explore this possibility in the next section. However, since in the unregulated economy it is impossible for agents to commit to limit the size of their banks, entry by unsound agents can be prevented

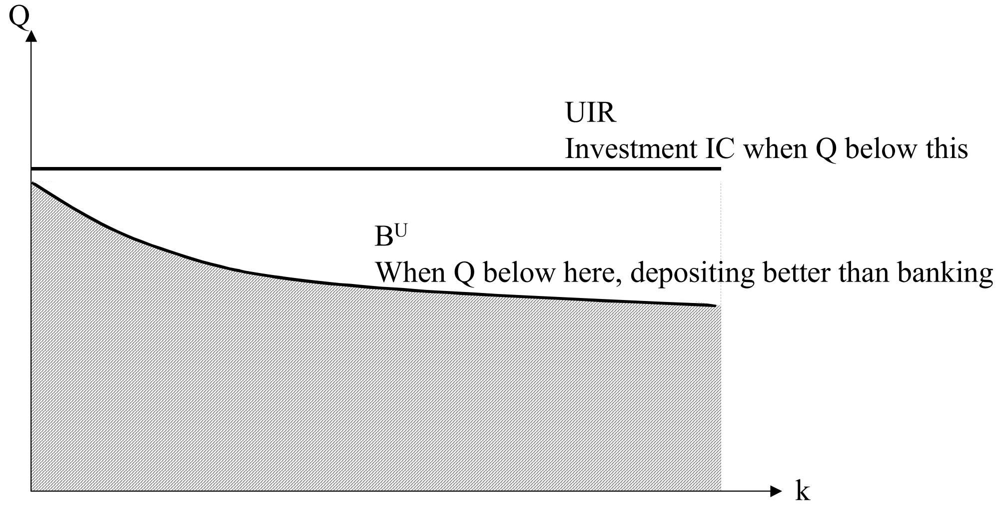

Figure 2: Unsound agent non-banking region.

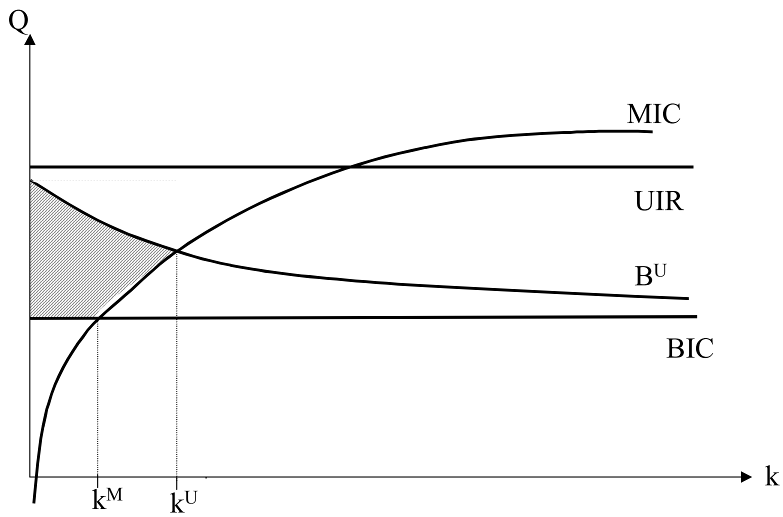

Figure 3: Unregulated equilibria with banks

only if the fraction of informed capital $\frac{\mu}{N}$ is so large that in equilibrium banks will be sufficiently small to deter unsound licence applicants.

Figures 2 and 3 illustrate this result. Figure 2 plots the UIR and B^U lines. Depositing in banks is both individually rational and incentive compatible in the shaded region. Figure 3 combines the regions illustrated in figures 1 and 2 in the case where MIC and B^U cross: the proof of proposition 2 demonstrates that this will occur when $C > \frac{R\Delta p^2}{Np_L+\Delta p}$. Denote by k^U the bank size at which these curves cross. Larger banks than this are not feasible because the payment necessary to induce sound agents to monitor would induce all of the unsound agents to set themselves up as bankers, and thus cause degeneration into autarky. The difficulty for the unregulated economy arises because no one observes or controls the volume of deposits banks accept, so the only realisable bank size is $\frac{N}{\mu}$. Thus, as is evident from the diagram, an efficient unregulated equilibrium is feasible only when $\frac{N}{\mu} \leq k^U$, which reduces to $C \leq C^U$. If the cost of monitoring is too high ($C > C^U$), efficient equilibria are not possible and the only possibility in the absence of regulation is autarky, with each agent investing his own endowment.[6]

For the remainder of the paper we will assume that $C > C^U$ so that unregulated efficient equilibria are not feasible. In the next section, we examine how in this case a regulator can improve upon the unregulated situation.

3. A Regulated Banking Sector

3.1. Regulator Technology and Regulatory Game

Sound agents have valuable monitoring skills which are denied to other agents. When only sound agents run banks it follows that social welfare is maximised by maximising the size of the banking sector. When $C > C^U$ social welfare cannot be maximised in an unregulated market because the cost of motivating the sound agents' monitoring is borne by the depositors, who do not fully internalise the monitoring benefits and hence undervalue them and fail to allocate their capital optimally. In this section we introduce a welfare-maximising agent called the *regulator* whose role is to correct for this market failure by controlling entry to the banking sector.

The regulator has two skills. Firstly, she can observe bank size and can therefore impose capital adequacy ratios by limiting the size of the bank to k times the capital of the banker. Secondly, she has access to an imperfect screening technology for evaluating licence applicant types. The regulator maximises social welfare by ensuring the existence of a sound banking sector and hence maximising the productive capacity of the economy. She is not *per se* concerned with questions of distribution.

The regulator has two policy instruments: she can allocate licences and she can set a capital adequacy requirement. We assume that the regulator awards precisely μ licences. The licence allocation procedure is as follows. The regulator firstly announces the size k of each bank. Agents decide whether or not they wish to apply for a banking licence and licence applicants form a pool from which the regulator samples repeatedly. Sampled applicants are audited: if the audit indicates that they are sound then they are awarded a licence; if it indicates that they are unsound then they are returned to the pool. We are therefore explicitly ruling out policies under which the number of licences awarded is contingent upon the number of licence applicants ("If I receive μ applications then I will award μ licences: otherwise I will award no licences"). We do so this mainly because the joint analysis of the optimal number of licences and size of banks is intractable, but our choice can also be justified on two grounds. Firstly, policies such as this one which rely on threats about off-the-equilibrium path behaviour are often *ex post* sub optimal and are therefore hard credibly to impose. Secondly, such policies also rely upon a precise knowledge of μ and hence may not be robust to imprecise parameter knowledge by the regulator.

