On the Relationship between Market Concentration and Bank Risk Taking*

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Abstract

We analyse risk-taking behaviour of banks in the context of spatial competition. Banks mobilise unsecured deposits by offering deposit rates, which they invest either in a prudent or in a gambling asset. Limited liability along with high return of a successful gamble induce moral hazard at the bank level. We show that when the market concentration is low, banks invest in the gambling asset. On the other hand, for sufficiently high levels of market concentration, all banks choose the prudent asset to invest in. We further show that a merger of two neighboring banks increases the likelihood of prudent behaviour. Finally, introduction of a deposit insurance scheme exacerbates banks' moral hazard problem.

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1 Introduction

Excessive involvement of banks and financial intermediaries in speculative gambling is one of the principal causes of the recent and past financial crises that the world economy has witnessed. It is also well known that high competition in the banking sector reduces (through different channels) a bank's incentives for prudent behaviour.[1] Thus, the designing of optimal financial safety nets has been the main challenge faced by the prudential regulators in the developed and emerging economies.

The main purposes of this paper are to establish the nature of association between market competition and risk taking in a banking sector where banks compete in a deposit market, and then exploit the such association to study the effects of bank mergers and deposit insurance on bank risk taking. To this end, we analyse a monopolistically competitive deposit market by using (possibly) the simplest model of such competition: a model of locational competition à la Salop (1979). Banks collect deposits from the potential depositors by offering deposit rates, and invest their total funds either in a prudent of in a gambling asset. No bank can commit to the choice of the degree of investment risk (safe or risky) since this decision is taken after the depositors have deposited their funds. In our model, risk neutral banks are subject to limited liability. The gambling asset offers a negative risk premium, but has a higher return if it succeeds.[2] The above characteristics of the assets induce banks to choose a risky investment which create a moral hazard problem at the bank level.

In equilibrium there exists a negative association between market concentration and bank risk taking. In the current model, as in Salop (1979), we use the transport cost that the depositors incur to travel to a bank relative to the number of banks as the measure

[1]See the works of Keeley (1990), Hellmann, Murdock and Stiglitz (2000), and Repullo (2004) for this argument.

[2]This assumption has been crucial in determining the risk-market power relationship in the works of Hellmann, Murdock and Stiglitz (2000) and Repullo (2004).

of market concentration.[3] For very low levels of market concentration, all banks invest in the gambling asset offering a high deposit rate. As concentration increases, a *gambling equilibrium* ceases to exist, and the banks invest in the prudent asset and offer a lower deposit rate. Next we analyse the effect of bank merger on the equilibrium risk taking. Merger between banks increases market concentration and makes gambling less likely. In other words, merger can be viewed as a substitute for safety nets that are aimed at guaranteeing financial stability. Finally, we study the effect of the introduction of a deposit insurance scheme on the equilibrium of the banking sector. Deposit insurance is meant to protect the depositors in face of bank failure. We show that such a scheme may exacerbate the risk-enhancing moral hazard problem by making gambling by the banks more likely.

The negative association between market concentration and bank risk taking has been established, among many others, by Matutes and Vives (1996) and Repullo (2004). Our work is similar to that of Repullo in flavour, who considers a dynamic model of banking based on spatial competition à la Salop (1979) with insured depositors to show that for very low level of market concentration, low intermediation margins reduce banks' franchise value and induce banks invest only in the gambling asset. Our model differs from Repullo (2004) in the following sense. We consider a model of static bank competition. We believe this to be adequate in order to analyse the effects of market power since, in the long run, free entry washes away monopoly rents that the banks enjoy in the short run. Repullo, as Hellmann, Murdock and Stiglitz (2000), analyses various forms of minimum capital requirements and deposit rate ceilings as effective instruments of prudential regulation. Our model also retains similarity with the work of Matutes and Vives (1996), who consider a model of bank competition where depositors have beliefs about the probability of failure of the banks, and banks can choose to invest in various risky assets where the riskiness depends on the market share enjoyed by each bank.

[3]This should not literally be interpreted as the cost (or time) a depositor spends in traveling to a bank. Banks could be differentiated because of differences in ATM facilities, availability in various regions, internet banking services, etc.

It is the presence of depositors' beliefs what generates consistency requirements that should be fulfilled in any equilibrium. They show that when there are economies of scale, depositors' expectations provoke vertical differentiation and give rise to multiple equilibria. Similarly, our model also imposes consistency requirements on the equilibria. But since we avoid the complexity added by the existence of beliefs, these requirements boil down to a no gambling condition requiring that if a bank makes its clients believe that it is going to invest in the prudent asset, at equilibrium it indeed does so. In a seminal paper, Boyd and De Nicoló (2005) suggest that the above mentioned negative relationship between market concentration and risk taking can be reversed if one considers simultaneous interaction between the deposit and the loan markets.

Our main objective is not to check the robustness of capital requirements and deposit rate ceiling as efficient policy instruments. In a simplest possible model of bank competition, we reestablish the well-known negative association between concentration and risk taking to show that bank mergers can induce prudent behaviour, whereas deposit insurance aggravates banks' incentives to gamble. Perotti and Suárez (2002) suggest that allowing solvent banks to acquire the bankrupt ones is an effective regulatory instrument in promoting financial stability in the short run.

Diamond and Dybvig (1983) argue that deposit insurance system prevents sunspot runs and therefore financial collapse. On the other hand, Baer and Brewer (1986), Demirgüç-Kunt and Detragiache (1998), and Demirgüç-Kunt and Huizinga (1998), among many others, find empirical evidence that explicit deposit insurance may provoke financial instability by exacerbating bank's risk-enhancing moral hazard problem. Thus, our result on the effectiveness of deposit insurance bears similarity with the above mentioned works.

2 Model

Consider a banking sector with n risk neutral banks located uniformly on a unit circle. Each bank i has a fixed amount of equity capital k.[4] Banks compete in deposit rates in order to mobilise deposit. Let $r = (r_1, \ldots, r_n)$ be the deposit rates offered by the banks with $r_i > 1$ for each i. Bank i's demand for deposit is given by $D(r_i, r_{-i})$, where r_{-i} is the vector of rates offered by the other banks.

There is a continuum of risk-neutral depositors, also uniformly distributed on the unit circle, with a unit of fund apiece. A depositor can deposit her fund in a bank which pays off a deposit rate in the next period. Deposits are assumed not to be insured.[5] Each depositor incurs a per unit transport cost t in order to travel to a bank.

Each bank invests its total fund (deposits plus capital) either in a prudent or in a gambling asset.[6] The prudent asset yields a constant return $\alpha > r_i$ for all $i = 1, \ldots, n$. The gambling asset, on the other hand, yields $\gamma > \alpha$ with a given probability θ and zero with probability $1 - \theta$. We assume that the success or failure of the gamble is independent across banks, and the prudent asset has an expected return higher than that of the gambling asset, i.e., $\alpha > \theta\gamma$. Each bank is subject to limited liability, i.e., in case a bank's project fails its depositors are not paid back.

