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# On the Relationship between Market Power and Bank Risk Taking*

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*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 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 power is low, banks invest in the gambling asset. On the other hand, for sufficiently high levels of market power, 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. (JEL Codes: D43; G28; G34)*

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# 1 Introduction

Competition in banking sectors is often conducive to banks being involved in high-risk activities. Keeley (1990), Hellmann, Murdock and Stiglitz (2000) and Repullo (2004), among many others, argue that high competition in the deposit market reduces a bank's incentives for prudent behaviour through the reduction of a bank's franchise value. A plethora of measures thus have been adopted by the prudential regulators to promote safety of the banking systems in the developed and emerging economies. Following the recommendations of Basle Committee on Banking Supervision, different forms of minimum capital requirement and deposit rate ceiling, or a combination of both (Hellmann, Murdock and Stiglitz, 2000; Repullo, 2004) are applied in order to curb banks' incentives for risk taking. On the other hand, deposit insurance is in use to enhance depositors' confidence and prevent systemic financial crises (Diamond and Dybvig, 1983).

The main purposes of this paper are to analyse the nature of the association between market power and bank risk taking when banks compete in a monopolistically competitive deposit market, and then exploit such association to study the effects of bank mergers and deposit insurance on the risk taking behaviour. To this end, we analyse 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 (deposits plus equity capital) either in a prudent or a gambling asset, and the depositors incur a per unit transport cost to travel to a bank in order to deposit their funds.[1] 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 an expected return lower than that of the prudent asset, but has a higher return if it succeeds. The above characteristics of the assets make the banks prone to choose a risky investment which creates a moral

[1] 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 geographic areas, internet banking services, etc. This is part of the transaction costs incurred by the depositors.

hazard problem at the bank level.

We show that in equilibrium there is a negative association between market power and bank risk taking. The intermediation margin of the banks is increasing in the ratio of the transport cost to the number of banks. Hence, as in Salop (1979), we use the transport cost relative to the number of banks as the measure of market power. For very low levels of market power, all banks invest in the gambling asset offering a high equilibrium deposit rate. If market power is very high, then a *gambling equilibrium* ceases to exist, and the banks invest in the prudent asset and offer a lower deposit rate, which is referred to as a *prudent equilibrium*. For an intermediate level of market power, both of the aforesaid equilibria exist. Next we analyse the effect of market power on welfare. Social welfare corresponding to both gambling and prudent equilibria decreases with market power since higher market power leads to lower consumer surplus. On the other hand, higher market power induces lower propensity to gambling. Thus, social welfare is maximised for a strictly positive level of market power. We further analyse the effect of bank merger on the equilibrium risk taking. Merger between banks increases banks' intermediation margin and makes gambling less likely. In other words, merger can be viewed as a substitute for prudential regulation that aims at guaranteeing financial stability. Finally, we study the effect of the introduction of a deposit insurance scheme on the equilibrium of the banking sector. Diamond and Dybvig (1987) argues that deposit insurance serves to protect the depositors in face of bank failure and to enhance depositors' confidence that prevents bank runs. We show that such a scheme may exacerbate the risk-enhancing moral hazard problem by making gambling by the banks more likely which conforms to a number of empirical findings.

The negative association between market power 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 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 power, 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 aspects. 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. Hellmann, Murdock and Stiglitz (2000) consider a model of bank competition to argue that a minimum capital requirement alone cannot serve as an effective prudential regulatory instrument, and this has to be combined with a deposit rate ceiling in order that efficiency can be achieved. Repullo (2004) shows that a risk-based capital requirement can undermine banks' incentive for risk taking and promote safety. Our model also retains similarity with the work of Matutes and Vives (1996), which considers a model of bank competition where depositors have beliefs about the probability of failure of the banks, and banks can choose to invest in different assets with different degrees of riskiness that depends on the market share of each bank. It is the presence of depositors' beliefs what generates consistency requirements that should be fulfilled in any equilibrium. Our model also imposes similar consistency requirements on the equilibria. Since we avoid the complexity added by the existence of such 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, in equilibrium it indeed does so. In a seminal paper, Boyd and De Nicoló (2005) suggest that the above mentioned negative relationship between market power and risk taking can be reversed if one considers simultaneous interaction between the deposit and the loan markets in which the borrowers, rather than the banks, choose the riskiness of a bank's investment.

The paper proceeds as follows. In Section 2 we describe the basic model with uninsured deposits. The following section describes and characterises the equilibrium of the banking sector, and studies the effect of market power on social welfare. Section 4 analyses the effects of bank merger and deposit insurance on the banks' risk taking behaviour. The paper concludes in Section 5. Proofs of our main results are presented in the appendices.

## 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 $k$.[2] Banks compete in deposit rates in order to mobilise deposits. 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 total deposits are 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.[3] 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 a gambling asset.[4] The asset return is in general stochastic with a given probability distribution, and is equal to $\tilde{y}$. In case of the prudent asset, $\tilde{y} = \alpha > r_i$ for all $i = 1, \ldots, n$ with probability 1, i.e., the return on the prudent asset is constant. For the gambling asset, on the other hand, we have $\tilde{y} = \gamma > \alpha$ with a given probability $\theta$ and $\tilde{y} = 0$ 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., $\alpha > \theta\gamma$. A bank $i$'s intermediation margin is given by $\mu = E[\tilde{y} - r_1]$, where $E[\,.\,]$ represents the expected value of the random variable. Each bank is subject to limited liability, i.e., in case a bank's project fails its depositors are not paid back.