There are two types of regulators. The screening technology employed by *good* regulators yields the wrong answer with probability 0; thus if the regulator is good, ex post all banks will turn out to be sound. We assume that the technology employed by *bad* regulators yields

[6] We have illustrated the case where $C < C^U \frac{p_H}{\Delta p}$ so that B^U and BIC do not cross: note that whether or not this occurs is not germane to our discussion as it will always occur for a value of k which exceeds k^U. The crossing point

$$k^B \equiv \frac{Rp_H - C}{Cp_L}\Delta p$$

of BIC and MIC is illustrated. It is easy to show that $k^U > k^B$ as we have drawn it if and only if $R\Delta p > C$, which is equation 1.

a fraction of good banks exactly equal to their fraction in the population of licence applicants, i.e. μ/b.[7] At the cost of reduced algebraic tractability we could endow good regulators with an imperfect technology and bad regulators with a technology which outperforms coin-tossing, but this would not affect our qualitative results. No one (including the regulator) knows the regulator's type. An *ex ante* probability a is assigned that she is good: we call a the regulator's *ability*.

We assume further that after licences are awarded, any regulator can learn through monitoring and auditing about the quality of banks. Specifically, we assume that after deposits have been made and banks have invested, the expected outcome (i.e. Rp_L or Rp_H) of each bank is revealed to the regulator with probability λ. Project type revelation events are independent across banks and λ is independent of the regulator's ability. Since λ is independent of the regulator's ability we interpret it as a parameter reflecting the transparency of banks' accounting procedures. If bank accounting is transparent, regulators are more likely to realise early that a bank is in trouble and can react to save some of the assets for depositors. We assume that after the regulator learns the project's type, she can force the bank to liquidate its investments and distribute its funds to the bank's depositors if she wishes. Liquidation yields a certain return of Rp_L per dollar invested by the bank. It follows that the regulator will never liquidate a sound bank.[8]

Liquidation of unsound banks is *ex post* welfare neutral and hence a commitment to liquidate them will be credible. Such a commitment will be *ex ante* optimal for two reasons. Firstly, unsound agents lose their endowments after liquidation and hence have a reduced incentive to apply for licences. Secondly, since depositors in unsound banks receive a share of the banker's endowment, this makes depositing more attractive. We consider in companion papers the effect upon optimal policy of an inability to perform *ex post* auditing and of repeated play.[9]

Figure 4 illustrates the time line for the game.

Note that all regulators will set k as high as is consistent with the monitoring IC constraint for bankers and with the participation constraint for depositors so as to maximise the volume of monitored investments.

[7] For simplicity, we ignore integer constraints. We could allow the bad regulator's technology to give the wrong answer with probability $\frac{1}{2}$ independently across applicants which would yield the same expected number of good banks and get around the integer constraint problem, but this would result in a random number of good banks, and thence considerably more algebraic complexity without much economic insight. The key idea which we wish to emphasise is that the bad regulator has a technology where the quality of the banking sector depends on the quality of the applicant pool.

[8] This set-up can also be interpreted as a reduced form for the idea that with transparent accounting systems, the general public will learn the likely project outcome for each bank with probability λ and that they will then be able to run on the bank. Suppose that their expected payoff from running is π. If the expected outcome is Rp_L, the depositors will run on the bank in order to stake their claim to $\pi > (R - Q)\, p_L$ now, rather than waiting until next period. Note that they will not run on sound banks as long as $(R-Q)p_H > \pi$, which must be the case or no bank could expect to surivive until its investments matured. If we keep this underlying model in mind, then the independence of λ from regulator ability seems more compelling. A system can be *ex post* transparent without the regulator having any particular skill in awarding licences *ex ante*. This interpretation also provides a role for "market discipline" in our model. We could, however, also allow λ to vary with regulator reputation. Our substantive results would be largely unaffected, but prospects would be much grimmer for regulators with poor reputations. In this respect, our model shows that forcing banks to report their earnings promptly and transparently offers a glimmer of hope for regulators in otherwise difficult circumstances.

[9] Morrison and White (2001a) examines the case where $\lambda = 0$. We demonstrate that in this case, deposit insurance is sometimes necessary to ensure the existence of a banking sector. In Morrison and White (2001b), we consider a repeated game and analyse the effects of reputational concerns upon the regulator's decision to liquidate low quality banks.

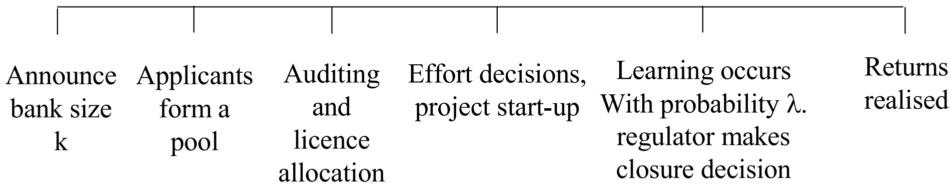

Figure 4: Time line for the regulator game.

3.2. Constraints with Regulation

Restricting k may result in equilibrium in deposit rationing. We assume that when the demand for deposit contracts exceeds their availability all depositors invest an equal proportion of their funds in a bank and self-manage the remainder. Note that in equilibrium no sound agent without a licence will wish to deposit, since at best he will deposit with another sound agent who will charge Q for managing his deposit. Suppose that in addition, all unsound agents without a licence will wish to deposit: we substantiate this claim below. If there are μ banks of which $s \leq \mu$ are sound then unsound agents will manage to deposit only the following fraction of their endowment:

$$\frac{(k-1)\,\mu}{N-\mu-(\mu-s)} = \frac{(k-1)\,\mu}{N-2\mu+s}; \tag{4}$$

the numerator of this expression is the volume of permitted deposits, equal to the total size of the banking sector less the endowment of the bankers, and the denominator is the number of agents wishing to deposit, equal to the number of agents without licences minus the number of sound agents without licences. The regulator's screening activities do not affect the incentives of the sound agents, but her ability to perform *ex post* auditing does. This is because with probability λ the regulator now discovers that a sound agent has not monitored and forces liquidation (i.e. confiscates her capital and earnings and redistributes it to depositors).[10] The incentive to monitor is thus improved, and the monitoring IC constraint becomes $(R+Q\,(k-1))\,p_H - C \geq (1-\lambda)\,(R+Q\,(k-1))\,p_L$, or

$$Q \geq MIC\,(k,\lambda) \equiv \frac{Ck - R\,(\Delta p + \lambda p_L)}{(k-1)\,(\Delta p + \lambda p_L)}.$$

The incentives of the unsound agents in the regulated economy are also altered, for three reasons. Firstly, the fact that the regulator audits banks may improve their confidence in the banking system and make them more willing to invest; secondly, the regulator sets limits on bank size which may cause rationing of banking services if they choose to invest in the banking system; and thirdly, the redistribution of liquidated banker funds renders bank depositing more attractive to them. Notwithstanding the changed incentives, we are still able to establish a result analogous to 1:

PROPOSITION 3 *Provided $N > 2\mu$, there are no asymmetric pure strategy equilibria in the regulated economy.*

[10]Note that none of our substantive results would change if the regulator never learned when sound agents failed to monitor (i.e. that instead of revealing expected outcomes, λ revealed only the type of the agent running the bank). We make this assumption for modelling consistency, and also in the belief that empirically it is easier for regulators to observe whether a bank's projects are profitable or not than to observe why they are not profitable.