The timing of the events is as follows. Banks simultaneously offer deposit rates. Depositors then choose the bank in which to deposit their funds. The deposit mobilisation is followed by the portfolio choice by the banks. Finally, project outputs are realised and the depositors are paid off. This timing is crucial in characterising the equilibrium risk taking behaviour. Since the investment decision is taken after the depositors have deposited their funds, a bank is unable to commit to a particular investment strategy.

[4] We do not explicitly model the sources of bank's capital. This may be the total of a bank's issued shares. We assume this to be exogenously given to the bank before it enters the deposit market.

[5] In Section 5 we analyse the effects of the introduction of a deposit insurance scheme.

[6] A bank might invest a fraction of its total fund in each asset. It is easy to show that optimality would imply that banks choose only one asset to invest in.

Thus the assumption that $\gamma > \alpha$ along with limited liability imply that the banks find it more attractive to invest in the gambling asset, which gives rise to a potential moral hazard problem at the bank level.

3 Equilibrium of the Banking Sector

3.1 Description

In this section we characterise the equilibrium of the banking sector where banks compete in the deposit market by offering deposit rates and choose a prudent asset or a gambling asset to invest in, and the depositors choose banks to place their funds. We focus on two types of symmetric equilibria. A prudent equilibrium where all banks choose to invest in the prudent asset, and a gambling equilibrium in which all banks invest in the gambling asset. We look for the subgame perfect equilibria of the stage game.

If a bank i chooses to invest in the prudent asset and the gambling asset, its expected profits are respectively given by

$$\pi^P(r_i, r_{-i}) = \alpha k + (\alpha - r_i)D(r_i, r_{-i}), \tag{1}$$

$$\pi^G(r_i, r_{-i}) = \theta\gamma k + \theta(\gamma - r_i)D(r_i, r_{-i}). \tag{2}$$

We solve the stage game by backward induction. A bank would choose to invest in the prudent asset if the expected profits from doing so exceed the expected profits from the gambling asset, i.e., $\pi^P \geq \pi^G$. This occurs if the volume of deposits of a bank satisfies the following *no gambling condition* (henceforth, NGC).

$$D_i \leq \frac{(\alpha - \theta\gamma)k}{(1-\theta)r_i - (\alpha - \theta\gamma)}. \tag{3}$$

Denote by $m \equiv \alpha - \theta\gamma$, which is a bank's expected marginal benefit of choosing to invest in the prudent asset instead of gambling. We assume that $(1-\theta)-m>0$ in order that the term in the right hand side of the above inequality is positive. Also, whenever the above condition is satisfied with equality, a bank is assumed to invest in the prudent asset. If the above inequality is reversed, i.e., a *gambling condition* (henceforth, GC) holds, then a bank would invest in the gambling asset. The condition NGC is a sort of incentive compatibility condition for the banks. As we have mentioned above that the structure of returns of the assets gives rise to a moral hazard problem that induces the banks to gamble, the above incentive compatibility condition makes the banks behave prudently. If the banks could commit to be prudent, then it would not be necessary to impose an NGC had the depositors preferred their banks to invest in the safe asset.

In the second stage a depositor takes the decision whether to place her fund in a bank. Consider a particular bank i and a depositor at a distance x from the bank. Suppose that she anticipates that the bank will invest in the prudent asset. Then she would deposit her unit fund if the following *participation condition* holds.

$$r_i - 1 \geq tx. \tag{4}$$

In case of the depositor expects the bank to gamble, the above condition turns out to be

$$\theta r_i - 1 \geq tx. \tag{5}$$

If one of the above two conditions is satisfied for each of the depositors, then no one leaves her fund idle. In other words, all the depositors in the economy are served by at least one bank. In this case a *covered market* is said to emerge. The above conditions may not hold for at least one depositor located between two neighbouring banks, and an *uncovered market* emerges. In the subsequent sections we only analyse the equilibria of a covered market.[7] It is worth noting that the depositors have no control over the portfolio

[7]Details of the characterisation of the equilibria of an uncovered market are available from the authors upon request.

choices of the banks. The above participation conditions imply that if a bank chooses to gamble instead of being prudent, then it must offer a higher deposit rate to its clients.

In the first stage of the game each bank sets the deposit rate in order to maximise its expected profits. In course of doing so, the banks must take into account the possible outcomes of the subgame that follows (stages 2 and 3). Hence, the aforesaid restrictions are imposed as constraints on the banks profit maximisation problem. For example, when all banks maximise expected profits subject to (3) and (4), then a *prudent equilibrium* is said to arise. It is worth noting that the condition NGC or GC determines banks' portfolio choice which follows the decision taken by the depositors. If there is a small number of depositors who place their funds in a particular bank, then this bank is more likely to invest in the prudent asset (since the NGC is more likely to be satisfied). Hence, the conditions NGC and GC are endogenous rather than being exogenous constraints.

We analyse two types of symmetric equilibria of the stage game, namely a prudent equilibrium and a gambling equilibrium. Let r^P and r^G denote the equilibrium deposit rates offered by the banks when all of them respectively choose the prudent asset and the gambling asset. A prudent equilibrium is a strategy profile in which all banks offer r^P and choose the prudent asset to invest in, and all depositors deposit their funds in a bank. On the other hand, a gambling equilibrium is a strategy profile in which all banks offer r^G and choose to gamble, and all depositors deposit their funds in a bank.[8]

3.2 Characterisation

In the following proposition we characterise the equilibria of the deposit market. Since the depositors have to incur a per unit transport cost t to travel to a bank, the transport cost relative to the number of banks in the economy, i.e., t/n is an appropriate measure of market concentration. This is because if the transport cost increases relative to the

[8]See Appendix for the expressions of r^P and r^G, and the necessary conditions under which they are optimal choices.

number of banks, given the total number of depositors, each bank can lower the deposit rate due to sufficiently high market power it enjoys.

