Last Bank Standing: What Do I Gain If You Fail?

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Abstract

Banks are highly leveraged institutions, potentially attracted to speculative lending even without deposit insurance. A counterbalancing incentive to lend prudently is the risk of loss of charter value, which depends on future rents. We show in a dynamic model that current concentration does not reduce speculative lending, and may in fact increase it. In contrast, a policy of temporary increases in market concentration after a bank failure, by promoting a takeover of failed banks by a solvent institution, is very effective. By making speculative lending decisions strategic substitutes, it grants bankers an incentive to remain solvent. Subsequent entry policy fine-tunes the trade-off between the social costs of reduced competition and the gain in stability.

Keywords: banking crises, bank mergers, charter value, market structure dynamics, prudential regulation.

JEL Classification: G21, G28, L10.

1 Introduction

Economists appreciate competition as a powerful source for efficiency, a principle which applies to the financial sector as well as any other industry. Increasing competition has historically played a large role in reducing the costs of financial intermediation; the process of global financial integration has led to new entry of foreign intermediaries, diversified the sources of finance, and reduced the cost of capital. However, the recent experience has seen banking crises arise in many developed countries and developing countries following liberalization and/or deregulation, both of which result in greater competition and entry (Sweden, Finland, Russia, as well as many countries in South East Asia and Latin America). Caprio and Klingebiel (1997) argue that the frequency of banking crisis has been increasing. This has raised concerns that rapid increases in competition in banking may have undesirable consequences due to the special characteristics of the industry. Increasingly, arguments have been raised for limiting the pace of liberalization, especially in developing countries, in which prudential regulation and legal enforcement are less established. This is resuscitating a classic debate among financial regulators: the notion that there exists a tradeoff between stability and competition, especially in banking markets.[1]

Banks are special because of both their liability and asset structure. The risk of short-term illiquidity risk caused by bank runs (Diamond and Dybvig, 1983) has led to the development of deposit insurance as well as the role of the central bank as a lender of last resort. For some, this has created a coun-

[1] The early history of banking in Western countries offers some parallels. The UK, France and the US all had a monopolistic bank in their early year of financial development; in the US at the beginning of the last century there were only four chartered banks, and the general view was that limited competition was essential for stability. Arguably, in those years the institutional capacity for regulation and enforcement were much weaker also in these countries.

tervailing moral hazard problem on the asset side, namely, the temptation for banks to take excessive risks in lending without suffering increased funding costs.

Certainly, if regulators were to allow individual bank failures while bailing out only depositors (and standing as lenders of last resort to avoid a confidence crisis among other banks), there would be a partial disciplining effect. In itself, this is not sufficient. Risk taking is attractive for shareholders of highly leveraged firms even when their creditors are exposed to default risk (Jensen and Meckling, 1976). Banks are highly leveraged institutions managing a resource, credit, which can be very easily misallocated in the short term with consequences which become visible only in the medium term. Moreover, bank closures may hurt investor confidence in other banks, and dissipate information capital on borrowers (Mailath and Mester, 1994).

The alternative is to allow a takeover of the failed bank's branch network. The key question is whether to encourage a takeover by a solvent bank or a new entrant. Both decisions affect future competition. Clearly, in a permanently more competitive environment, banks' future rents are smaller and thus the risk-taking option is more attractive. The literature has recognized this ex ante effect of competition by examining the case in which bank failure leads to the loss of the rents associated with a banking license (i.e. its charter value) —see Suarez (1994) and Matutes and Vives (1996).

In this paper we focus on circumstances where prudential supervision is ineffective, due to information or enforcement problems. When direct supervision fails, indirect measures such as the enhancement of charter value may help to control the marginal incentives for risk taking. Hellmann, Murdock, and Stiglitz (1998) argue that limits on deposit rates may be an effective approach.

Charter value, the present value of future rents, is strictly a forward-looking concept. In this paper we argue that it is the anticipated future degree of competition rather than current concentration, that affects its value and thus the critical risk-taking decision. Accordingly, we conceive a dynamic model in which in which deposit rates are market determined, and the main incentive mechanism is the policy response to bank failure. Importantly, market structure is endogeneous, varying between lower and higher levels of competition. Changes in concentration are driven by entry and exit produced by bank failures, mergers and entry policy.

Our main conclusion is that current concentration does not in general encourage less speculative lending, and may aggravate it. Rather, it is expected market concentration in the future, contingent on bank failures, which may produce a strong incentive effect for proper bank lending. In the process we are able to offer an explanation for the common practice among bank regulators to encourage takeovers of failed banks by healthy institutions, rather than allowing a bank closure or new entry.

In our model, there are two policy tools through which banking regulation can affect the value of a 'last bank standing' strategy. The first is the rescue policy for failed banks. Should the bank be put in hands of an entrant or merged with one of the survivors? The second policy decision concerns the subsequent regulatory policy. If a crisis results in reduced competition, should entry be encouraged to restore previous levels of competition?[2]

In our model the bank regulator, in the face of bank insolvency, may use a deliberate bank closures and merger policy as an incentive structure to discourage speculative banking. We consider an oligopolistic banking industry in which there are incentives for excessive risk-taking. We identify two policy

[2]This could result from explicit entry requirements, or tolerance towards entry-deterrance strategies by incumbent banks.

instruments: the choice of the long-term regulatory framework, which affects the rate of potential entry and thus the future degree of competition; and the ex post merger policy of allowing takeovers of failed banks by solvent institutions, which comes at the cost of reduced competition.

In bad states of the economy, banks which opt for speculative lending will become insolvent. The closure and banking competition policy affects then not just through a banker's incentive to lend prudently, but also his competitors'. The banking supervisory authorities trade off the deadweight losses of (temporary) monopoly against the gains in dissuading speculation.

We analyse the socially optimal combination of rescue and entry policies taking into account the resulting trade-off between stability and competition; or more specifically, between the efficiency losses due to excessive risk-taking and social deadweight losses due to reduced competition. Our main finding is that an active merging policy, which temporarily reduces competition after a bank failure, creates ex ante incentives for less speculative lending. Duopolists' lending strategies become strategic substitutes, in the sense that if a bank expects its competitors to pursue a risky strategy, this increases its incentive to remain solvent.[3]

A useful finding, related to the dynamics of market structure, is that, contrary to the intuition in a static model, a higher current market concentration may lead banks to be more inclined towards speculative lending. The reason is that, since higher market power is temporary (due to entry), charter value under a more concentrated market structure is only moderately higher than in normal market conditions, while the larger current deposit base allows existing banks to engage in larger-scale speculative lending in the short

[3] Freixas (1999) argues that the optimal policy should be ambiguous, i.e. the authorities should follow a mixed strategy; this approach is usually termed "constructive ambiguity". We obtain a similar results in our optimal market structure strategy.

run. This tends to create a stronger temptation to gamble, certainly when the gains from speculation are large.

In such a case it is always optimal to maximize concentration after a crisis, and to fine-tune the trade-off between competition and stability by adjusting the rate of subsequent entry. This determines the duration of the period of increased concentration. The intuition for this solution is that both the probability of higher concentration and the entry rate are effective in tranfering rents to a prudent duopolist bank, and involve an equal social cost *conditional on being* in a duopoly state. But if the welfare criterion assigns positive probability to the possibility of *starting* in a monopoly state, then it is optimal to rest on future concentration rather than a lower entry rate, since the latter would slow down the transition from the monopoly state to a more desirable duopoly state.