Proof. In the appendix. □

Proposition 3 tells us that only two belief sets are rational for unsound agents: either they believe that whenever possible all agents will apply to the regulator for a banking licence, or they believe that only sound agents will apply for a licence. In the former case the likely quality of a randomly chosen bank is lower than in the latter, when all banks will be sound, independently of the regulator's ability. We therefore call the former beliefs *pessimistic* and the latter ones *optimistic*. The above argument demonstrates that some rationing will be necessary when pessimistic expectations obtain and regulators have low screening ability.

It is convenient when reasoning about the regulated economy to define the quantities $\mathcal{L}$ and $\mathcal{G}$ to be respectively the expected loss and gain which an unsound agent experiences when making a deposit in an unsound or a sound bank, compared to managing his own project. Then

$$\begin{aligned}\mathcal{L} &= Rp_L - \left\{(R-Q)(1-\lambda)p_L + \lambda Rp_L\frac{k}{k-1}\right\},\\ \mathcal{G} &= (R-Q)p_H - Rp_L = R\Delta p - Qp_H.\end{aligned}$$

With this notation, the expected return to an unsound agent of banking is

$$Rp_L + \mathcal{L}(k-1),$$

the expected income from depositing when there are optimistic expectations is

$$Rp_L + \frac{(k-1)\mu}{N-\mu}\mathcal{G},$$

and the expected income from depositing when pessimistic expectations obtain is

$$Rp_L + \frac{(k-1)\mu}{N-\mu}\left[a\mathcal{G} + \frac{(1-a)}{N-\mu}\left(\mu\mathcal{G} - (N-\mu)\mathcal{L}\right)\right].$$

The first of the terms in the square brackets corresponds to the case where the regulator is good and the second to the case where the regulator is bad. In this case, note that the rationing fraction is modified in line with equation 4 and that the depositor will make a profit or a loss, according to the type of banker which he encounters.

Optimistic expectations are sustainable only if unsound agents prefer bank investment to licence application when it is anticipate that only sound agents will manage banks. In other words, if the return from depositing exceeds that from banking, given that there are optimistic expectations:

$$\frac{\mu}{N-\mu}\mathcal{G} \geq \mathcal{L}. \tag{OPIC}$$

Rearranging gives us the following equivalent expression in (k, Q) space:

$$Q \leq B^O(k) \equiv \frac{R\left(\mu\Delta p + \lambda p_L\left(\frac{N-\mu}{k-1}\right)\right)}{N(1-\lambda)p_L + \mu(p_H - (1-\lambda)p_L)}.$$

Similarly, pessimistic beliefs are sustainable only if unsound agents prefer to apply for a banking licence rather than to invest in a bank when they anticipate that all agents will apply for a banking licence:

$$\mathcal{L}(N-a\mu) \geq \mathcal{G}\mu\left(\frac{aN-2a\mu+\mu}{N-\mu}\right). \tag{PESSIC}$$

This equation can similarly be rearranged to give a necessary condition $Q \geq B^P(a,k)$ in (k,Q) space for pessimistic beliefs to obtain.

The IR condition for unsound agents to invest in a bank rather than to run their own project when there are pessimistic beliefs is the following:

$$\frac{aN - 2a\mu + \mu}{N - \mu}\mathcal{G} \geq (1-a)\mathcal{L}, \tag{RIR}$$

or

$$Q \leq R_{IR}(a,k) \equiv R\frac{(aN - 2a\mu + \mu)\Delta p + \frac{\lambda p_L}{k-1}(1-a)(N-\mu)}{p_H(aN - 2a\mu + \mu) + p_L(1-a)(N-\mu)(1-\lambda)}.$$

Finally, define $B^{OP}(a,k)$ to be the locus of points in (k,Q) space along which unsound agents are indifferent between banking and running their own projects. Along B^{OP}, $Rp_L + \mathcal{L}(k-1) = Rp_L$ or

$$\mathcal{L} = 0. \tag{BOP}$$

Hence $B^{OP}(a,k) = \lambda\frac{R}{k-1}$.

We can re-write the BIC constraint as follows:

$$\mathcal{G} = R\Delta p - C. \tag{BIC1}$$

We now determine the properties of $B^O(k)$, $B^P(a,k)$ and $B_{IR}(a,k)$ and we demonstrate that, at relevant parameter values, B^{OP} lies below all of these lines. We will be concerned with equilibria in which one of the three constraints OPIC, PESSIC, RIR is binding and it therefore follows that agents will always prefer banking to running their own project. In consequence, we will be able to disregard B^{OP} for the remainder of the paper.

PROPOSITION 4 *$B^O(k)$, $B^P(a,k)$, $B^{OP}(a,k)$ and $R^{IR}(a,k)$ have a common intersection point which is above BIC. All four lines are decreasing in k. For values of k to the right of the intersection point, R^{IR} and B^P are increasing in a and $B^{OP} < B^P \leq B^O \leq R^{IR}$.*

Proof. It is clear from equations OPIC, PESSIC, BOP and RIR that the four lines all pass through $(\mathcal{L}=0, \mathcal{G}=0)$, or $\left(Q = R\frac{\Delta p}{p_H}, k = 1 + \lambda\frac{p_H}{\Delta p(1-\lambda)}\right)$. Equation BIC1 implies that $\mathcal{G} > 0$ on BIC and hence that intersection point must occur for $Q > BIC$.

To differentiate with respect to k, note that $\frac{d\mathcal{L}}{dk} = \frac{dQ}{dk}(1-\lambda)p_L + \lambda R\frac{p_L}{(k-1)^2}$ and $\frac{d\mathcal{G}}{dk} = -\frac{dQ}{dk}p_H$, whence, using OPIC, $\frac{dB^{OP}}{dk}\left[(1-\lambda)p_L + \mu\frac{p_H}{N-\mu}\right] + \lambda R\frac{p_L}{(k-1)^2} = 0$ and $\frac{dB^{OP}}{dk} < 0$. The result for the other lines follows similarly.

That R^{IR} and B^P are decreasing in a is proved by straightforward differentiation: the details appear in the appendix. Finally, it is easy to demonstrate by direct substitution of the expression for $\frac{dB^P}{dk}$ that $\frac{d\mathcal{L}}{dk} > 0$ along B^P and hence that to the right of the intersection point, $\mathcal{L} > 0$ on B^P. Since $\frac{\partial \mathcal{L}}{\partial Q} = (1-\lambda)p_L > 0$, it follows that $B^{OP} < B^P$ to the right of the intersection point. Since $B^P(a=1,k) = B^O(k)$ and we have shown that B^P is increasing in a, $B^P \leq B^O$. Finally, it is immediately apparent from equations OPIC and RIR that $R^{IR}(a=0,k) = B^O(k)$ and since R^{IR} is increasing in a, that $B^O \leq R^{IR}$. □

The result is illustrated in figure 5. The intuition for it as follows. Along B^P, unsound agents are indifferent between depositing and running a bank when expectations are pessimistic. It follows that on this line they gain nothing more from running a bank than they would from depositing. When B^P intersects with RIR, it follows that depositors, who are indifferent