PROPOSITION 1 *For a given level capital of each bank, k*

(a) *there exists a threshold level of market concentration, $\bar{\phi}$, such that if $\frac{t}{n} \in [0, \bar{\phi}]$ (low market concentration), then only a gambling equilibrium exists with the banks offering deposit rate $r^G = \gamma - \frac{t}{\theta n}$,*

(b) *if $\frac{t}{n} \in \left[\bar{\phi}, \phi^G\right]$ (intermediate levels of market concentration), both a gambling and a prudent equilibria exist with banks offering $r^G = \gamma - \frac{t}{\theta n}$, and $r^P = \bar{r}$ or $\alpha - \frac{t}{n}$, respectively, where $\bar{r} \equiv \frac{m(kn+1)}{1-\theta}$ is the deposit rate at which the NGC binds with equal deposit for all banks,*

(c) *if $\frac{t}{n} \in \left[\phi^G, \phi^P\right]$ (high levels of concentration), then only a prudent equilibrium exists with banks offering $r^P = \alpha - \frac{t}{n}$ or $1 + \frac{t}{2n}$.*

The intuition behind the above proposition is fairly simple. When the market concentration is very low, competition erodes banks' profit, thus leaving little incentive for them to invest in the prudent asset. On the other hand, for very high degree of concentration, banks earn quasi-monopoly rent, and hence they have incentives to choose the prudent asset in order to preserve that. For even a higher values of $\frac{t}{n}$, the market becomes uncovered, i.e., banks offer even lower deposit rate which is not conducive to attract the depositors located at a longer distance.[9] Proposition 1 is summarised in the following figure.

[Insert Figure1 about here]

Also, for intermediate levels of concentration, banks might invest in the prudent asset by offering a lower deposit rate or in the gambling asset by offering a higher rate that

[9]We omit the analysis of an uncovered market that emerges for $t/n \geq \phi^P$ in which only a prudent equilibrium exists.

compensates for the expected loss to the depositors due to a positive probability of failure in gambling.

4 Social Welfare

In the current set up social welfare is the total consumers' surplus net of aggregate transport cost. Welfare is independent of the equilibrium deposit rate since it is a transfer from the banks to the depositors. Thus, the social welfare under the prudent and gambling equilibria are respectively given by

$$\begin{aligned} W^P &= \alpha(kn+1) - 2nt\int_0^{\frac{1}{2n}} x dx = \alpha(kn+1) - \frac{t}{4n}, \\ W^G &= \theta\gamma(kn+1) - \frac{t}{4n}. \end{aligned}$$

Figure 2 depicts the relationship between social welfare and the level of market concentration. The curve labeled W^G is the social welfare as a function of market concentration under a gambling equilibrium, and that labeled W^P is the welfare under a prudent equilibrium.

[Insert Figure 2 about here]

Welfare under both equilibria decreases with concentration. In particular, for a given level of market concentration where both the equilibria exist, i.e., for $\frac{t}{n} \in \left[\bar{\phi}, \phi^G\right]$, welfare is higher in case all banks behave prudently.[10] From the above figure it is clear that social welfare is discontinuous with respect to market concentration. It is also worth noting that welfare is maximised at $t/n = \bar{\phi} > 0$.[11] The above findings are summarised in the following proposition.

[10]This is because $W^P - W^G = m(kn+1) > 0$.
[11]See Appendix for a proof of this assertion.

PROPOSITION 2 *Social welfare decreases with market concentration both under gambling and prudent equilibria. The levels of market concentration for which both equilibria exist, social welfare is always higher under prudent equilibrium. Moreover, social welfare is maximised at a strictly positive level of market concentration.*

There are two channels via which the level of market concentration affects social welfare. When market concentration increases the aggregate consumers' surplus is diminished, and hence lower is the total welfare. On the other hand, increased market concentration leads to prudent behaviour, thereby increasing social welfare. These two opposite effects result in a maximum social welfare not at the highest degree of competition (i.e., not at $t/n = 0$), but at a lower degree of competition (at $t/n = \bar{\phi}$).

5 Extensions

In this section we study two important extensions of the model presented in Section 3. The first is the effect of an increase in the market concentration due to a merger between two neighbouring banks on the circle. Next we analyse how the introduction of a deposit insurance scheme exacerbates the moral hazard problem of the banks.

5.1 Bank Merger

It is obvious that merger between banks enhances market concentration. Keeping in mind the anti-competitive issues, merger is often viewed as welfare-decreasing because of its adverse effects on the consumers surplus. In the current set up, following the analysis of the previous sections, merger among banks has an additional effect on the welfare because of its implications for risk taking. In particular, merger, via increased market concentration, enhances the incentives for prudent behaviour of the banks. In reality the competition authorities in most of the countries would not have the implications of a merger for risk taking in mind while scrutinising a possible merger. This calls for a policy coordination between the antitrust authority and the prudential regulator in the context of a bank merger, the case that is quite different from a merger between two firms. Having this motivation in mind, an immediate extension of our baseline model is the analysis of the implications of a horizontal merger between several banks for the equilibrium in our model. For analysing the effect of a merger on the risk taking behaviour of the banks, we make the following assumption. When two neighbouring banks merge, the merged entity does not shut down the operation of one of the two offices. In other words, a merged bank can be viewed as a multiplant firm, operating the pre-merger banks as "plants".

The effects of mergers in spatial competition models are studied, among others, by Levy and Reitzes (1992) and Brito (2003). It is shown that mergers generally lead to a price increase. Nonetheless, these models do not consider merger under investment uncertainty. In this subsection, we focus on the implications of a merger on the risk taking behaviour of the banks. We consider the case of a bilateral merger between any pair of neighboring banks. Further, Brito (2003) shows that, in a circular city model, closing one of the locations is not profitable for the merged entity. Therefore, we also assume that the merged bank continues to operate from both of the pre-merger locations. This can be justified by the existence of a sufficiently high relocation cost. In addition, we assume for simplicity that no efficiency gains result in from a merger.

Suppose that the timing of the events described in Section 2 includes an initial stage where a pair of neighbouring banks merge.[12] When such merger takes place, a symmetry argument cannot be applied to solve the game since the impact of the merger on rival banks depends on their location. Without loss of generality, let the merged entity be composed of banks i and $i+1$. In this case, it is easy to show (Levy and Reitzes, 1993)

[12] We do not discuss merger profitability since a merger of any pair of neighbouring banks is always profitable in the circular city model (see Brito, 2003). Also, it is also well-known that mergers are generally profitable when reaction functions are upward sloping (see Deneckere and Davidson, 1985).

that after the merger takes place each bank offers a lower deposit rate and that the deposit rate offered by a bank j ($\neq i$ and $i+1$) is decreasing in the distance between this bank and banks i and $i+1$. In the following proposition we analyse the impact of a merger on the risk-taking behaviour of the banks.