[2] 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 a bank before it enters the deposit market.

[3] In Section 4 we analyse the effects of the introduction of a deposit insurance scheme.

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

The timing of 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 of 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. 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 each depositor chooses a bank to place her fund. 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 total 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. 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 depositors preferred their banks to invest in the safe asset and if the banks could commit to be prudent, then it would not be necessary to impose an NGC.

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 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. If one of the above conditions does not hold for at least one depositor located between two neighbouring banks, then an *uncovered market* emerges. In the subsequent sections we only analyse the equilibria of a covered market.[5] It is worth noting that the depositors have no control over the portfolio 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 that 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 thus is a strategy profile in which all banks offer $r^P$ and choose the prudent asset to invest in, and each depositor deposits her fund 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 each depositor deposits her fund in a bank.[6]

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

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

The intermediation margins for each bank in a prudent and in a gambling equilibria are respectively given by $\mu^P = \alpha - r^P$ and $\mu^G = \theta\left(\gamma - r^G\right)$.

## 3.2 Characterisation

In the following proposition we characterise the equilibria of the deposit market. If the transport cost increases relative to the number of banks, given the total number of depositors, then each bank has a higher margin which reflects a higher market power. In fact, it will be shown that, under both equilibria, the intermediation margins equal $t/n$. Hence for our economy, $t/n$ is taken as a measure of market power.

Proposition 1 *For a given level of bank capital k,*

*(a) there exists a threshold level of market power, $\bar{\phi}$, such that if $\frac{t}{n} \in [0, \bar{\phi}]$ (low market power), 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 values of market power), both a gambling and a prudent equilibria exist with banks offering $r^G = \gamma - \frac{t}{\theta n}$, and $r^P = \alpha - \frac{t}{n}$,*

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

From the above proposition, notice that the intermediation margins in a gambling and a prudent equilibria are $\mu^P = \mu^G = t/n$. The intuition behind the above proposition is fairly simple. When the market power 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 power, 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 $t/n$, 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.[7] Proposition 1 is summarised in the following figure.

[Insert Figure1 about here]

Also, for intermediate levels of power, banks might invest in the prudent asset by offering a lower deposit rate $r^P$, or in the gambling asset by offering a higher rate $r^G$ which compensates for the expected loss to the depositors due to a positive probability of failure in gambling.

### 3.3 Social Welfare

In the current set up social welfare is the total consumer surplus net of the 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 power. The curve labeled $W^G$ is the social welfare as a function of market power under a gambling equilibrium, and that labeled $W^P$ is the welfare under a prudent equilibrium.[8]

[Insert Figure 2 about here]

[7]We only consider the interior solutions to the banks' maximisation problem. There are equilibria with two corner solutions, namely, $r^P = \alpha - \bar{r}$, where $\bar{r}$ is the deposit rate that makes the NGC satisfy with equality when each bank has an amount of deposits equal to $1/n$, and $r^P = 1 + (t/2n)$, the deposit rate that makes the participation condition satisfy with equality for each bank. We do not consider the above two equilibrium rates in order to avoid discontinuities in our analysis. We also omit the analysis of an uncovered market that emerges for $t/n > \phi^P$ in which only a prudent equilibrium exists.

[8]We express the welfare as a function of $t/n$ for convenience. It is indeed a function of $t$ as $n$, the number of banks is held fixed.

Welfare under both equilibria decreases with market power. In particular, for a given level of market power where both the equilibria exist, i.e., for a $\frac{t}{n} \in [\bar{\phi}, \phi^G]$, welfare is higher in case all banks behave prudently.[9] From the above figure it is clear that social welfare is discontinuous with respect to market power. It is also worth noting that welfare is maximised at $t/n = \bar{\phi} > 0$.[10] The above findings are summarised in the following proposition.

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

There are two channels via which the level of market power affects social welfare. When market power increases the aggregate consumer surplus is diminished, and hence lower is the welfare. On the other hand, increased market power 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 $t/n = \bar{\phi}$).

# 4 EXTENSIONS

In this section we study two extensions of the model presented in Section 3. The first is the effect of an increase in the market power 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.

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

## 4.1 Bank Merger

Merger between banks enhances market power by increasing the intermediation margins. Keeping in mind the anti-competitive issues, merger is often viewed as welfare-reducing because of its adverse effects on the consumer surplus. In the current set up, following the analysis of the previous sections, merger among banks has an additional effect because of its implications for risk taking. In particular, merger, via increased market power, enhances the incentives for prudent behaviour of the banks. In reality the competition authorities in most countries, while scrutinising a possible merger, would not have in mind the implications of a merger for risk taking. 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 extension of our baseline model is to analyse the implications of horizontal mergers for the equilibrium of our model.