The literature on regulatory monitoring and intervention in banking usually models intervention in an individual bank default.[4] In our approach, since regulatory intervention in an individual bank failure creates external effects, the optimal policy takes into account the effect on the structure of the banking system. In particular, it considers the strategic substitutability between the risk-taking decisions of competing banks, whereby the choice by one bank to pursue a speculative strategy increases the incentive by other banks to act more prudently.

Our results indicate that an active use of competition policy can have a powerful effect on the stability of the banking system. While we believe that this results applies best to countries with weak regulatory frameworks, we are convinced that its application extends to the established practice in

[4] Both Aghion et al. (1998) and Mitchell (1998a) obtain an optimum degree of regulatory intervention in a context of asymmetric information: a tough intervention policy leads to bad loans being rolled over, causing deterioration of collateral, while a soft approach leads to a lack of incentives for prudence.

developed countries as well.[5]

Our normative results presume that supervisory authorities can commit to a long-term intervention and regulatory policy. On the other hand, a substantial part of the analysis may be also interpreted as an indication of the effect of an exogenously given intervention policy. For regulators to be able to manage competition for the sake of stability, their intervention and regulatory policy must be directed to enhance ex ante incentives. Otherwise, the temptation is always to increase competition.

In the model we focus explicitly on bank competition in the (insured) deposit market. While competition in lending is also important, its effects are very model-sensitive, as they depend on assumptions about the informational barriers to entry and the appropriability of information itself.[6] To a large extent our results might be applied to the analysis of risk-taking in any industry. Yet the application to banking is the most natural, given the nature of credit transactions. Besides deposit insurance, lending decisions are specially vulnerable to the asset sustitution problem, as it is difficult for outsiders to monitor the quality of bank loans. The ease of speculation, and its potential reward, is thus particularly attractive for bank shareholders.

The structure of the paper is as follows. Section 2 describes the basic model. Section 3 characterizes the symmetric equilibrium of the bankers' lending game. Section 4 examines its comparative statics. Section 5 focuses

[5]The regulatory problem would become trivial under sufficiently large or fully risk-based capital requirements. Yet, given the difficulties to assess the true value of bank capital and the quality of bank assets, realistic capital requirements do not seem able to fully substitute for the type of mechanism that we examine.

[6]Increases in competition may destroy incentives for ex ante investment by banks in monitoring and information gathering. Caminal and Matutes (1997) show that some degree of market power is needed to ensure proper monitoring of borrowers. Anand and Galetovic (1997) find that only a (collusive) oligopolistic market can support information gathering. These results have received some empirical support (e.g. Petersen and Rajan, 1995). Yet Schnitzer (1998) shows that competition does not reduce the bank's ex ante incentive to screen in the case in which the information gathered remains private.

on the design of the optimal regulatory policy. Section 6 contains a brief discussion of asymmetric equilibria and the issue of commitment. Section 7 concludes. The proofs of all the formal results appear in the Appendix.

2 The model

Time is continuous and indexed by t. All agents are risk neutral and infinitely lived, and discount time at the rate r. There exists a banking industry made up of two *bank branches.* At any point in time, each of these branches may be owned and managed by a different banker or by the same one. The banking industry is a *duopoly* in the first case and a *monopoly* in the second. Active bankers come out from a large population of potential bankers.

Each bank branch takes one unit of insured deposits either from some local depositors, on which they can exert market power, or from depositors at some financial center, who require some given interest rate. These funds are invested in either *prudent lending* or *speculative lending.* Under prudent lending, the flow of profits per branch and unit of time is π in a duopoly and of $(1+\rho)\,\pi$ in a monopoly, where $\rho > 0$ captures the existence of rents due to the absence of competition in the local deposit market. Importantly for the policy analysis, these rents come at a cost $(1+\tau)\rho\pi$ per branch and unit of time in terms of local depositors' surplus.[7]

Under both market structures, speculative lending adds an extra flow return of $\gamma\pi$ per branch and unit of time, but leaves the bank exposed to *solvency shocks.* Solvency shocks occur randomly according to a Poisson process with arrival rate λ and produce capital losses on speculative lending

[7] The Appendix shows how the parameters ρ and τ of our reduced form can be related to the primitives of an explicit model of competition in the local deposit market.

equivalent to a fraction $\sigma < 1$ of the managed funds. We assume that

$$\gamma\pi - \lambda\sigma < 0, \tag{1}$$

so the expected net return from speculative lending (relative to prudent lending) is negative.

We also assume that σ is large relative to the perpetuity value of a branch's future profits so that bankers hit by a solvency shock are unwilling to restore the solvency of their banks through a voluntary recapitalization.[8] Thus, whenever a bank becomes insolvent, a banking authority intervenes, replaces the failed banker, and contributes $1 - \sigma$ to each failed branch so as to fully pay back to its depositors.

The banking authority must also decide who will own and manage the branches of the failed bank from that point onwards. We assume that when *all the incumbent bankers* fail, the authorities opt for two new bankers, giving raise to a duopoly, since in this case there is no reason to reward any of the previous bankers and competition produces a higher social return. In contrast, we consider the possibility that when *only one duopolist bank* fails, its competitor is allowed to take over the failed branch as a reward for being solvent.[9] The probability that such a policy converts the survivor into a (temporary) monopolist is denoted by μ. We want to analyze whether the prospects of becoming a monopolist is a useful "carrot" for encouraging duopolist bankers to lend prudently.

We think of duopoly as the stable (or *long-run*) market structure of the banking industry: one in which rents are low enough for no further entry to

[8] In terms of the notation used below, we assume that σ exceeds a banker's value of being a duopolist, v_D, and also a half of the value of being a monopolist, v_M.

[9] This can take the form of either a (free) merger through which the branch of the failed bank is formally transferred to the solvent bank or a (temporary) closure of the competing branch. What matters is that the solvent banker obtains the gains from becoming a monopolist.

take place. We think of monopoly, instead, as a market structure in which extra profits call for further *entry.* We model this entry as a Poisson process with arrival rate δ. When a new banker enters, the incumbent loses one of the bank branches in favor of the entrant and the industry becomes a duopoly again. Thus market structure will evolve in response to the exits due to bank failure, the merging policy applied by the authorities when only one duopolist fails, μ, and the rate at which the entry of a competitor makes bank monopolies arrive to an end, δ.

We consider that both μ and δ are determined by a long-term regulatory and supervisory framework set up at some ex ante date by a benevolent government.[10] Arguably the merging rate μ relates to crisis resolution practices. In particular, to the attitude of supervisors towards competition and concentration during episodes of bank failure. We think that either by developing a reputation for rewarding the solvent incumbents or just by delegating the supervisory function to an agent close to the interests of the banking industry, it is possible to implement the desired μ. On the other hand, if potential new bankers face random time-varying entry costs, the entry rate δ can be controlled through the stringency of regulatory entry requirements or through the tolerance of bank competition authorities towards incumbents' entry deterrence strategies.