PROPOSITION 3 *For each bank in the deposit market, the likelihood of prudent behaviour increases following a pair of neighboring banks merge.*

Proposition 2 suggests that a merger in the banking sector increases the likelihood that the banks choose to invest in the prudent asset. The intuition behind is as follows. Prior to the merger each bank has independently maximised its expected profit. In the post-merger stage, merged banks realise that lowering the deposit rate in one location increases the expected profit in the other. Consequently, the merged entity lowers the deposit rate, and this induces other banks to lower the deposit rate as well. Hence, both the expected profits of investing in the prudent and the gambling assets increase for all banks. A lower deposit rate makes the NGC more likely to be satisfied, thereby increasing the likelihood of prudent behaviour. One may think that the above intuition is only true if the merging banks are neighbours, since a bank can affect only its neighbour's profits. However, according to Levy and Reitzes (1992), a merger between non-neighboring banks in the circular city model also leads to a fall in the deposit rate. Thus, our results would not substantively change if we have allowed two non-neighbouring banks to merge.

5.2 Deposit Insurance

In this subsection we consider the introduction of a deposit insurance scheme that partially insures each depositor. Deposit insurance schemes are designed to prevent systemic confidence crises. In the current context the effect of such regulatory measure remains ambiguous for low deposit insurance. A little amount of deposit insurance increases a bank's deposit by compensating for the transport cost. On the other hand, deposit insurance induces banks to compete more fiercely and thus reduces bank's incentives to behave prudently by increasing the moral hazard at the bank level since they are protected by limited liability.

Under a deposit insurance scheme, which is denoted by $\delta \in (\theta, 1]$, even if a bank i fails while gambling, its depositors are paid back δ fraction of the promised deposit rate r_i. A full insurance scheme corresponds to $\delta = 1$. Whenever $\delta < 1$, the depositors are partially insured, and the limiting case, where $\delta = \theta$, corresponds to no insurance.

In the following proposition we show that when the deposit insurance is sufficiently high, then a gambling equilibrium exists over a higher range of the values of market concentration compared to the case of no insurance. In other words, under a regime of (partial, but high) deposit insurance banks are more likely to gamble.

PROPOSITION 4 *There exists a threshold level of deposit insurance $\bar{\delta} \in (\theta, 1)$ such that whenever $\delta \geq \bar{\delta}$, the likelihood of gambling by all banks increases with δ.*

Although the effect of deposit insurance on risk taking is not totally unambiguous (for $\delta \leq \bar{\delta}$), the fact that a high deposit insurance exacerbates banks' moral hazard problem is fairly intuitive. In general, since the banks are protected by limited liability in case the gamble fails, a high insurance induces them to gamble. In this case, as the banks do not have to pay back their depositors, the underlying moral hazard has more bite on the risk taking behaviour of the banks. Notice that, under a deposit insurance scheme δ, a bank's objective function under gambling changes (since it shifts out the demand for deposits); whereas that under prudent behaviour remains unchanged. This makes the gambling asset more attractive for the banks. Consequently, deposit insurance induces fiercer competition and leads to a situation where a gambling equilibrium is more likely to occur.

6 Conclusion

This paper uses a model of a baking sector based on spatial competition, and establishes a negative association between market concentration and risk taking by the banks. We further show that a merger between banks makes all the banks less likely to gamble, whereas a high deposit insurance exacerbates banks' incentive problem. We argue that higher market concentration works as a device to refrain banks from being involved in high-risk activities.

When the banks compete only in the deposit market, the reason that induces a negative association between market power and risk taking is fairly intuitive. Most of the works in this context argue that a highly competitive banking sector leads to the erosion of current profit, and thereby a decrease in the franchise value of the banks. A low franchise value diminishes a bank's incentives for prudent behaviour as a successful gambling yields high return. Such logic has been established in the literature (as in our case) under the crucial assumption that banks can independently choose the level of asset risk. Boyd and De Nicoló (2005) show that if the banks are allowed to compete both in the deposit and credit markets, and if banks do not have any control over the riskiness of the assets they invest in (which is decided by the banks' borrowers), then the established negative association between market power and risk taking can be reversed. We, as done in the long-standing literature on risk taking and market concentration, stick to the assumption that banks are able to decide on the riskiness of their investment.

Having established the negative relationship between market concentration and risk taking, we have argued that a merger between two banks incentivise all the banks to behave prudently. The reason is that merger leads to increases concentration. Such result reinforces the findings of Perotti and Suárez (2002) who show that, in the presence of last bank standing effects, letting the solvent banks to acquire the failed ones can enhance efficiency by providing the banks with incentives to behave prudently.

Deposit insurance is a popular regulatory measure that is sought to protect depositors from the expected loss due to excessive speculation by banks. Such measure is adopted in almost all the countries with a few exceptions. We argue that small amount of deposit insurance has ambiguous effect on risk taking, but high insurance is conducive to more gambling by exacerbating banks' moral hazard problem. This result confirms the findings of Demirgüç-Kunt and Detragiache (1998). In other words, high deposit insurance causes a significant reduction in market discipline on bank risk taking, which is in conformity with several empirical findings in the existing literature such as Baer and Brewer (1986), and Demirgüç-Kunt and Huizinga (2003).

Appendix A: Proof of Proposition 1

Prior to characterising the equilibria of the banking sector, we first analyse the necessary conditions for existence of prudent and gambling equilibria. We assume that $\theta\gamma + 2 < 3\theta r_i$ for all $i = 1, \ldots, n$.[13]

Prudent Equilibrium:

First we consider a symmetric prudent equilibrium in which all banks offer the same deposit rate and invest in the prudent asset, and all depositors are served. We compute the demand for deposit of bank i when it offers r_i and all the rival banks offer r. If the depositors anticipate that all banks are going to choose the prudent asset, then the demand for deposit of bank i is given by:

$$D(r_i, r) = \frac{r_i - r}{t} + \frac{1}{n}. \tag{6}$$

All banks must comply with the NGC in order that the market structure that arises at

[13]This condition can be rewritten as $\frac{\theta r_i - 1}{\theta\gamma - 1} > \frac{1}{3}$. This implies that the proportion of net return to the depositor at a distance 0 from bank i to the net return from investing a unit fund must be high enough in order to attract this depositor.

equilibrium is indeed a prudent equilibrium. Second, there is no depositor who has an incentive to keep her fund idle, i.e., for any depositor and for any bank the participation condition (4) must hold good. Thus, bank i's shareholders choose r_i to maximise, subject to NGC and (4), the following expected profit following problem:

$$\alpha k + (\alpha - r_i)\left(\frac{r_i - r}{t} + \frac{1}{n}\right). \tag{7}$$

Let $r_i = r = r^P$ be the candidate optima for the above maximisation problem, which are summarised below.