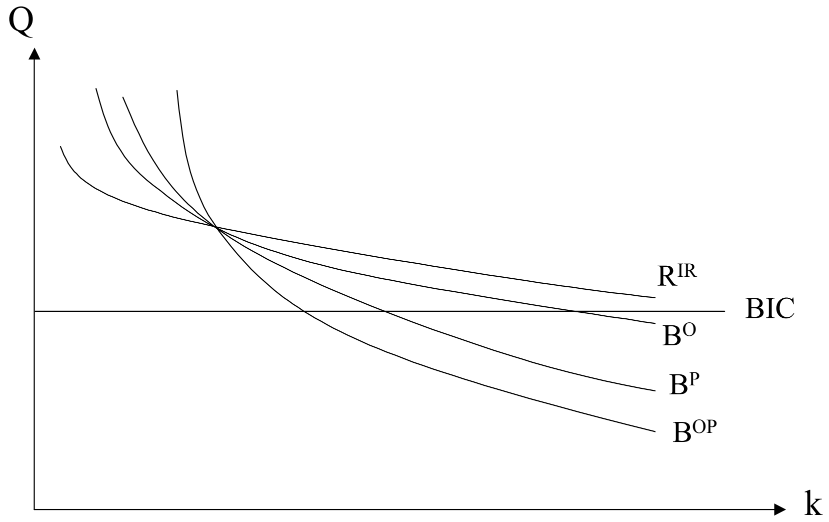

Figure 5: Regulated economy constraints.

between their own projects and running a bank, extract Rp_L from depositing. Since at this point there is no advantage from unsound banking, it follows that sound bankers extract all of the surplus which they make, so that depositors are in addition indifferent between their own projects and investment in a bank when expectations are optimistic.

For the second part of the proposition, at the intersection point depositors are indifferent between investing in sound and unsound banks. For smaller banks, they actually anticipate a gain from the *ex post* disbursement of unsound banker funds and hence prefer to invest in unsound banks. This renders the indifference point B^P for pessimistic assumptions above that for optimistic assumptions, B^O. This becomes increasingly true as the regulator's ability worsens and hence B^P increases as a decreases. Similarly, for $k > 1 + \lambda \frac{p_H}{\Delta p(1-\lambda)}$, the redistributive benefits associated with investment in an unsound bank are outweighed by its inability to monitor and hence the effect is reversed.

3.3. Optimal Policy Selection

The regulator's role is to maximise social welfare. She can adopt either of two policies. Firstly, she can limit k and adopt a *tight capital adequacy policy* so as to ensure that only sound agents find banking attractive. Secondly, she can adopt a *loose capital adequacy policy.* This will result in larger banks which will attract unsound bankers so that the average quality of banks will be lower. To understand how the policies work, define k^P and k^{MP} to be respectively the intersection points of B^P with BIC and MIC, and let k^O, k^{MO} and k^R, k^{MR} be the corresponding points for B^O and R^{IR}.

(i) Tight Regulatory Policy

The region within which the regulator can achieve the tight capital adequacy policy is illustrated in Figure 6. As in the unregulated case, she requires both banking and monitoring to be incentive compatible for sound agents, so that Q and k will be selected to lie above BIC and MIC. She also requires unsound agents to prefer depositing to banking: this requires that the

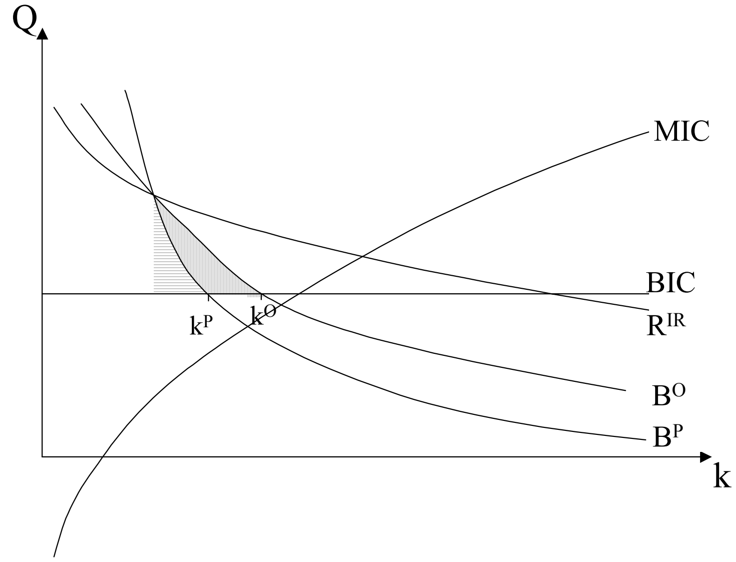

Figure 6: Tight capital adequacy policy.

(Q, k) pair lies below the B^P line in the case where there are pessimistic expectations and below the B^O line when there are optimistic expectations. These cases correspond respectively to the regions shaded with horizontal and vertical lines. Note that when the regulator employs this policy, she is using capital requirements to exclude unsound agents from the banking market: in other words, to resolve an *adverse selection* problem. It is clear from the diagram that the regulator will set k equal to k^O when optimistic expectations obtain and to k^P when pessimistic expectations obtain. Furthermore, by proposition 4, k^P and k^{PM} will both decrease as a worsens, so that the maximum size for the banking sector with pessimistic expectations will fall as a falls. When there are optimistic expectations, however, the size of the banking sector under tight regulation is independent of regulatory ability, as it is anticipated that only sound agents will apply for licences (and the MIC constraint does not bind) so the regulator's ability is entirely irrelevant.

(ii) Loose Regulatory Policy

Figure 7 indicates the region within which the regulator can achieve the loose capital requirements policy. In this case, the B^P and B^O constraints are violated, so (Q, k) pairs will lie above the respective lines and all agents will apply for a banking licence. In this case, the regulator's policy will be constrained only by the requirement that unsound agents prefer depositing to managing their own project: in other words, (Q, k) must lie below the R^{IR} line, at the minimum of k^R and k^{MR}. For high abilities a, RIR will be relatively flat and the size of banks will be k^{MR}. In this case, the MIC constraint also binds and the regulator is therefore setting capital requirements in order to resolve a *moral hazard* problem. Proposition 4 demonstrates that min $\left(k^R, k^{MR}\right)$ will drop as a drops and hence that the maximum size of the banking sector with loose capital requirements will fall as regulator ability falls.

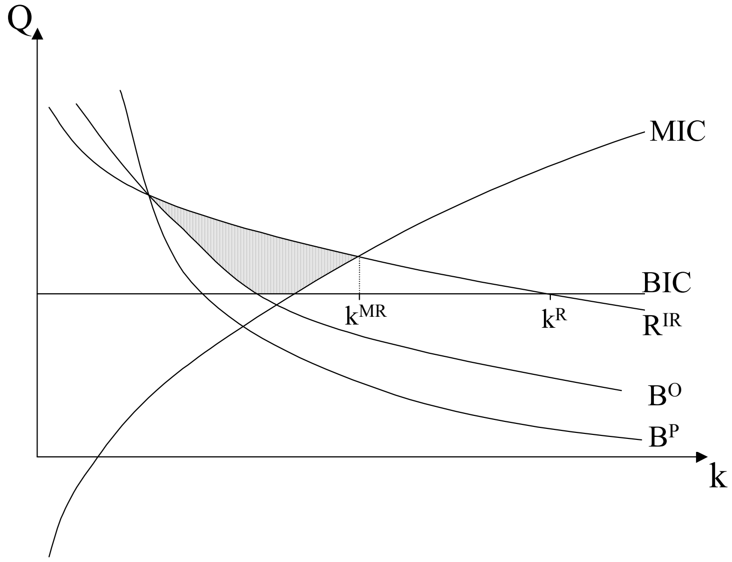

Figure 7: Loose capital adequacy policy.