3 Equilibrium

The ingredients described above define a stochastic game in continuous time. At any date t there are two possible states, depending on whether the banking industry is a monopoly, $s_t = M$, or a duopoly, $s_t = D$. In monopoly dates,

[10]The importance of commitment for the implementation of the optimal policy is discussed in Section 6.

a single banker plays against nature, deciding how to lend the deposits managed by his two branches. In duopoly dates, there are two bankers, one at each branch, deciding how to lend their respective deposits. These simple stage games are repeated until the arrival of a solvency shock, at any date, or an entrant, in a monopoly date, produces the failure of one of the existing banks and/or modifies the market structure of the banking sector. When a bank fails, the corresponding banker is dismissed and exits the game. But the game continues with the survivor banker and/or the new bankers who replace the failing ones.

In the analysis of the bankers' game, we restrict attention to Markov strategies, that is, we assume that the past influences current play only through the state variable s_t, which summarizes the effect of history on payoff functions and action spaces. For tractability, we also impose symmetry in bankers strategies.[11] Accordingly, we describe the Markov lending strategy of a representative banker as a pair $(m, d) \in [0, 1] \times [0, 1]$ that, allowing for mixed strategies, specifies the probability that he gets involved in speculative lending while in monopoly and duopoly, respectively.

Adopting the notion of Markov Perfect Equilibrium, an equilibrium strategy would be a pair (m, d) involving an instantaneous best response to competing bankers who, by symmetry, follow the same strategy. To characterize these reciprocal best responses we can use dynamic programming. Given the time-invariant nature of the problem, we hereafter drop all time indices.

Let v_M and v_D denote the values of a monopolist bank and a duopolist bank, respectively. The instantaneous return from being a monopolist is thus

[11] In Section 6 we briefly discuss the asymmetric Markov Perfect Equilibria that the model may support in some regions of the parameter space.

given by the Bellman equation:

$$rv_M = \max_{m \in [0,1]} \left[2\left(1+\rho+\gamma m\right)\pi - \lambda v_M m - \delta(v_M - v_D) \right]. \qquad (2)$$

The first term in its RHS collects the stage profits from prudent or speculative lending, the second represents the expected capital losses due to dismissal if the bank is hit by a solvency shock, and the third accounts for the expected capital loss from becoming a duopolist if an entrant arrives. The multiplication by two in the first term reflects that the monopolist banker owns the two branches.

To derive a similar expression for a duopolist, let d^* denote the lending strategy followed by his competitor duopolist. Then

$$rv_D = \max_{d \in [0,1]} \left[\left(1+\gamma d\right)\pi - \lambda v_D d + \lambda d^*(1-d)\mu(v_M - v_D) \right], \qquad (3)$$

where the first and second terms in the RHS can be interpreted exactly as in (2), whereas the third accounts for the expected capital gain that the duopolist obtains if, at the arrival of a solvency shock, he survives his competitor and gets control of the failed branch, becoming a monopolist.

An equilibrium is a lending strategy (m, d) that solves the Bellman equations (2) and (3) for $d^* = d$.

3.1 Individual incentives for speculative lending

The contribution of speculative lending to the value of a monopolist bank is captured by the terms multiplied by m in (2). The trade-off is between the instantaneous excess return $2\gamma\pi$ and the expected capital loss λv_M that associate with speculative lending:

$$2\gamma\pi - \lambda v_M \gtreqless 0 \qquad (4)$$

The monopolist will get involved in speculative lending if this expression is positive. Its second term captures the usual effect of charter values on a bank's attitude towards risk: the incentives for prudence given by the fear to lose the bank's future rents in case of failure.

The contribution of speculative lending to the value of a duopolist bank is measured by the terms multiplied by d in (3):

$$\gamma\pi - \lambda v_D - \lambda d^* \mu(v_M - v_D) \gtreqless 0. \tag{5}$$

Again, there is a trade-off between the excess return $\gamma\pi$ and the expected capital loss λv_D that associate with speculative lending. The third term relates to the bank authority's merging policy during solvency crises. When there is a positive probability that, if only one duopolist fails, the surviving bank becomes a monopolist, a strategic substitutability between the lending decisions of the duopolists emerges:

Proposition 1 *Since the value of a monopolist bank, v_M, is no lower than the value of a duopolist bank, v_D, the lending decisions of duopolists (d, d^*) are strategic substitutes.*

The strategic substitutability is due to the combination of an active merging policy, $\mu > 0$, and the gains from becoming a monopolist, $v_M - v_D \geq 0$. This combination produces what we call the *last bank standing effect*, which allows a bank to profit from surviving its competitors. At the arrival of a solvency shock, the more involved in speculative lending the competitor is, the more likely is the prudent duopolist to become a monopolist. So the greater are his incentives to lend prudently.

3.2 Solving for equilibrium

We now account for the simultaneous determination of the individual strategies (m, d) and the endogenous variables d^*, v_M, and v_D. Our task is simplified by the fact that v_D will take one of two values. In particular, it follows from (3) that, if $d = d^* = 0$, then

$$v_D = v_D^0 \equiv \frac{\pi}{r}, \tag{6}$$

while, if $d = d^* = 1$, then

$$v_D = v_D^1 \equiv \frac{(1+\gamma)\,\pi}{r+\lambda}. \tag{7}$$

Moreover, from the linearity of the maximand in (3), if a duopolist finds optimal some $d \in (0,1)$, then any other d would also be optimal. Since this includes $d = 1$, any mixed strategy equilibrium with $d = d^* \in (0,1)$ would also associate with $v_D = v_D^1$.

Our next result shows that duopolists have a propensity to lend speculatively whenever the parameter that captures the importance of the gains from speculative lending, γ, exceeds the critical value

$$\gamma^0 \equiv \frac{\lambda}{r}. \tag{8}$$

Lemma 1 *For modest speculative gains, $\gamma \leq \gamma^0$, the equilibrium involves $d = 0$ and $v_D = v_D^0$, while for large speculative gains, $\gamma > \gamma^0$, it involves $d > 0$ and $v_D = v_D^1$.*

This intuitive result suggests a separate discussion of the cases with modest and large speculative gains.

3.2.1 Modest speculative gains

With $\gamma \leq \gamma^0$, duopolists lend prudently and the value of a duopolist bank is v_D^0. Completing the characterization of the equilibrium simply requires substituting $v_D = v_D^0$ in (2) so as to recursively determine the values of m and v_M:

Proposition 2 *Suppose speculative gains are modest, $\gamma \leq \gamma^0$. Then:*

1. If $\delta \leq 2r\rho$, the equilibrium features $(m, d) = (0, 0)$.

2. Otherwise, there is a critical value

$$\alpha \equiv \frac{2r + 2r\rho + \delta}{2r + 2\delta} < 1 \tag{9}$$

such that the equilibrium features $(m, d) = (0, 0)$ for $\gamma \leq \alpha\gamma^0$ and $(m, d) = (1, 0)$ for $\gamma > \alpha\gamma^0$.

The novel part of this result is the characterization of a monopolist's lending decision. It turns out that a banker who lends prudently as a duopolist may speculate as a monopolist. This seems strange in light of the conclusions of previous studies based on static market structures. They have familiarized us with the idea that market power capitalizes in charter values which, in turn, discourage risk taking. Actually such logic still applies and explains why we get $m = 0$ if the entry rate δ is sufficiently small. However, if δ is large, monopoly states do not last long, so v_M may be very close to v_D. In contrast, a monopolist's short-term gains from speculative lending are twice as large as those of a duopolist, since it temporarily manages two bank branches rather than one. With a large entry rate, this *scale effect* dominates the *charter value effect*, making a monopolist more inclined towards risk than a duopolist.