$$r^P = \begin{cases} \bar{r} & \text{if } \frac{t}{n} \leq \alpha - \bar{r}, \\ \alpha - \frac{t}{n} & \text{if } \alpha - \bar{r} \leq \frac{t}{n} \leq \frac{2(\alpha-1)}{3}, \\ 1 + \frac{t}{2n} & \text{if } \frac{2(\alpha-1)}{3} \leq \frac{t}{n} \leq 2(\bar{r}-1), \end{cases}$$

where $\bar{r} \equiv \frac{m(1+nk)}{1-\theta}$ is the deposit rate that makes the NGC bind with equal deposit for all banks. Notice that $\bar{r}$ is an increasing function of a bank's capital k. If all banks have higher amount of k, the NGC is more likely to be satisfied for each bank, and hence they are more likely to behave prudent. Also, it is clear from the NGC that, for a very low levels of k, this condition is less likely to be satisfied. Therefore, k can be interpreted as a minimum capital standard imposed by the central bank. And a suitable combination of r_i and k can guarantee that the banks invest in the prudent asset.[14]

Gambling Equilibrium:

In a symmetric gambling equilibrium all banks offer the same deposit rate and invest in the gambling asset, and all depositors are served. We first compute the demand for deposit of bank i when it offers a deposit rate r_i and the rivals offer r. Note that if a bank

[14]See Proposition 2 in Hellmann, Murdock and Stiglitz (2000) for a discussion.

i promises a deposit rate r_i, a depositor in this bank gets (in expected terms) θr_i back. If the depositors anticipate that all banks are going to choose the gambling asset (i.e., for all banks condition GC holds), the deposit of bank i is given by

$$D(r_i, r) = \frac{\theta(r_i - r)}{t} + \frac{1}{n}. \tag{8}$$

Here, one should take two restrictions into account. First, all the banks must comply with the GC in order that the equilibrium is indeed a gambling equilibrium (stage 3 of the game). Second, there is no depositor who has incentive to keep her fund idle, i.e., the participation condition (5) must hold good. Hence, bank i's shareholders choose r_i to maximise, subject to GC and (5), the following expected profit

$$\theta\gamma k + \theta(\gamma - r_i)\left(\frac{\theta(r_i - r)}{t} + \frac{1}{n}\right). \tag{9}$$

Let $r_i = r = r^G$ be the candidate optima for the above maximisation problem. These are summarised below.

$$r^G = \begin{cases} \gamma - \frac{t}{\theta n} & \text{if } \frac{t}{n} \leq \theta(\gamma - \bar{r}), \\ \bar{r} & \text{if } \theta(\gamma - \bar{r}) \leq \frac{t}{n} \leq 2(\theta\bar{r} - 1), \\ \frac{1}{\theta}\left(1 + \frac{t}{2n}\right) & \text{if } \frac{t}{n} \geq 2(\theta\bar{r} - 1). \end{cases}$$

Now we check that under what conditions the above candidate deposit rates survive as equilibria. Take a symmetric gambling equilibrium with deposit rate r and suppose that a bank deviates to a deposit rate that will induce it to behave prudently. The profit function following such deviation is given by:

$$\pi^{G\to P} = \alpha k + (\alpha - r^*)\left(\frac{r^* - \theta r}{t} + \frac{1}{n}\right).$$

This deviation r^* must be credible. So we have to compute also the deposit rate, r', that will leave the bank indifferent between investing in the prudent asset and the gambling asset. That is,

$$\frac{r^* - \theta r}{t} + \frac{1}{n} = \frac{mk}{(1-\theta)r' - m} \tag{10}$$

$$\iff r' - \theta r = \left(\frac{\bar{r} - r'}{r' - \frac{m}{1-\theta}}\right)\frac{t}{n}. \tag{11}$$

Notice that the LHS is increasing and the RHS is decreasing in r'. Now take the three candidates for a gambling equilibrium. We will see that deviations arise easily. Nevertheless, for sufficiently low levels of market concentration a gambling equilibrium exists. First, consider $r^G = \gamma - \frac{t}{\theta n}$. Suppose first that the bank deviates to a rate r^* that generates a deposit greater than $\frac{1}{n}$. This occurs when

$$\frac{r^* - \theta\gamma}{t} + \frac{2}{n} > \frac{1}{n} \iff r^* > \theta\gamma - \frac{t}{n}.$$

In this case, it cannot be the case that $r^* \geq \bar{r}$ because then the NGC is not satisfied and the deviation is not credible. This imposes the restriction that $\theta\gamma - \frac{t}{n} < r^* < \bar{r}$. Hence, there can be no such deviation whenever $\frac{t}{n} < \theta\gamma - \bar{r}$. It is easy to see that if $\frac{t}{n} \geq \theta\gamma - \bar{r}$, then a bank can deviate by choosing $r^* = \theta\gamma - \frac{t}{n}$ which is a credible deviation since it generates the same deposit as before. Hence, this candidate for r^G can be ruled out for the interval $[\theta\gamma - \bar{r},\, \theta(\gamma - \bar{r})]$. Now, suppose that $\theta\gamma - \bar{r} > \frac{t}{n}$. Notice that

$$\frac{\partial \pi^{G\to P}}{\partial r^*}\Big|_{r^*=\theta\gamma - \frac{t}{n}} = \frac{m}{t} > 0.$$

So that the deviator's profit is increasing in r^* for a deviation such that $r^* \leq \theta\gamma - \frac{t}{n}$.

Since this deviation must be credible, the best the deviating bank can do is to set the maximum deposit rate consistent with prudent behavior. After rewriting equation (10), this rate is defined by the expression

$$r' - \theta\gamma + \frac{t}{n} = \left(\frac{\bar{r} - r'}{r' - \frac{m}{1-\theta}} \right) \frac{t}{n} \Longleftrightarrow r' - \theta\gamma = \left(\frac{\bar{r} - 2r' + \frac{m}{1-\theta}}{r' - \frac{m}{1-\theta}} \right) \frac{t}{n} .$$

Notice that this condition is not the same as the NGC of the maximisation problem while finding a prudent equilibrium.

Now we want to check when profits after this deviation are still below those under the prudent equilibrium. Profits after and before deviation, respectively, are:

$$\begin{aligned} \pi' &= \alpha k + \left(\alpha - r')(\frac{r' - \theta\gamma}{t} + \frac{2}{n} \right) = \theta\gamma k + \theta(\gamma - r') \left(\frac{r' - \theta\gamma}{t} + \frac{2}{n} \right), \\ \pi^G &= \theta\gamma k + \frac{t}{n^2} . \end{aligned}$$

Tedious calculations show that $\pi' \leq \pi^G$ if and only if:[15]

$$\frac{t}{n} \leq \theta(\gamma - r') - \sqrt{\theta(\gamma - r')}\sqrt{r'(1-\theta)} < \theta\gamma - \bar{r} , \tag{12}$$

where the last inequality holds good whenever $\theta\gamma - \bar{r} > \frac{t}{n}$.[16] Thus we have found an upper bound for this r^G. Notice that this bound might be negative. This is the case whenever $\theta\gamma < r'$. However, one can show that if $\frac{t}{n} \leq \theta\gamma - \bar{r}$, then $r' < \theta\gamma - \frac{t}{n}$, and so the upper bound is positive. Let us write

$$\varphi\left(\frac{t}{n}\right) = \theta(\gamma - r') - \sqrt{\theta(\gamma - r')}\sqrt{r'(1-\theta)} .$$

The fact that φ is a function of t/n makes it impossible to know a priori whether con-

[15] There is another condition: $\frac{t}{n} \geq \theta(\gamma - r') + \sqrt{\theta(\gamma - r')}\sqrt{r'}(1-\theta)$. But if we assume that $\theta\gamma - \bar{r} > \frac{t}{n}$, then it turns out that $r' < \bar{r}$, and hence this condition never holds good in the relevant region.