(iii) Policy Choice

In choosing between the tight and the loose capital policies identified above, the regulator is attempting to maximise the productive capacity of the economy. She must therefore weigh up the benefits which come from a large banking sector (in which sound bankers maximise the productivity of their investments) and the concomitant costs of a lower average quality of banker. The better the regulator's reputation, the larger the banking sector with loose capital requirements can be and the higher the average quality of the banks within it. This section is relatively technical and can be skipped in a first reading. The results of the analysis are summarised in the following subsection.

Before examining the trade-off in detail, we establish some elementary facts about the geometry of the curves MIC, $B^O(k)$ and $B^P(a,k)$. Recall that k^O and k^P are the respective intersection points of B^O and B^P with BIC. k^M is the intersection between MIC and BIC, i.e the bank size at which sound agents' monitoring constraint becomes stronger than their participation constraint. Proposition 5 examines the properties of these intersection points:

Proposition 5 *$k^O < k^P$. Furthermore, either $k^O < k^M < \frac{N}{\mu}$ or $k^O > k^M > \frac{N}{\mu}$. Finally, $k^M > \frac{N}{\mu}$ if and only if*

$$\lambda > \lambda^M \equiv \frac{CNp_L - (Rp_H - C)\,\mu\Delta p}{CN(N-\mu)\,p_L + \mu^2 p_H (R\Delta p - C)}.$$

Proof. Substituting $Q = \frac{C}{p_H}$ into equations OPIC, MIC and MIC yields

$$\begin{aligned}
k^O &= 1 + \frac{\lambda R (N-\mu)\, p_L p_H}{C(1-\lambda)(N-\mu)\,p_L - (R\Delta p - C)\,\mu p_H},\\
k^M &= 1 + \frac{((R\Delta p + \lambda p_L) - C)\,p_H}{(1-\lambda)\,Cp_L},\\
k^P &= 1 + \frac{\lambda R p_H p_L N (N-\mu)}{CN(N-\mu)(1-\lambda)\,p_L - \mu^2 p_H (R\Delta p - C)}.
\end{aligned}$$

Simple manipulations give us

$$k^O < k^M \text{ iff } k^O < \frac{N}{\mu} \text{ iff } k^M < \frac{N}{\mu}.$$

The expression for λ^M is also the product of straightforward manipulations.[11] □

To understand how the trade-off is made, consider firstly the case where optimistic expectations obtain. Proposition 5 tells us that the only interesting case is where $\lambda < \lambda^M$ (since otherwise the regulator will successfully screen out unsound bankers by simply setting $k = \frac{N}{\mu}$) and we therefore restrict ourselves to this. The regulator then has to choose between imposing loose capital requirements of $\min\left(k^R, k^{MR}\right)$ and tight capital requirements of k^O. Recall from proposition 4 that $R^{IR}(a,k)$ is decreasing in k. It follows from examination of figure 6 that the maximum size of a bank in a loose regulatory environment drops along with the quality of the average bank as the regulator's reputation a drops. In other words, the social welfare derived from a loose capital adequacy policy drops monotonically as a drops. When optimistic expectations obtain unsound agents will not apply for licences whenever such a policy is feasible and hence $B^O(k)$ and k^O are not dependent upon a. Proposition 6 demonstrates that there exists a_O^* such that the regulator selects a tight capital adequacy policy precisely when $a < a_O^*$.

PROPOSITION 6 *When optimistic expectations obtain, there exists* $a_O^*(C,\lambda) > 0$ *such that the regulator prefers a tight capital adequacy policy precisely when* $a < a_O^*(C,\lambda)$.

Proof. Substitute $a = 0$ into RIR and OPIC to see that B^O and R^{IR} coincide when $a = 0$, so that the regulator will definitely choose tight requirements over loose when $a = 0$. Since the welfare obtained from tight capital requirements is not reputation dependent under optimistic expectations and that obtained from loose capital requirements monotonically decreases as a drops the result follows immediately. □

The case with pessimistic expectations is more complicated because both $B^P(a,k)$ and $R^{IR}(a,k)$ are decreasing in a so that the welfare derived from both tight and loose capital adequacy policies is monotonically decreasing as a drops. To understand the regulator's decision, we must consider two cases: where k^R is respectively less than and greater than k^M. In the first case, the relevant intersection point for both B^P and R^{IR} is with the horizontal line BIC. Manipulation of the relevant expressions allows us to show that

$$k^R < k^M \text{ iff } \lambda < \lambda^*(C,a) \equiv 1 - \frac{(Rp_H - C)\,p_H}{C\left(\frac{1-a}{\mu + a(N-\mu)}\right)(N-\mu)\,p_L + Rp_Lp_H},$$

[11] The expressions for k^O and k^P reveal the subtle yet important role played by the transparency of the system, λ. If the probability of ex post revelation of poor investment decisions is zero, then $k^O = k^P = 1$ and the economy is in autarky. In other words, capital requirements can be used to solve adverse selection problems only if the system has some transparency. This is not obvious, and would not be true in a partial equilibrium model. The simple intuition for the benefit of capital requirements is the following. Sound banks must receive payments roughly in proportion to the size of the bank to be induced to monitor, and this tends to attract unsound agents into the banking system. In a partial equilibrium setting one would expect limiting bank size through capital requirements to make entry by unsound agents unattractive, even when there is no possibility of *ex post* confiscation of assets by the regulator. In a general equilibrium model this is not enough, however, because unsound agents' best outside option is to deposit in the banking system. An increase in capital requirements then not only leads to a decrease in the attractiveness of running a bank, but also, as a consequence of rationing effects, to a decrease in the probability of being able to invest in a bank. Both of these effects are in direct proportion to the size of the banking sector. Thus the net effect on unsound agents incentive constraint is zero, *unless* managing a bank also entails the additional risk (not proportional to the size of the banking sector) of having one's capital confiscated (i.e. unless $\lambda \neq 0$). These issues are explored further in Morrison and White (2001a).

and it can be shown by direct differentiation that $\frac{\partial\lambda^*}{\partial C} > 0$ and $\frac{\partial\lambda^*}{\partial a} < 0$. Define the *welfare gap* to be the difference per bank between the welfare of the tight capital policy and the loose one. The welfare gap is obtained by subtracting the volume of monitored depositor funds managed by the representative bank in each economy:

$$WG^{PESS} = \left(k^P - 1\right) - \left(k^R - 1\right) \frac{(\mu + a(N - \mu))}{N}$$