3.2.2 Large speculative gains

If speculative gains are large, lending prudently while in duopoly, $d = 0$, ceases to be an equilibrium and the value of a duopolist bank is v_D^1. Yet, because of the strategic substitutability between duopolists lending decisions, the equilibrium does not necessarily feature $d = 1$.[12] Specifically, when γ is

[12] Notice that the fact that (5) is positive for $d^* = 0$ and $v_D = v_D^0$ does not imply that it is non-negative for $d^* = 1$ and $v_D = v_D^1$.

close to γ^0, the last bank standing effect invites the duopolist to choose $d = 0$ if $d^* = 1$, while its absence invites him to choose $d = 1$ if $d^* = 0$.[13] As shown below, in a case like this, the unique symmetric equilibrium involves a mixed strategy $d \in (0, 1)$.

To articulate the discussion, we study sequentially the cases with a prudent monopolist and with a speculative monopolist. As proved in the Appendix, the monopolist bank lends prudently if and only if $\delta \leq 2r\rho$ and $\gamma^0 < \gamma \leq \beta\gamma^0$, where

$$\beta \equiv \frac{(2r + 2r\rho)(\lambda + r) + r\delta}{(2r + \delta)(\lambda + r) + r\delta}, \tag{10}$$

which is decreasing in δ. Hence, with the same intuition as above, the involvement of a monopolist in speculative lending depends on confronting the *double* gains from speculative lending with the likely loss of a charter whose value decreases with the entry rate δ.

The following proposition characterizes the equilibrium for the case in which the entry rate is low enough to make the monopolist bank unwilling to speculate:

Proposition 3 (Prudent monopolist) *Suppose $\delta \leq 2r\rho$ and $\gamma^0 < \gamma \leq \beta\gamma^0$. Then, there is a critical value*

$$x = \frac{(r + \delta)(r\gamma - \lambda)}{\lambda\mu\left[2\lambda(1 + \rho) + 2\rho + r - r\gamma\right]} \tag{11}$$

such that the equilibrium lending strategy is $(m, d) = (0, \min\{x, 1\})$.

The critical value x is the unique value of d^* for which (5) equals zero given the equilibrium value of the difference $v_M - v_D$ when $m = 0$. Notice that x equals zero if $\gamma = \gamma^0$ and increases as the gains from speculative lending

[13] As we further discuss in Section 6, this opens the possibility of sustaining asymmetric Markov Perfect Equilibria.

increase. If x becomes larger than one, then duopolists lend speculatively with probability one. But whether that occurs or not, as well as the incidence of speculative lending among duopolist when $d = x < 1$, depends on the various parameters of the model, including μ and δ.

Along the same lines, we characterize the equilibrium for the case in which the entry rate is large enough to make the monopolist bank willing to speculate.

Proposition 4 (Speculative monopolist) *Suppose* $\gamma > \max\{\gamma^0, \beta\gamma^0\}$. *Then, there is a critical value*

$$y = \frac{(r + \lambda + \delta)(r\gamma - \lambda)}{\lambda\mu(r + \lambda)(1 + 2\rho + \gamma)} \tag{12}$$

such that the equilibrium lending strategy is $(m, d) = (1, \min\{y, 1\})$.

Qualitatively y behaves like x. We discuss the determinants of these two variables in the next section.

3.3 Summing up

Figure 1 depicts the regions of the parameter space in which each of the identified equilibrium regimes arises. The $\delta - \gamma$ space is horizontally divided by the line $\gamma = \gamma^0$, which separates the areas with $d = 0$ and $d > 0$. According to Proposition 2, the area with $d = 0$ is then obliquely divided by the curve $\gamma = \alpha\gamma^0$, giving raise to the regions where the equilibrium strategies are $(0, 0)$ and $(1, 0)$, respectively. Similarly, the area with $d = 1$ is divided by the curve $\gamma = \beta\gamma^0$, delimiting the regions where the equilibrium strategies are $(0, x)$ (Proposition 3) and $(1, y)$ (Proposition 4), respectively.[14]

[14] It is easy to prove using (11) and (12) that, at the boundary between the two areas, $x = y$, so d is continuous.

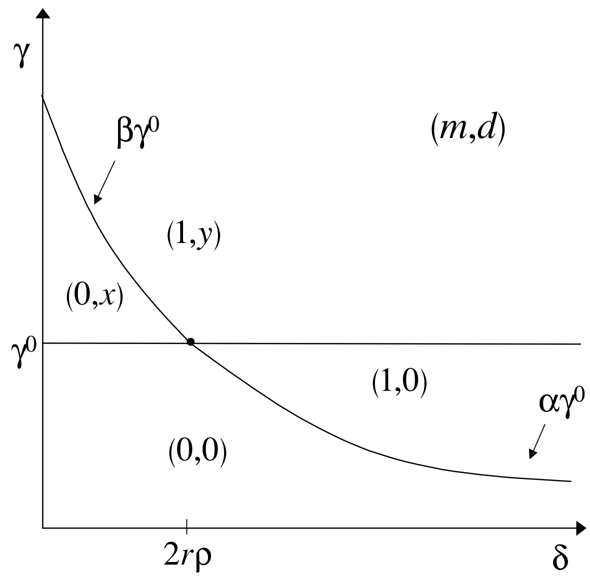

Figure 1: Equilibrium regimes

4 The impact of policy on the equilibrium

When speculative gains are modest ($\gamma << \gamma^0$) duopolist banks lend prudently and, consequently, never fail. Hence, irrespectively of the values of μ, δ, and the lending decision of a monopolist bank m, the banking industry converges to a duopoly state in which both lending decisions and the level of competition attain their first best values. Clearly there is no role for policy in this case.

In contrast, when speculative gains are large ($\gamma > \gamma^0$), duopolists get involved in speculative lending with positive probability. The first best is no longer implementable, and the policy parameters μ and δ have an influence on the equilibrium outcomes. A trade-off between the prudence of lending decisions and the level of competition in the banking industry may then arise.

We henceforth focus on this case.

Table 1 reports the impact of the various parameters of the model on the equilibrium lending decisions of monopolists and duopolists, m and d. For m, we study the shifts in the line $\gamma = \beta\gamma^0$ and report a positive, negative or zero sign depending on whether the corresponding parameter expands, reduces or produces no change in the region where $m = 1$. For d, we report the (coinciding) sign of the partial derivatives of x and y with respect to each parameter.

Table 1
Comparative statics

Parameter	Effect on m	Effect on d	Direct effect on ϕ
Merging rate μ	0	−	+
Entry rate δ	+	+	−
Speculative gains γ	+	+	0
Insolvency risk λ	−	−	+
Monopoly rents ρ	−	−	0
Discount rate r	+	+	0

The behavior of d reflects the operation of the last bank standing effect. The merging rate μ increases the probability that a safe duopolist bank becomes a monopolist in reward for being solvent and, thus, encourages duopolist banks to lend prudently. On the other hand, the entry rate δ reduces the expected duration of the monopoly state and, thereby, the size of the capital gains from becoming a monopolist; so increasing δ encourages duopolists to lend more speculatively.