[16] Notice that $\theta(\gamma - r') - \sqrt{\theta(\gamma - r')}\sqrt{r'(1-\theta)} = \theta\gamma - r' + \sqrt{r'(1-\theta)}(\sqrt{r'(1-\theta)} - \sqrt{\theta(\gamma - r')})$. When $\theta\gamma - \bar{r} > \frac{t}{n}$, both $\theta\gamma > r' > \bar{r}$ hold good.

dition (12) holds in the region $[0, \theta\gamma - \bar{r}]$. Thus, we need then to find a fixed point of $\varphi\left(\frac{t}{n}\right)$ in order to ensure the existence of an interval where this candidate cannot be dominated. First, it is easy to see that φ is decreasing in r', and by the Implicit Function Theorem, that $\partial r'/\partial\left(\frac{t}{n}\right) < 0$. Hence, φ is increasing in t/n. Moreover, one can show that $r'(0) = \theta\gamma$ and that $r'(\theta\gamma - \bar{r}) = \bar{r}$. Hence, $\varphi(0) = 0$, and

$$\varphi(\theta\gamma - \bar{r}) = \theta(\gamma - \bar{r}) - \sqrt{\theta(\gamma - \bar{r})}\sqrt{\bar{r}(1-\theta)} < \theta\gamma - \bar{r}.$$

Also $\varphi(t/n)$ is concave. The above ensure the existence of a fixed point which is denoted by $\bar{\varphi}$. Next, consider the corner solution $\bar{r}$. This generates profits equal to $\pi^G(\bar{r}) = \theta\gamma k + \theta(\gamma - \bar{r})\frac{1}{n} = \alpha k + (\alpha - \bar{r})\frac{1}{n}$. If a bank deviates by choosing a deposit rate $r' = \bar{r}$ and the prudent asset, then it obtains $\pi' = \alpha k + (\alpha - \theta\bar{r})\frac{1}{n}$, which is higher than that before the deviation. Also $r' < \bar{r}$ and the deviation is credible (i.e., the bank indeed wants to be prudent). Finally, consider the other corner solution $\frac{1}{\theta}\left(1 + \frac{t}{2n}\right)$. It is easy to see that a bank can profitably deviate by posting a deposit rate $1 + \frac{t}{2n}$ and choosing the prudent asset to invest in. Hence a symmetric gambling equilibrium exists if and only if

$$\frac{t}{n} \leq \min\left\{\bar{\varphi}, \frac{2(\theta\gamma - 1)}{3}\right\} \equiv \phi^G.$$

Now consider a candidate for symmetric prudent equilibrium with deposit rate r and suppose that a bank deviates to a deposit rate r^* that will make it gamble. Following is the profits from such deviation.

$$\pi^{P\to G} = \theta\gamma k + \theta(\gamma - r^*)\left(\frac{\theta r^* - r}{t} + \frac{1}{n}\right).$$

Again one should consider as well the limit deposit rate $\underline{r}$ for the bank to credibly gamble after the deviation. This rate is now defined by the following equation

$$\frac{\theta \underline{r} - r}{t} + \frac{1}{n} = \frac{mk}{(1-\theta)\underline{r} - m}.$$

First, consider the corner solution $r^P = \bar{r}$. The deviating deposit rate is

$$r^* = \frac{\bar{r} + \theta\gamma}{2\theta} - \frac{t}{2\theta n},$$

Notice that for the profits after deviation to be greater than before, r^* must satisfy the following inequality:

$$(\gamma - r^*)(\theta r^* - \bar{r}) > \frac{t}{n}(r^* - \bar{r}).$$

If with this deviation the bank gets a smaller deposit. i.e., if $r^* < \bar{r}/\theta$, it cannot be the case that $r^* < \bar{r}$, because otherwise the banks would want to gamble. And if $\bar{r} \le r^* \le \bar{r}/\theta$, it is easy to see that there is no r^* satisfying the above condition. Hence, any deviation must be such that $r^* > \bar{r}/\theta$. Now, let use check what the deviation will be. The following derivative

$$\left.\frac{\partial \pi^{P\to G}}{\partial r^*}\right|_{r^*=\frac{\bar{r}}{\theta}} = \frac{\theta}{t}\left(\theta\gamma - \bar{r} - \frac{t}{n}\right)$$

implies that if $t/n \ge \theta\gamma - \bar{r}$, the bank maximises profits by deviating with the minimal r^* possible, i.e., $\bar{r}/\theta$; but we know that in that case the bank is not better off by deviating. Therefore, t/n must be greater than $\theta\gamma - \bar{r}$. The indirect profit function with this deviation is given by

$$\pi^* = \theta\gamma k + \frac{1}{t}\left(\frac{\theta\gamma - \bar{r}}{2} + \frac{t}{2n}\right)^2.$$

Recall that the profits prior to the deviation were

$$\pi^P = \alpha k + \frac{1}{n}(\alpha - \bar{r}) = \theta\gamma k + \theta(\gamma - \bar{r})\frac{1}{n}.$$

Hence, the deviation is profitable if and only if

$$\frac{\theta(\gamma-\bar{r})^2}{4}-\left(\frac{\theta\gamma+(1-2\theta)\bar{r}}{2}\right)\frac{t}{n}+\left(\frac{t}{2n}\right)^2>0.$$

This above condition boils down to:[17]

$$\frac{t}{n}<\theta\gamma+\bar{r}(1-2\theta)-2\sqrt{(1-\theta)\bar{r}\theta(\gamma-\bar{r})}\,.$$

We also need to show that this deviation is credible. In fact one can show that $r^*>\bar{r}$ since this holds good whenever $t/n<\theta\gamma+\bar{r}(1-2\theta)$. This together with the fact that by assumption this deviation generates a deposit $D^*>1/n$ implies the consistency of this interior deviation (recall that $t/n<\theta\gamma-\bar{r}$). Hence, for this range, this candidate for r^P can be ruled out; it can only survive in the range

$$\theta\gamma+\bar{r}(1-2\theta)+2\sqrt{(1-\theta)(\gamma-\bar{r})\theta\bar{r}}>\alpha-\bar{r}=\bar{\phi}\leq\frac{t}{n}\,.$$