For $\lambda < \lambda^*$ the regulator will select a tight policy over a loose policy precisely when the welfare gap is positive. The region where this occurs is bounded by a curve λ^F which is obtained by direct substitution into the expression for WG^{PESS}. Implicit differentiation of this expression gives us

$$\frac{\partial\lambda^F}{\partial C} > 0, \frac{\partial\lambda^F}{\partial a} > 0.$$

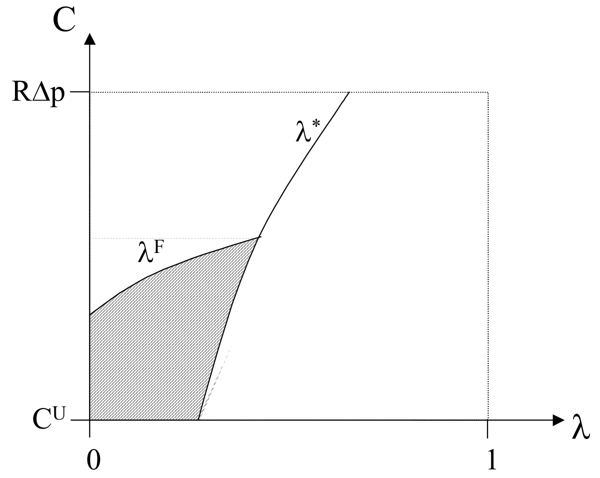

Figure 8: Policy selection when $k^R < k^M$.

This situation is illustrated in figure 8, which illustrates all possible (λ, C) pairs in regulated economies. For $\lambda < \lambda^*$, the regulator will select the tight capital adequacy policy in the shaded region. The size of this region increases as a drops so that tight regulatory policies have increasing utility for lower reputations. Note that as C increases the value of a tight regulatory policy decreases. This is because to render monitoring incentive compatible for sound bankers one has to give them a higher level of compensation Q and this attracts more unsound bankers. To avoid their participation one has to reduce the bank size still further with tight capital requirements: in so doing, one reduces the welfare level in tightly regulated economies.

For $\lambda > \lambda^*$, the situation is slightly more complicated. The size of a loosely regulated economy is determined by the intersection k^{MR} between the R^{IR} line and the MIC line, provided this is less than $\frac{N}{\mu}$: it is otherwise equal to $\frac{N}{\mu}$. The dividing line between these two regions is shown in figure 7 as λ^I. To understand the behaviour of the chart between λ^* and λ^I, recall that the welfare level in a loosely regulated economy is an increasing function of the bank size, which is determined by the intersection point between the R^{IR} line and either BIC or MIC. Since R^{IR} varies with a and neither MIC nor BIC does, the welfare elasticity of the loosely regulated economy with respect to ability is dependent upon the slope of either BIC or MIC. Consider an economy situated at the intersection point between λ^F and λ^* so that the regulator is indifferent between tightly and loosely regulated economies. The welfare elasticity of the loosely regulated economy will be determined for marginally higher λ by the positive slope of the MIC line and will therefore be less than the elasticity for marginally lower λ, which depends upon the flat BIC line. It follows that a marginal increase in λ will increase the welfare in the tightly regulated economy further than in the loosely regulated economy so that *ceteris paribus* the tightly regulated economy is strictly preferred. For this reason the slope of the border λ^G between tightly and loosely regulated economies experiences a discontinuous upwards jump at λ^*.

When $\lambda > \lambda^I$ the tightly regulated economy becomes increasingly attractive for higher λ, while the loosely regulated economy has constant size and hence yields a constant welfare level and so the border λ^H becomes steeper still. For $\lambda > \lambda^J$, $k^{PB} = \frac{N}{\mu}$ and the regulator will always select the tight regulatory policy.

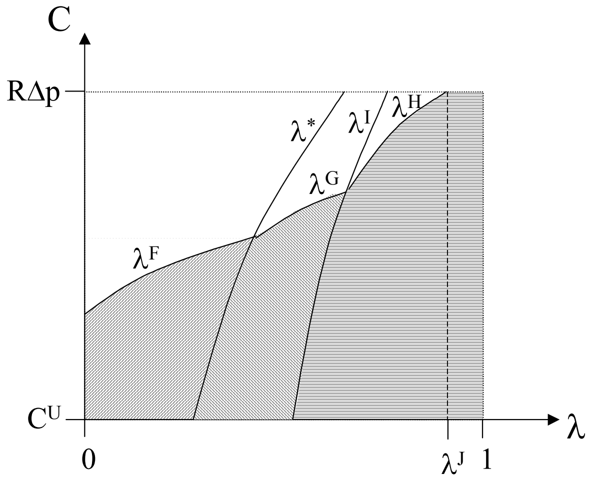

Figure 9: Policy selection for all k^R.

The shaded region in figure 9 illustrates every possible (C, λ) pair at which the tightly regulated economy is preferred to the loosely regulated economy. The size of the shaded region expands as the regulator's ability drops, but it does not expand to fill the entire parameter range. We summarise our discussion in the following proposition.

Proposition 7 *When pessimistic expectations obtain there exists* $a_P^*(C, \lambda)$*, possibly equal to* 0*, such that the regulator prefers a tight capital adequacy policy precisely when* $a < a_P^*(C, \lambda)$.

(iv) Optimal Regulatory Policy

The results of the foregoing analysis are summarised in figure 10, which depicts the optimal choice of capital requirements as a function of regulator reputation. Regulators with high reputation ($a > a_O^*(C, \lambda)$) will follow a loose capital adequacy policy, using capital requirements mainly to solve moral hazard problems and relying on their auditing ability to resolve the adverse selection problem. On the other hand, regulators with very poor reputation ($a < a_P(C, \lambda)$) will prefer to follow a tight capital requirement policy.[12] This "small is beautiful" approach is

[12] We have illustrated the case where regulators with poor reputation prefer to follow a tight regulatory policy with pessimistic expectations. As discussed in the previous subsection, this may or may not occur, depending on parameter values. If it does not occur, the distinction between regulators with poor and medium reputations becomes degenerate.

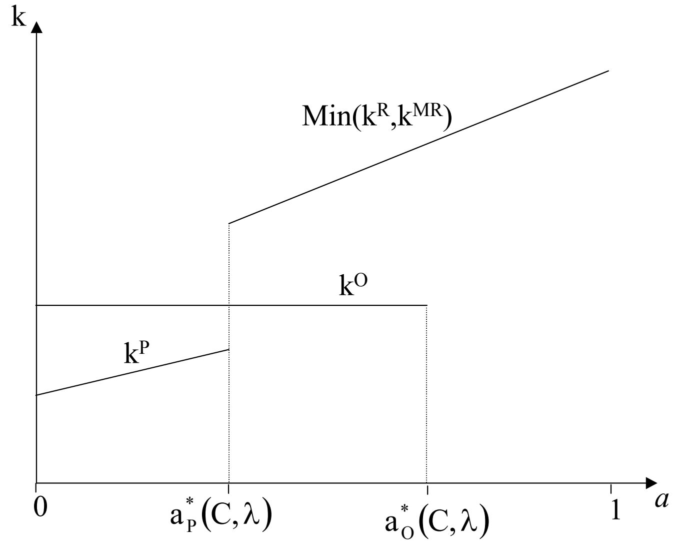

Figure 10: Bank size vs. regulator reputation.

optimal because tight regulation substitutes for their lack of screening ability and hence yields a quality gain whose welfare effects more than offset the losses in production from a smaller banking sector. Conversely, good regulators can mostly solve the adverse selection problem through *ex ante* screening and hence experience a relatively small quality gain from a move to tight regulation.