The behavior of m reflects the conventional charter value effect. The merging rate μ happens to have no impact on monopolists' lending decisions because the value of a monopoly bank does not depend on μ, neither directly nor through the value of a duopolist bank.[15] In contrast, the entry rate δ reduces the expected duration of the monopoly state and, hence, the value of a monopolist bank. So increasing the entry rate makes monopolists more inclined towards speculative lending.

By and large, the results indicate that restricting competition may produce gains in terms of prudence.[16] To rigorously examine this trade-off, we must account for the endogenous dynamics of market structure. Entry, failures, and mergers produce recurrent transitions between monopoly and duopoly states. The monopoly state M may terminate because the monopolist becomes insolvent or because a competitor enters, so the arrival of the duopoly state D follows a Poisson process with intensity $\varphi_M = \lambda m + \delta$. The expected duration of a monopoly state is thus φ_M^{-1}. State D terminates when just one of the two duopolists fails and the bank authorities grant the failing branch to the survivor. So state M arrives at a Poisson rate $\varphi_D = 2\mu\lambda(1-d)d$ and the expected duration of state D is φ_D^{-1}.

The relative frequency of monopoly states along the history of the banking industry can then be computed as the *relative* duration of monopoly states:

$$\phi = \frac{\varphi_M^{-1}}{\varphi_M^{-1} + \varphi_D^{-1}} = \frac{2\mu\lambda(1-d)d}{2\mu\lambda(1-d)d + (\lambda m + \delta)}. \tag{13}$$

Model parameters may affect this frequency both directly and through the equilibrium values of m and d. The direct effects appear in the last column of Table 1. As for the indirect effects, notice that ϕ is decreasing in m since a speculative monopolist tends to endure shorter than a prudent one. In contrast, since mergers require that duopolists' lending decisions diverge, ϕ

[15] Together with the fact that γ^0 is independent of the policy parameters, this result implies that the regions described in Figure 1 are invariant to μ.

[16] The effects of the remaining parameters of the model follow a similar pattern: prudent (speculative) lending is always encouraged by those factors that increase (reduce) the value of a bank charter or the gains from becoming a monopolist bank.

is increasing in d if $d < 1/2$ and decreasing if $d > 1/2$.[17] When the direct and indirect effects are put together, the trade-off between prudence and competition arises, except possibly when $d < 1/2$.

5 Optimal policies

We have already argued that when speculative gains are modest, there is no room for policy: the banking industry converges to an absorbing duopoly state in which banks lend prudently. In contrast, with large speculative gains, increasing the merging rate μ or reducing the entry rate δ favors prudent lending and, thus, reduces the social losses due to speculative lending. However, these policies tend to increase the relative frequency of monopoly states and, thus, the deadweight losses due to the lack of competition.

In general, the present value of the total social losses as estimated in a monopoly state, L_M, does not coincide with the present value of the total social losses as estimated in a duopoly state, L_D. Both can be obtained from the following system of Bellman equations:

$$rL_M = 2[(\lambda\sigma - \gamma\pi)m + \tau\rho\pi] + \varphi_M(L_D - L_M)$$

and

$$rL_D = 2(\lambda\sigma - \gamma\pi)d + \varphi_D(L_M - L_D),$$

where $\lambda\sigma - \gamma\pi$ accounts for the net social losses per branch and unit of time due to speculative lending and $\tau\rho\pi$ accounts for those due to the lack of competition. The solutions for L_M and L_D show that each of these measures puts extra weight on the losses occurring in its corresponding initial state. So L_M and L_D are generally minimized at different choices of μ and δ.

[17] Divergence is the most likely when $d = 1/2$. In equilibria without divergence ($d = 1$ or $d = 0$), it is never the case that a duopolist survives its competitor, so monopoly never arises and we have $\phi = 0$.

To focus our discussion, we can consider the problem of a social planner who must fix μ and δ without knowing the state in which his policy will first be applied. He might then reasonably use the relative frequency of monopoly states, ϕ, as an estimate of the probability that the policy starts to be applied in a monopoly date and minimize $\phi L_M + (1-\phi)L_D$. Ignoring innocuous constants, this is equivalent to minimizing the criterion:

$$C = \phi[\tau\rho\pi + (\lambda\sigma - \gamma\pi)\, m] + (1-\phi)\, (\lambda\sigma - \gamma\pi)\, d, \tag{14}$$

which is a weighted average of the flow of losses per branch and unit of time expected in each of the states of the banking industry.[18]

The optimal policy could then be found by minimizing C after taking into account the dependence of m, d, and ϕ with respect to the regulatory parameters μ and δ. The problem for characterizing this policy is, however, that the underlying optimization program is not convex. Specifically, shifts in monopolists' lending decision m (which occur on the $\gamma = \beta\gamma^0$ curve in Figure 1) may produce a discontinuity in C. If δ is low enough to guarantee $\gamma \leq \beta\gamma^0$ and thus $m = 0$, the equilibrium is characterized by long periods of prudent monopolistic banking combined with short periods of more speculative and competitive banking. In contrast, if δ is high enough to induce $m = 1$, short periods of speculative monopolistic banking alternate with longer periods of more prudent competitive banking. Which of these alternatives dominates lastly depends on the relative sizes of $\tau\rho\pi$ and $\lambda\sigma - \gamma\pi$. In general the solution must be found numerically.

A relevant case in which we can go further in characterizing the social

[18] The criteria for the minimization of L_M (or L_D) would be equivalent to C except for the weighting factor ϕ which should be replaced by $\phi_M \equiv \frac{r+\varphi_D}{r+\varphi_M+\varphi_D}$ (or $\phi_D \equiv \frac{\varphi_D}{r+\varphi_M+\varphi_D}$) in order to give proper extra weight to the losses incurred in the corresponding initial state. Importantly, the differences between the alternative criteria tend to vanish when the discount rate r is small, since $\lim_{r\to o} \phi_M = \lim_{r\to o} \phi_D = \phi$.

ranking of the various combinations of μ and δ arises when policy choices are restricted to the region where monopolist banks lend speculatively.[19]

Proposition 5 *When policy choices are restricted to the region where monopolist banks lend speculatively, it is always optimal to set $\mu = 1$ and to implement the preferred mix of prudence and competition through an adequate choice of δ.*

In the region where monopolist banks lend speculatively, our regulatory parameters have a marginal impact on social losses only through the incidence of speculative lending among duopolists, d, and through the relative frequency of monopoly dates, ϕ. Inducing any given d requires guaranteeing certain capital gains to the duopolist that survives his competitor when a solvency shock arrives. These gains (and hence d) can be kept constant by increasing the merging rate μ as the entry rate δ decreases and vice versa. From a social point of view, both increasing μ and lowering δ has a cost in terms of a greater frequency of monopoly states. If social losses are evaluated from the perspective of an initial duopoly state (that is, via L_D), μ and δ turn out to be perfect substitutes for the inducement of any given d. If the initial state is, however, a monopoly with some positive probability, choosing a large δ has the advantage, in terms of the relevant measure of social losses, of speeding up the transition to a (more desirable) duopoly state, while μ is irrelevant for determining such a transition. Therefore it is preferable to guarantee the required capital gains to the duopolists through a high merging rate rather than a low entry rate.[20]

We now numerically analyze how the entry rate δ should respond to changes in the environment. Inspired by the explicit model of competition

[19] Either because $m = 1$ is globally optimal or because some exogenous lower bound to δ impedes the implementation of $m = 0$.