Now consider the interior solution $r^P=\alpha-\bar{r}$. There are two candidates for best reply. The first one is the interior best response deviation $r^*=\frac{\alpha+\theta\gamma}{2\theta}-\frac{t}{\theta n}$, and the other is the limit deposit rate that is consistent with gambling, which is denoted by $\underline{r}$ and is given by

$$\frac{\theta\underline{r}-\alpha}{t}+\frac{2}{n}=\frac{mk}{(1-\theta)\underline{r}-m}\,.$$

In that case

$$\begin{aligned}\underline{\pi}&=\theta\gamma k+\theta(\gamma-\underline{r})\left(\frac{\theta\underline{r}-\alpha}{t}+\frac{2}{n}\right)=\alpha k+(\alpha-\underline{r})\left(\frac{\theta\underline{r}-\alpha}{t}+\frac{2}{n}\right),\\ \pi^P&=\alpha k+\frac{t}{n^2}\,.\end{aligned}$$

[17] The other condition is $t/n\geq\theta\gamma+\bar{r}(1-2\theta)+2\sqrt{(1-\theta)\bar{r}\theta(\gamma-\bar{r})}>\alpha-\bar{r}$. So it has no bite in this region.

And

$$\pi^P \geq \pi^* \Longleftrightarrow \frac{t}{n^2} \geq (\alpha - \underline{r}) \left(\frac{\theta \underline{r} - \alpha}{t} + \frac{2}{n} \right).$$

A bit of calculations show that the last inequality has no solution and that $\pi^P \geq \underline{\pi}$ always holds. Hence, we must focus on the case where the bank deviates with $r^* = \frac{\alpha+\theta\gamma}{2\theta} - \frac{t}{\theta n}$. One can show that this cannot be the case. The total deposit generated by this deviation is $\frac{2}{n} - \frac{m}{t}$ which is positive if and only if $t/n > m/2$. We also have

$$\begin{aligned} \pi^* &= \theta\gamma k + \frac{1}{t} \left(\frac{t}{n} - \frac{m}{2} \right)^2, \\ \pi^P &= \alpha k + \frac{t}{n^2}, \end{aligned}$$

And

$$\pi^P < \pi^* \Longleftrightarrow \frac{t}{n} < \frac{m^2}{4(1-\theta)\bar{r}}.$$

It is clear that $\frac{m^2}{4(1-\theta)\bar{r}} < \frac{m}{2}$. So if under this deviation deposit is positive, the profits it generates are smaller than under our candidate and therefore it survives as a symmetric prudent equilibrium. Finally, consider the other corner solution $r^P = 1 + \frac{t}{2n}$. It is clear that a bank will not deviate to an gambling deposit rate under an uncovered market. It will not get a deposit greater than $\frac{1}{n}$ and it will have to pay higher deposit rates. Then, the only alternative is to deviate to a gambling deposit rate. The best response deposit rate is given by

$$r^* = \frac{\theta\gamma + 1}{2\theta} - \frac{t}{4\theta n}.$$

But it is easy to check that with this deposit rate the market is still uncovered. For the consumer at a distance $\frac{1}{2n}$ it is true that

$$\theta r^* - \frac{t}{2n} = \frac{\theta\gamma + 1}{2} - \frac{3t}{4n} < 1,$$

where the last inequality holds because in this case we have $t/n \geq \frac{2(\alpha-1)}{3}$. Summarising the above, one can say a symmetric prudent equilibrium exists if and only if

$$\bar{\phi} \leq \frac{t}{n} \leq \phi^P, \text{ where } \phi^P \equiv 2(\bar{r} - 1).$$

This completes the proof of the proposition.

Appendix B: Proof of Proposition 2

The facts that, both under prudent and gambling equilibria, social welfare decreases with market concentration, and that it is always higher under a prudent equilibrium are obvious from the discussions in Section 4. Thus, we only prove the last part of Proposition 2. We would like to show that $W^P\left(n\phi^G\right) \geq W^P(0)$. Notice that

$$\begin{aligned} W^P\left(n\phi^G\right) &= \alpha(kn+1) - \frac{\phi^G}{4}, \\ W^P(0) &= \theta\gamma(kn+1). \end{aligned}$$

We know that

$$\phi^G \equiv \min\left\{\bar{\varphi}, \frac{2(\theta\gamma - 1)}{3}\right\} \leq \frac{2(\theta\gamma-1)}{3}.$$

Therefore,

$$W^P\left(n\phi^G\right) \geq \alpha(kn+1) - \frac{(\theta\gamma-1)}{6}.$$

On the other hand,

$$\begin{aligned} & \alpha(kn+1) - \frac{(\theta\gamma-1)}{6} \geq \theta\gamma(kn+1), \\ \Longleftrightarrow \quad & m(kn+1) = (1-\theta)\bar{r} \geq \frac{(\theta\gamma-1)}{6}, \\ \Longleftrightarrow \quad & \bar{r} \geq \frac{(\theta\gamma-1)}{6(1-\theta)}. \end{aligned}$$

Recall that $\bar{r} \geq 1$. Now we show that $\frac{(\theta\gamma-1)}{6(1-\theta)} \leq 1$. For this to happen, we need

$$\gamma \leq \frac{6(1-\theta)+1}{\theta}.$$

Now consider the assumption $\theta\gamma + 2 < 3\theta\, r_i$. For this to be meaningful, we need $r_i \geq 1$. Therefore, the above assumption is equivalent to $\gamma < \frac{3\theta-2}{\theta}$. Hence, it only remains to check that

$$\frac{3\theta-2}{\theta} \leq \frac{6(1-\theta)+1}{\theta} \Longleftrightarrow \theta \leq 1.$$

This completes the proof of the proposition.

Appendix C: Proof of Proposition 3

Without loss of generality, we consider the merger of banks i and $i+1$. Let Π^P and Π^G be the expected profits of the merged entity under prudent and gambling strategies respectively. The profit maximization problem for the merged bank can be expressed as

$$\begin{aligned}
\max_{r_i, r_{i+1}} \Pi^P &\equiv \pi^P(r_i, r_{-i}) + \pi^P\left(r_{i+1}, r_{-(i+1)}\right), \\
\max_{r_i, r_{i+1}} \Pi^G &\equiv \pi^G(r_i, r_{-i}) + \pi^G\left(r_{i+1}, r_{-(i+1)}\right).
\end{aligned}$$

A merger between a pair of neighbouring firms in the circular city model has been analysed by Levy and Reitzes (1993) when transport costs are linear, who show that a merger of a pair of neighboring firms increases the price. Thus, following Levy and Reitzes (1993), it is clear that the equilibrium deposit rates r^P and r^G decrease for all banks $i = 1, \ldots, n$. Hence, it is immediate to see that the NGC is more easily satisfied.