The optimal capital policy for regulators with a medium reputation for screening ($a_O(C, \lambda) > a > a_P(C, \lambda)$) is contingent upon expectations. It transpires that these regulators will choose to copy the loose capital policy of higher reputation regulators when expectations are pessimistic, and will employ the tight capital policy of lower reputation regulators when expectations are optimistic. The reasons are as follows. When pessimistic expectations obtain a severe contraction of the banking system is required to exclude unsound banking licence applicants and interim quality regulators will prefer to set loose capital requirements and to fall back upon their *ex ante* screening technology. With optimistic expectations the use of capital adequacy requirements completely to resolve the adverse selection problem entails a less significant cost in terms of reduction in the size of the banking sector and interim quality regulators will therefore choose to set tight capital adequacy requirements.

3.4. Banking Crises

Our model admits two possible sets of rationally-held (self-fulfilling) beliefs. Proposition 3 demonstrates that unsound agents can have optimistic expectations about the quality of the banking sector, in which case they will refrain from licence application, or they can have pessimistic expectations, in which case they will all apply for a licence whenever this is desirable. Suppose that a shift in occurs from optimistic to pessimistic expectations when a tight capital adequacy policy is in place. Such a change could be interpreted as a 'crisis of confidence' in the banking system. Notice that this can rationally occur independently of any change in fundamentals or in the regulator's reputation. In this case, the regulator can select one of two courses of action.

Firstly, she can elect to retain a tight capital adequacy policy. She will do so precisely when $a < a_P^* (C, \lambda)$. In this case she will react to the lowering of expectations by tightening capital requirements from k^O to $k^P < k^O$. In other words, she will optimally *institute* a credit crunch as the optimal *response* to a crisis of confidence. This prediction is in contradiction to other stories in which confidence crises are a consequence of credit crunches. Our model could thus explain the credit crunch of the late 1980s when capital requirements were significantly tightened in response to concern over banks' exposure to derivatives markets and over their losses in loans to less developed countries.

The second possible response to a crisis of confidence is to relax capital requirements and to adopt a loose capital adequacy policy. This will occur when $a_P^* (C, \lambda) < a < a_O^* (C, \lambda)$. In this case the regulator allows expectations to become self-fulfilling. Our model thus demonstrates that relatively strong regulators will elect to fall back upon their reputation when there is public concern over the quality of banks.

One could also consider a simple extension of our model where the regulator is unsure *ex ante* whether the public's expectations will be optimistic or pessimistic and has to choose her regulatory policy before they are revealed to her. Then assuming that the regulator's reputation is sufficiently poor that she wishes to set capital levels to solve the adverse selection problem, two forms of regulation are possible. The regulator can hope for optimistic expectations and follow a looser regulatory policy ($k = k^O$) which will maximise the size of banks and so allow the largest possible amount of funds to be channelled into profitable investments. But if she does so the economy will be vulnerable to panics if expectations turn out instead to be pessimistic. Alternatively she can follow a tighter regulation policy ($k = k^P$) which ensures that panics will not occur despite her poor reputation for auditing, but this means that when expectations are optimistic the banking sector is inefficiently small, and so output is inefficiently low. So the regulator faces a trade-off between inefficiently limiting production and avoiding crises of confidence. It is should be clear that it may in fact be optimal to allow the economy to be vulnerable to panics if these occur with sufficiently low probability and if the regulator expects to be able to react quickly enough by changing policy. Thus in our model a banking crisis does not necessarily constitute evidence of bad regulatory policy.

4. Conclusion

In recent years, banking crises have become increasingly common and increasingly expensive to deal with. Prudential regulation of banks is supposed to prevent or at least to reduce the frequency of such crises. In this paper we have examined the role of the regulator in the auditing of banks and in the setting of capital requirements in preventing crises. In doing this we departed from the existing debate in the literature, which has largely ignored the impact of regulator reputation on policy. We have shown that *if public confidence in the regulator's ability to detect bad banks through audit is sufficiently high then crises will not occur.* Capital adequacy requirements are then useful mainly in restricting bank size to be small enough to avoid moral hazard problems. Such regulation can be looser the better is the regulator's reputation for auditing banks. We also show that capital regulation can be looser in economies where accounting procedures are more transparent.

On the other hand, if the regulator's reputation is poor, then crises may occur. The regulator then has several policy options. She can follow a loose regulation policy which will maximise the size of banks and so allow the largest possible amount of funds to be channelled into profitable investments. But if she does so, the quality of the banking sector will be low. Alternatively she can follow a tight regulation policy which raises the average quality of the banking system, at the cost of reducing its size. Other things being equal, poor regulators must always follow tighter capital regulation policy than good regulators.

Existing international regulation of bank capital focuses on the need to ensure a "level playing field" to ensure fair competition among financial institutions from different countries. Our analysis suggests that this emphasis may be misplaced, since within a given country it is optimal to have stricter regulations when expectations are pessimistic, when accounting is less transparent, and the regulator's reputation for identifying incompetent banks gets worse. In other words, a less competent regulator should impose tighter capital adequacy requirements. This suggests that other things being equal we should not impose a uniform standard across all countries, as is currently *de facto* the case with the Basle accord. Such a one-size-fits-all approach is likely to precipitate crises in countries with poor regulators and inefficiently limit bank size in economies with very competent regulators. Instead, a better policy would be to tie the laxity of capital requirements in an economy to a measure of the 'reputation' of that economy's banking regulator for rooting out problems before they occur. For example, if a country has experienced few bank collapses in the past, this country could be allowed to have looser capital requirements than one which has experienced frequent banking crises. Although outside the scope of this paper, one can also imagine that such a structure might have other beneficial effects, such as enhancing the incentives for efficient oversight by banking regulators and indeed 'peer-monitoring' among banks. Indeed, de facto some regulators with less strong reputations for oversight have already moved in this direction by imposing tighter regulation than the Basle Accord requires. This fact may seem difficult to rationalise if one thinks of regulators as trying to improve the position of their own financial institutions in the world; yet makes perfect sense within the context of our theory, because regulators can substitute for the public's lack of confidence in their lack of screening ability by imposing tighter regulation.

References

Bhattacharya, S.: 1982, Aspects of monetary and banking theory and moral hazard, *Journal of Finance* **37**(2), 371 – 84.

Dewatripont, M. and Tirole, J.: 1993a, Efficient governance structure, *in* C. Mayer and X. Vives (eds), *Capital Markets and Financial Intermediation*, Cambridge University Press, Cambridge, U.K.