[20] The same result applies if L_M is taken as the relevant measure of social losses.

described in the Appendix, we set $\rho = 1/8$ and $\tau = 5/2$, and consider different scenarios centered on the following baseline values of the remaining parameters: $\pi = 0.03$, $\gamma = 1.4$, $\lambda = 0.06$, $\sigma = 0.8$, and $r = 0.06$. Our results are summarized in the four panels of Figure 2. Each panel depicts, as a function of one of the parameters, the socially optimal value of the entry rate, δ, the induced frequency of monopoly states, ϕ, and the average "exposure" of a bank branch to solvency shocks, $\phi m + (1-\phi)\, d$. We briefly comment on them:

Profitability. The panel on the top left corner is generated by varying π and γ simultaneously so as to keep the expected gains from speculative lending (i.e., $\gamma\pi$) constant. So this exercise captures the effects of an increase in bank profitability. It shows how banks become more and more prudent as the value of their future rents increases. The social planner resolves the more favorable trade-off between prudence and competition by allowing higher entry. The frequency of monopoly decreases both because duopolists fail less frequently and because monopoly states last shorter.

Private cost of speculative lending. The panel on the top left corner is produced by varying λ and σ simultaneously so as to keep the social cost of speculative lending (i.e., $\lambda\sigma - \gamma\pi$) constant. This captures the effects of altering the private cost of speculative lending (bankers' risk of suffering a solvency shock if they lend speculatively).[21] As one might expect, bankers react to a larger cost by getting less involved in speculative lending, which explains the dramatic fall in their exposure to

[21] Not surprisingly, the picture obtained is the mirror image of the one that arises when we consider the private gains from speculative lending. That is, when γ and σ are simultaneously changed, keeping the social cost of speculative lending constant.

solvency shocks, as well as the inverted-U shape of the curve describing the frequency of monopoly states (recall that, ceteris paribus, monopolies are the most likely to emerge when $d = 1/2$). The most surprising finding in this exercise is the flatness of the optimal regulatory response. In the case depicted in Figure 2, the entry rate δ gets reduced as λ increases.[22] Our explanation for this is that the entry rate has a greater impact on duopolists' lending decisions when speculative lending is less obviously profitable, so it is then when it makes more sense to socially sacrifice competition for prudence.

Social cost of speculative lending. The panel on the botton left corner is generated by varying σ, which captures the social cost of speculative lending. When σ is sufficiently low, the trade-off between prudence and competition gets resolved at a corner: the entry rate is set at a high value, duopolists get not discouraged to lend speculatively, and the frequency of monopoly is zero (since duopolists never fail separately). As σ increases, entry is restricted so as to induce more prudent lending strategies. The cost is a higher frequency of monopoly states.

Discount rate. The panel on the botton right corner is produced by changing r. A larger discount rate makes both the bankers and the social planner to put less weight on future rents or losses. On bankers side, this weakens the charter value effect as well as the last bank standing effect, which explains the dramatic increase in their exposure to solvency shocks and, once again, the inverted-U shape of the curve describing the frequency of monopoly states. On the social planner's side impatience means giving more weight to a likely initial monopoly state from

[22] To enhance the visibility of the effects we have chosen $\sigma = 0.75$ as a benchmark in this exercise.

which a higher δ guarantees a quicker exit. Somewhat surprisingly, instead of trying to moderate bankers' speculative lending, the optimal policy response in the case depicted in Figure 2 is to give priority to competition, slightly increasing δ and, hence, bankers' speculative tendencies.

[INSERT FIGURE 2]

6 Discussion

6.1 Asymmetric equilibria

The possibility of asymmetric Markov perfect equilibria arises in the region of the parameter space where duopolists' mixed strategy is non-generated, i.e., $0 < d < 1$. The candidate equilibrium involves a duopolist who lends prudently ($d = 0$) while his subsequent competitors lend speculatively ($d^* = 1$). The prudent duopolist reaches a value greater than v_d^1 and never fails, while its speculative competitors reach a value of just v_d^1 and fail whenever a solvency shock arrives. In terms of exposure to solvency crises, this equilibrium is equivalent to a mixed strategy equilibrium with $d = 1/2$ although, because duopolists here always take divergent lending decisions, the solvency shock leads to monopoly with probability μ rather than $\mu/2$.

Starting from this type of asymmetric equilibria, policy can only affect the incidence of speculative lending by modifying the equilibrium regime, that is, either by altering m or by leading to an area where duopolists play symmetric strategies. Policy can, however, affect the frequency of the monopoly state in a more continuous fashion. If policy choices are restricted to the region where monopolist banks lend speculatively, it would be optimal to set $\mu = 1$ and to fix δ at the maximum value compatible with the most desirable regime in terms duopolists' average d.[23]

It is possible to check that when speculative gains are larger than but arbitrarily close to γ^0, the equilibrium with mixed strategies involves $d < 1/2$ and a frequency of monopoly arbitrarily close to zero. Hence there exists a region of the parameter space in which the above asymmetric equilibrium is strictly dominated by our symmetric mixed strategy equilibrium. Consequently, focusing on symmetric equilibria implies no obvious loss in terms of either economic intuition or socially desirable outcomes.

6.2 The importance of commitment

Commitment is indispensable to implement $d < 1$ when speculative gains are large. A myopic or uncommitted policy-maker would always fix $\mu = 0$ at the point of intervening in a crisis and $\delta \to \infty$ once in a monopoly.

Given the repeated nature of the game played by the policy-maker and the successive bankers, we might think of implementing the full commitment values of μ and δ on the basis of some "triggering" type of strategies on banks' side. The Folk Theorem suggests that commitment might certainly be obtained as an outcome if the discount rate is low enough. Yet triggering strategies would lead us out of the current Markovian environment, where agents are not allowed to condition their play on payoff-irrelevant features of history. Within the current environment, commitment should thus come from some type of legal mandate or reputation, or alternatively from the delegation of the relevant decisions to some properly chosen supervisors.

Perhaps authorities may commit to sustain a given policy for some time but not forever. We might formalize this through a random arrival process that determines when the policy-maker has the opportunity to revise his

[23]Notice that it is always possible to induce an equilibrium with $d = d^* = 1$ by choosing a sufficiently large δ.

policy. The revised policy would then be different if the revision takes place in a monopoly state than if it takes place in a duopoly state, so observed policies would fluctuate. Yet, when fixing μ and δ, the policy-maker would anticipate how his own future behavior might erode or increase the relevant bank charter values. So he would adjust μ and δ in order to sustain the charter values which are more convenient to induce his desired mix of prudence and competition.

7 Conclusions

In this paper we have addressed the question of how to control speculative behavior in banking if the direct supervision of lending decisions is inadequate. Banks may act more prudently if the loss of their banking charter in bankruptcy is significant and also if there are significant gains from remaining solvent when relevant competitors fail. We have shown that a temporary phase of concentration in the banking sector after bank failures can reinforce stability and, thus, reduce the risk of a systemic banking crisis. We can thus rationalize the common policy whereby bank supervisors promote takeovers of weaker institutions by solvent banks: such a policy will induce banks to pursue more prudent lending strategies by suggesting that a solvent bank may profit from a rival bank's failure.