Appendix D: Proof of Proposition 4

When the depositors of a bank are insured a fraction δ of the deposit rate, The demand function faced by each bank i under a gambling strategy by all banks is given by

$$D(r_i, r) = \frac{\delta(r_i - r)}{t} + \frac{1}{n}.$$

Thus to obtain a gambling equilibrium under deposit insurance, bank i's shareholders choose r_i to maximise, subject to GC and (5), the following expected profit following problem:

$$\theta\gamma k + \theta(\gamma - r_i)\left[\frac{\delta(r_i - r)}{t} + \frac{1}{n}\right]. \tag{13}$$

It is easy to show (similar to the proof of Proposition 1) that only the interior solution $\gamma - \frac{t}{\delta n}$ survives as an equilibrium deposit rate. And this exists only if

$$\frac{t}{n} \leq \delta(\gamma - \bar{r}).$$

Further, it is easy to check that for $t/n > \delta\gamma - \bar{r}$, a bank can profitably deviate by choosing the prudent asset and a deposit rate $\delta\gamma - t/n$. So we will focus on the complementary region. A bank can deviate to the prudent asset by choosing a deposit rate

$$r^* = \frac{\delta\gamma + \alpha}{2} - \frac{t}{n},$$

and the total deposit of this deviating bank is given by

$$D\left(r^*, r^G\right) = \frac{\alpha - \delta\gamma}{2t} + \frac{1}{n}.$$

This deposit is too high so that if this bank offers r^*, it would still want to gamble. Note that we need $t/n > \frac{\delta\gamma - \alpha}{2}$ in order to ensure non-negative expected profits. Let us look at the total deposit generated by such deviation. Consistency requires that

$$\frac{\alpha-\delta\gamma}{2t}+\frac{1}{n}\leq\frac{mk}{(1-\theta)\left(\frac{\alpha+\delta\gamma}{2}-\frac{t}{n}\right)-m}.$$

The above implies that this is the case if and only if

$$\begin{aligned} & \left(\delta-\frac{\alpha}{\gamma}\right)\left(\delta+\frac{1}{\gamma}\left(\alpha-\frac{2m}{1-\theta}\right)\right)\geq 0, \\ \iff \quad & (\delta-\bar{\delta})(\delta-\underline{\delta})\geq 0, \end{aligned}$$

where $\bar{\delta}\equiv\frac{\alpha}{\gamma}>\underline{\delta}$, and $\underline{\delta}$ is the other root of the the equation when the above expression is satisfied with equality. Now consider the case when $\delta\geq\bar{\delta}$. This deviation is credible, and we must check under what condition profit following a deviation to r^* is not higher than π^G, i.e.,

$$\alpha k+\frac{1}{t}\left(\frac{\alpha-\delta\gamma}{2}+\frac{t}{n}\right)^2\leq\theta\gamma k+\frac{\theta t}{\delta n^2}.$$

The above requires

$$\delta(\bar{r}-\gamma q)\frac{t}{n}+\frac{\delta(\alpha-\delta\gamma)^2}{4(1-\theta)}+q\left(\frac{t}{n}\right)^2<0,$$

where $q=(\delta-\theta)/(1-\theta)$. The above expression yields the following two roots of t/n.

$$\begin{aligned} z^+ &= \frac{\delta(\gamma q-\bar{r})}{2q}+\frac{1}{2q}\sqrt{\delta^2(\gamma q-\bar{r})^2-\frac{\delta q(\alpha-\delta\gamma)^2}{1-\theta}}, \\ z^- &= \frac{\delta(\gamma q-\bar{r})}{2q}-\frac{1}{2q}\sqrt{\delta^2(\gamma q-\bar{r})^2-\frac{\delta q(\alpha-\delta\gamma)^2}{1-\theta}}. \end{aligned}$$

Straightforward calculations show that $z^-=\frac{\delta\gamma-\alpha}{2}$. Therefore, we only need to focus on z^+ (recall that, by assumption, $\frac{t}{n}>(\delta\gamma-\alpha)/2$). A deviation is not profitable as long as $t/n\leq z^+$. Hence, we require

$$\frac{t}{n}\leq\min\left\{\frac{2(\delta\gamma-1)}{3},\,\delta\gamma-\bar{r},\,z^+\right\},$$

in order to support a gambling equilibrium with deposit insurance. Tedious calculations yield that

$$\frac{\partial z^+}{\partial \delta} > 0.$$

Hence, this threshold is increasing in δ.

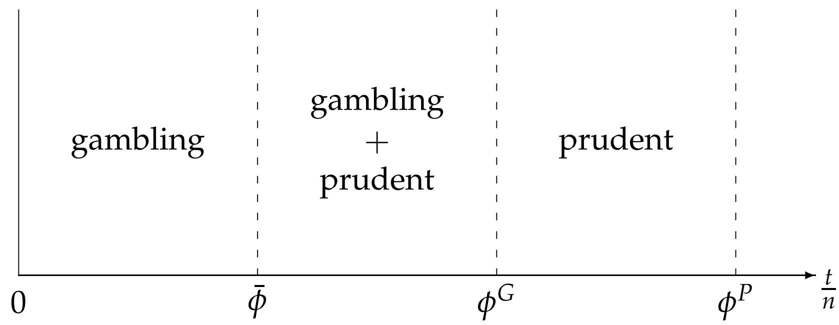

Figure 1: Characterisation of equilibria

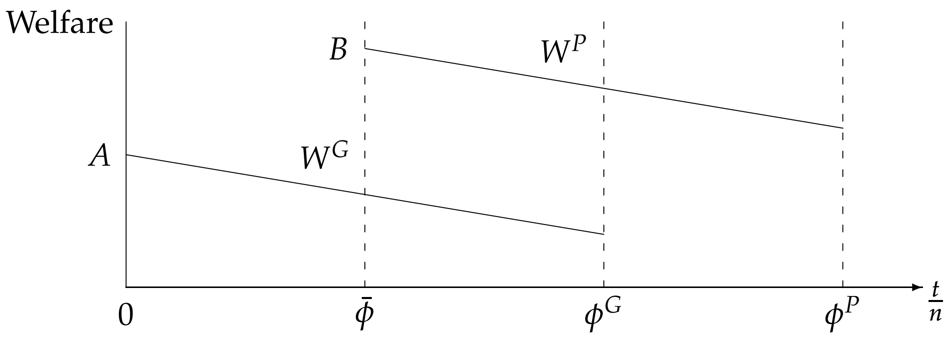

Figure 2: Social welfare and market concentration

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