Dewatripont, M. and Tirole, J.: 1993b, *The Prudential Regulation of Banks*, MIT, Cambridge, Mass.

Diamond, D. W. and Dybvig, P.: 1983, Bank runs, deposit insurance and liquidity, *Journal of Political Economy* **91**, 401–19.

Diamond, D. W. and Rajan, R. G.: 2000, A theory of bank capital, *Journal of Finance* **55**(6), 2431 – 2465.

Holmström, B. and Tirole, J.: 1997, Financial intermediation, loanable funds and the real sector, *Quarterly Journal of Economics* **112**(3), 663 – 691.

Morrison, A. D. and White, L.: 2001a, Deposit insurance, incentives and welfare, *Working paper*, Oxford Financial Research Center, University of Oxford.

Morrison, A. D. and White, L.: 2001b, Should banking regulators have fixed term contracts?, *Working paper*, Oxford Financial Research Center, University of Oxford.

Rochet, J.: 1992, Capital requirements and the behaviour of commercial banks, *European Economic Review* **36**, 1137–1178.

Appendix

Proof of Proposition 3

Suppose that b agents apply for a licence in a rational economy and that the regulator has ability a. Let

$$\alpha_b = a + (1-a)\frac{\mu}{b}$$

be the probability that an arbitrary bank is sound and let r_b be the expected payout from investment in a bank:

$$r_b = \alpha_b (R-Q) p_H + (1-\alpha_b)\left\{(1-\lambda)(R-Q)p_L + \lambda R p_L \frac{k}{k-1}\right\}.$$

The first of these terms is the expected return from investing in a sound bank. The expression in curly brackets is the return from investing in an unsound bank: the first of the terms gives the expected return if the bank's quality is not detected by the regulator and the second includes the redistribution of banker funds in the event that the bank's low quality is detected. Finally, note that the income which unsound bankers earn from running an unsound bank is $(1-\lambda)(R+(k-1)Q)p_L$.

Let R_b be the proportion of wealth which a depositor will invest in a bank given that the regulator is bad. As we demonstrate in section 3.2, $R_b = \frac{(\mu-1)\mu}{N-2\mu+\frac{\mu^2}{b}}$. In any asymmetric pure strategy rational equilibrium, unsound depositors must prefer not to become bankers and unsound bankers must prefer not to become depositors. In other words,

$$R_b r_b + (1-R_b) R p_L \geq (1-\lambda)[R+(k-1)Q] p_L \geq R_{b-1} r_{b-1} + (1-R_{b-1}) R p_L. \qquad (5)$$

When an unsound agent applies for a licence, he knows that he will be unsuccessful and hence will be a depositor if $a=1$. It follows that it suffices to show that 5 cannot be satisfied when $a=0$. Straightforward manipulation yields:

$$\begin{aligned}&\frac{\partial}{\partial b}\left[R_b(r_b - Rp_L) + Rp_L\right]_{a=0}\\ &= \frac{\mu^2(k-1)}{b^2\left(N-2\mu+\frac{\mu^2}{b}\right)}\left\{\left[(R-Q)(\Delta p + p_L) - p_L R\lambda\frac{k}{k-1}\right]\left(\frac{\mu^2}{(N-2\mu)b+\mu^2}-1\right)\right.\\ &\qquad\left.+\frac{\mu}{N-2\mu+\frac{\mu^2}{b}}\left[(1-\lambda)(R-Q)p_L - \frac{Rp_L}{k-1}(k(\lambda+1)-1)\right]\right\}.\end{aligned}$$

Since $N > 2\mu$, the first of these terms is clearly negative. The second term has the same sign as $(1-\lambda)(R-Q)p_L - \frac{Rp_L}{k-1}(k(\lambda+1)-1) < (R-Q)p_L - Rp_L\frac{k}{k-1} < 0$: this concludes the proof.

Proof of Proposition 4

That R^{IR} is decreasing in a to the right of the intersection point follows from straightforward differentiation of equation RIR. The proof for $B^P(a,k)$ is slightly more difficult. Note that equation PESSIC can be written

$$
\begin{aligned}
&\left\{(R+Q(k-1))(1-\lambda)-R\right\} p_L (N-\mu)\left(1-\frac{\mu}{N}\right) \\
&\quad = (k-1)(R-Q)\mu\left\{a\left(1-\frac{\mu}{N}\right)p_H+(1-a)\left(\frac{\mu}{N}p_H+\left(1-\frac{\mu}{N}\right)p_L\right)\right\} \\
&\qquad\qquad - Rp_L(k-1)\mu + aRp_L(k-1)\frac{\mu^2}{N} \\
&\qquad\qquad\qquad + \left(1-\frac{\mu}{N}\right)\lambda(1-a)\mu p_L\left\{Q(k-1)+R\right\}, \text{ or} \qquad (6) \\
&\qquad\qquad\qquad Q(k-1)B_1 = RB_2
\end{aligned}
$$

where

$$
\begin{aligned}
B_1 &= (1-\lambda)(N-\mu)\left(1-\frac{\mu}{N}\right)p_L+\mu\Pi-\left(1-\frac{\mu}{N}\right)\lambda(1-a)\mu p_L \\
B_2 &= \lambda(N-\mu)\left(1-\frac{\mu}{N}\right)p_L+(k-1)\mu\Pi-\mu(k-1)p_L \\
&\quad +a(k-1)\frac{\mu^2}{N}p_L+\left(1-\frac{\mu}{N}\right)\lambda(1-a)\mu p_L
\end{aligned}
$$

and $\Pi = p_L\frac{\mu}{N}\Delta p + a\left[\left(1-\frac{\mu}{N}\right)\Delta p - \frac{\mu}{N}p_H\right]$. Differentiate throughout with respect to a to get:

$$
\begin{aligned}
Q'(a)(k-1)B_1 &= RB_2'(a) - Q(k-1)B_1'(a) \\
&= \frac{1}{a}(N-\mu)\left(1-\frac{\mu}{N}\right)\left\{(R+Q(k-1))(1-\lambda)-R\right\}p_L \\
&\quad -\frac{\mu^2}{Na}(k-1)\Delta p(R-Q)+Q\frac{(k-1)}{a}\mu p_L \\
&\quad -\frac{\{R+Q(k-1)\}}{a}\lambda\mu\left(1-\frac{\mu}{N}\right)p_L.
\end{aligned}
$$

Substituting from 6, we obtain

$$
\begin{aligned}
Q'(a)(k-1)B_1 &= \left\{(R-Q)((N-\mu)\Delta p-\mu p_H)+R\mu p_L\right\}\frac{(k-1)}{N}\mu \\
&\quad -(R+Q(k-1))\lambda\mu\left(1-\frac{\mu}{N}\right)p_L.
\end{aligned}
$$

Direct substitution yields $Q'(a)=0$ when $Q = R\frac{\Delta p}{p_H}$ and $k = 1+\lambda\frac{p_H}{\Delta p(1-\lambda)}$ at the intersection point. Note that the derivative is monotonically decreasing in decreasing in Q, so $Q < R\frac{\Delta p}{p_H}$ implies that the derivative is negative, as required.