There are several directions of research that we plan to develop along this theme. First, the need for the strategic substitutability implicit in the outlined regulatory policy may be important when the basic incentive to take excessive risk is reinforced when other banks are believed to be acting speculatively.

There are at least two possible sources of this strategic externality. The first is the ability of bankers to postpone recognition of bad loans; this may lead them to keep recapitalizing bad loans, finally to announce them simultaneously to other banks in order to avoid being singled out for poor performance (Rajan, 1994). The second cause is what is described in Mitchell (1998a) as the "too many too fail" effect. This phenomenon was studied first in the context of transition economies by Perotti (1998) and Mitchell (1998b). The basic idea is that when many institutions (either borrowers or lenders) face pressure for costly adjustment, their incentive to comply may depend on the expected strategy by others, since authorities may be unable to force a very large number of defaulters into bankruptcy. This inability may either arise because of logistical limits to enforcement, as it may have been the case for bankruptcy reform in Hungary in the early 90s, or because of the political pressure exercised by an united front, as in the case of trade and bank arrears in Eastern Europe at the beginning of transition or in the banking crises of Russia, Mexico and South East Asia. In some other cases, it is the fear of fire sale liquidation of collateral which could further affect the solvency of other banks which makes the threat to close not credible ex post.

The ex post decision on industry concentration is clearly relevant not just for shareholders, but also for bank managers. The banker who chooses to remain solvent while others go for broke may be renouncing short-term profits in the expectation of the chance of being asked to run a larger bank and thus to gain better compensation or larger private benefits of control. In practice, many bank mergers are in truth takeovers, where the managers in control of the combined bank are often the bankers who managed to remain (more) solvent.

APPENDIX

An explicit model of competition for deposits

Banks need to raise one unit of deposits per branch in order to finance their lending activity. For the purposes of this section, assume that banks plan to lend prudently and this yields a return r per unit of time. Assume also that deposits raised at some financial center cost r per unit of time, while the demand for local deposits is

$$D = a + bs,$$

where s is the interest rate paid on these deposits and the parameters a and b satisfy $a \geq 0$, $b > 0$, and $a + br < 3$. Thus

$$s(D) = \frac{D - a}{b} \tag{15}$$

is the associated inverse demand function.

A monopolist bank will choose its supply of deposits, D_M, so as to maximize the profit flow $[r - s(D)]D$. Given (15), the corresponding first order condition yields

$$D_M = \frac{a + br}{2},$$

which produces profits equal to

$$\Pi_M = \frac{(a + br)^2}{4b}. \tag{16}$$

Notice that $D_M < 3/2 < 2$ so the monopolist bank will complement its funding with deposits raised at the financial center.

Assuming that duopolist banks compete a la Cournot in the market for local deposits, each duopolist will find his best response, D_D, to its competitor's supply of local deposits, D^*, by maximizing $[r - s(D + D^*)]D$ with respect to D. From the first order condition of this problem, by symmetry, we obtain:

$$D_D = \frac{a+rb}{3},$$

under which each duopolist's profits are

$$\Pi_D = \frac{(a+rb)^2}{9b}. \tag{17}$$

Notice that $D_D < 1$ so duopolists will also complement their funding with deposits raised at the financial center.

In terms of the parameters of our model, the previous expressions imply:

$$\pi = \Pi_D = \frac{(a+rb)^2}{9b} \text{ and } \rho = \frac{\Pi_M}{2\Pi_D} - 1 = \frac{1}{8}.$$

To obtain a similar expression for τ, we can compute the difference between the areas of the triangles of deadweight losses (relative to perfect competition) that appear in monopoly and in duopoly:

$$2\tau\rho\pi = \frac{b}{2}\{[r - s(D_M)]^2 - [r - s(D_D)]^2\} = \frac{5\,(a+rb)^2}{72b},$$

which corresponds to what we have denoted $2\tau\rho\pi$. Given the above values of π and ρ, this implies $\tau = \frac{5}{2}$.

Proofs

Proof of Proposition 1 Given (5) and the fact that d^* has no direct impact on v_M or v_D, we just need to show that $v_M - v_D \geq 0$. Suppose, on the contrary, that $v_M - v_D < 0$. Then, the signs of the third terms in the RHS of (2) and (3) imply

$$rv_M > \max_{m\in[0,1]} [2\,(1+\rho+\gamma m)\,\pi - \lambda v_M m] > \max_{m\in[0,1]} [(1+\gamma m)\,\pi - \lambda v_M m] \tag{18}$$

and

$$rv_D \leq \max_{d\in[0,1]} [(1+\gamma d)\,\pi - \lambda v_D d] < \max_{d\in[0,1]} [(1+\gamma d)\,\pi - \lambda v_M d]\,.$$

But this implies $rv_M > rv_D$, which is a contradiction.■

Proof of Lemma 1 From (6), one can immediately see that γ^0 is the maximum value of γ for which (5) is negative with $d = d^* = 0$ and $v_D = v_D^0$.■

The following intermediate result characterizes the solution to the decision problem of a monopolist under a given value of v_D:

Lemma A1 *There is a critical value*

$$v^* = \frac{2\pi\left[(r+\delta)\gamma - \lambda(1+\rho)\right]}{\lambda\delta} \tag{19}$$

such that the optimal lending strategy of a monopolist bank is $m = 0$ *if* $v_D > v^*$, $m = 1$ *if* $v_D < v^*$, *and any* $m \in [0,1]$ *if* $v_D = v^*$.

Proof For a given value of v_D, it follows from (2) that if $m = 0$ then

$$v_M = v_M^0(v_D) \equiv \frac{2(1+\rho)\pi + \delta v_D}{r+\delta}, \tag{20}$$

while if $m = 1$ then

$$v_M = v_M^1(v_D) \equiv \frac{2(1+\rho+\gamma)\pi + \delta v_D}{r+\delta+\lambda}. \tag{21}$$

Moreover, $2\gamma\pi - \lambda v_M^0(v_D) = 2\gamma\pi - \lambda v_M^1(v_D) = 0$ only at $v_D = v^*$. So (4) is negative if $v_D > v^*$, positive if $v_D < v^*$, and zero if $v_D = v^*$, which implies the optimality of the values of m proposed for each of these three cases.■

Proof of Proposition 2 By Lemma A1, determining m when speculative gains are modest requires comparing v_D^0 and v^*. It follows from (6) and (**??**) that $v_D^0 \geq v^*$ is equivalent to $\gamma \leq \alpha\gamma^0$. When $\delta \leq 2r\rho$ we have $\alpha \geq 1$ so $m = 0$ for all $\gamma \leq \gamma^0$. Otherwise, we have $\alpha < 1$ so $m = 0$ for $\gamma \leq \alpha\gamma^0$ and $m = 1$ for $\alpha\gamma^0 < \gamma \leq \gamma^0$.■

The following intermediate result characterizes the equilibrium lending decisions of a monopolist bank when speculative gains are large.

Lemma A2 *Suppose speculative gains are large, $\gamma > \gamma^0$. Then*

1. *If $\delta > 2r\rho$, the equilibrium features $m = 1$.*

2. *Otherwise, $\beta \geq 1$ and the equilibrium features $m = 0$ for $\gamma \leq \beta\gamma^0$ and $m = 1$ for $\gamma > \beta\gamma^0$.*

Proof By Lemma A1 determining m when speculative gains are large requires comparing v_D^1 and v^*. It follows from (7) and (**??**) that $v_D^1 \geq v^*$ is equivalent to $\gamma \leq \beta\gamma^0$. When $\delta > 2r\rho$ we have $\beta < 1$ so $m = 1$ for all $\gamma > \gamma^0$. Otherwise, we have $\beta \geq 1$ so $m = 0$ for $\gamma^0 \leq \gamma \leq \beta\gamma^0$ and $m = 1$ for $\gamma > \beta\gamma^0$.■

Proof of Proposition 3 From Lemmas 1 and A2, with $\delta \leq 2r\rho$ and $\gamma^0 < \gamma \leq \beta\gamma^0$, we necessarily have $d > 0$, $v_D = v_D^1$ and $m = 0$. To find the equilibrium value of d, let x denote the unique solution to the equation

$$\gamma - \lambda v_D^1 - \lambda x\mu[v_M^0(v_D^1) - v_D^1] = 0,$$

whose explicit expression appears in (11). Notice that $\gamma^0 < \gamma \leq \beta\gamma^0$ implies $\gamma\pi - \lambda v_D^1 > 0$ and $v_M^0(v_D^1) - v_D^1 \geq v_M^1(v_D^1) - v_D^1 > 0$, guaranteeing $x > 0$. Yet x can be greater or smaller than 1. If $x > 1$, we can substitute $d^* = 1$ in equation (5) and check that the resulting expression is positive, so the equilibrium is $(m, d) = (0, 1)$. Otherwise, the unique equilibrium is $(m, d) = (0, x)$, since neither $d = d^* = 0$ nor $d = d^* = 1$ produce a consistent sign in (5), while $d^* = x$ makes the duopolists indifferent towards any possible choice of d, including $d = x$.■

Proof of Proposition 4 From Lemmas 1 and A2, with $\gamma > \max\{\gamma^0, \beta\gamma^0\}$ we necessarily have $d > 0$, $v_D = v_D^1$ and $m = 1$. To find the equilibrium value of d, let y denote the unique solution to the equation

$$\gamma\pi - \lambda v_D^1 - \lambda y \mu [v_M^1(v_D^1) - v_D^1] = 0,$$

whose explicit expression appears in (12). Notice that $\gamma > \gamma^0$ implies $\gamma\pi - \lambda v_D^1 > 0$ which, together with $v_M^1(v_D^1) - v_D^1 > 0$, guarantees $y > 0$. Yet y can be greater or smaller than 1. If $y > 1$, we can substitute $d^* = 1$ in (5) and check that the resulting expression is positive so the equilibrium is $(m, d) = (1, 1)$. Otherwise, the unique equilibrium is $(m, d) = (1, y)$, since neither $d = d^* = 0$ nor $d = d^* = 1$ produce a consistent sign in (5), while $d^* = y$ makes the duopolists indifferent towards any possible choice of d, including $d = y$.■

Proof of Proposition 5 In the region with $m = 1$, μ and δ have a marginal impact on C only through the incidence of speculative lending among duopolists, d, and the relative frequency of monopoly dates, ϕ. One can check using the expression for d provided in Proposition 4 and (13) that all the combinations of μ and δ that induce a constant d are ranked in terms of ϕ, which decreases as the entry rate increases. But, with $m = 1$, the social losses measured in (14) are unambiguously increasing in ϕ, so the result follows.■

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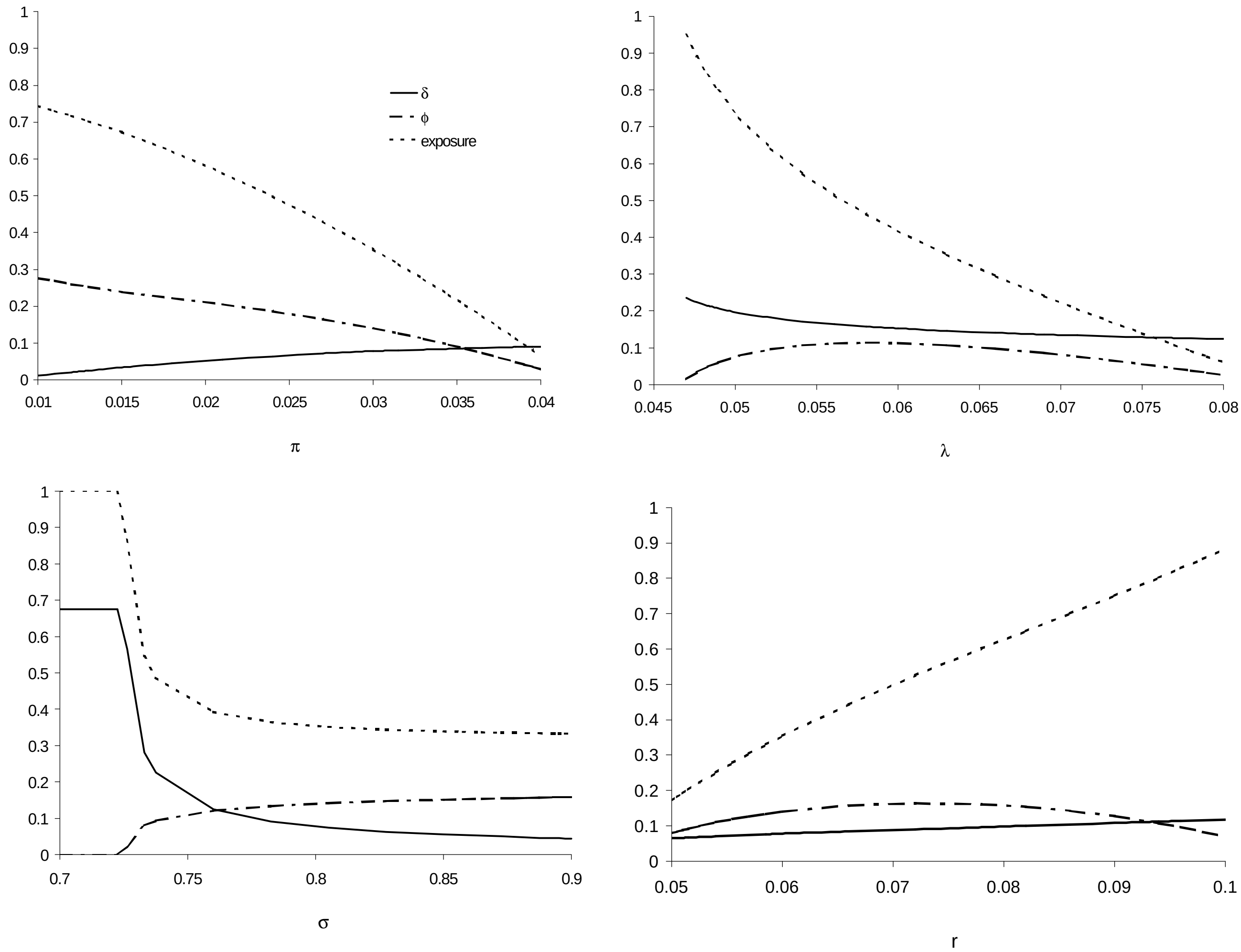

Figure 2: Optimal policies