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 for 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. Thus, for analysing the effect of a merger on the risk taking behaviour of banks, we make the following assumption. When two neighbouring banks merge, the merged entity does not shut down the operation in one of the two offices. In other words, a merged bank can be viewed as a multiplant firm, operating the pre-merger banks as separate "plants". This can be justified by the existence of a sufficiently high relocation cost or a resistance against layoffs by the employees. In addition, we assume for simplicity that no efficiency gains result in from a merger.[11]

Suppose that the timing of events described in Section 2 includes an initial stage where a pair of neighbouring banks merge. 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) 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 its distance from the merged entity. In the following proposition we analyse the impact of a merger on risk taking.

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 this 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 or higher intermediation margin 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, following Levy and Reitzes (1992), a merger between non-neighboring banks in the circular city model also leads to a fall

[11]The efficiency gains from merger is generally realised in the long run. Thus, we find it more appropriate not to make such assumptions in our static model which is essentially of short run in nature. Further, we do not discuss merger profitability since a merger of any pair of neighbouring banks is always profitable in the circular city model (Brito, 2003). Also, it is also well-known that mergers are generally profitable when reaction functions are upward sloping (Deneckere and Davidson, 1985).

in the deposit rate. Thus, our results would not substantively change if we have allowed two non-neighbouring banks to merge.

## 4.2 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 (Diamond and Dybvig, 1983). 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 $\delta$ 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 power 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 $\delta$.*

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 $\delta$, a bank's objective function under gambling changes (since it shifts out the total volume of 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.

What is then the effect of deposit insurance on welfare? Note that welfare does not change directly because of the introduction of deposit insurance. This is because, although the equilibrium deposit rates change, they are just transfers from the banks to the depositors. Hence following Proposition 4, Figure 2 would look exactly the same as that before the introduction of insurance, except the point $\phi^G$ (the upper limit of a gambling equilibrium) shifting to the right due to an increase in the insurance amount above $\bar{\delta}$. In other words, the range of the values of market power that supports both equilibria now expands. Consequently, this measure may reduce welfare since there is a range for which only a prudent equilibrium emerged, but its introduction would now create the possibility of a gambling one.

## 5 Conclusions

This paper uses a model of a banking sector based on spatial competition, and establishes a negative association between market power and risk taking by the banks. 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 the 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 power, stick to the assumption that banks are able to decide on the riskiness of their investment.

Unlike Hellmann, Murdock and Siglitz (2000) and Repullo (2004), our goal in this paper is not to check the robustness of capital requirements and deposit rate ceiling as efficient policy instruments. Analysing a simple model of monopolistic competition, we establish a negative association between power and risk taking to show that bank mergers can induce prudent behaviour. The reason is that a merger leads to increase in market power via increased intermediation margin. Mergers are often viewed as welfare-reducing because of their adverse anti-competitive effects on consumer surplus. But in the presence of systemic risk and uncertainty the welfare implications of merger may go in the other direction. Banal-Estañol and Ottaviani (2006) show that, when risk aversion is strong enough, mergers between Cournot firms reduce prices and improve social welfare. In the current context, a merger between two banks reduces the likelihood of gambling as it generates higher intermediation margin for each bank, although higher margins in both gambling and prudent equilibria imply lower consumer surplus. In a similar context as ours, Perotti and Suárez (2002) suggest that allowing solvent banks to acquire the failed ones is an effective regulatory instrument in promoting financial stability in the short run.

As opposed to the positive effect of bank mergers on risk taking, a deposit insurance scheme may increases the likelihood of gambling. 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 have argued that small amount of deposit insurance has ambiguous effect on risk taking, whereas high insurance is conducive to more gambling by exacerbating banks' moral hazard problem, and it may even reduce social welfare by making gambling more likely. At this juncture it is worth noting that a removal of deposit insurance is not able to completely eliminate gambling since a gambling equilibrium exists even with uninsured deposits. This is because the bank moral hazard problem emerges from the high return of a successful gamble and limited liability, which is shown to be aggravated by high deposit insurance. Our result is in conformity with the empirical findings of Baer and Brewer (1986), Demirgüç-Kunt and Detragiache (1998), and Demirgüç-Kunt and Huizinga (1998), among many others, who assert that explicit deposit insurance may provoke financial instability by exacerbating bank's risk-enhancing moral hazard problem. In other words, high deposit insurance causes a significant reduction in market discipline on bank risk taking, thereby increasing the banks' incentives to gamble.

# 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 $i = 1, \ldots, n$.[12]

**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 total deposits of bank $i$ when it offers $r_i$ and all the rival banks offer $r$. If the depositors

[12]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.

anticipate that all banks are going to choose the prudent asset, then the deposits 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 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.[13]

**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 total deposits of bank $i$ when it offers a deposit rate $r_i$ and the rivals offer $r$. Note that if a bank $i$ promises a deposit rate $r_i$, a depositor in this bank gets (in expected terms) $\theta\, r_i$ 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.

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

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

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 power 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:[14]

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

where the last inequality holds good whenever $\theta\gamma - \bar{r} > \frac{t}{n}$.[15] 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

[14]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.

[15]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.

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 $\varphi$ is a function of $t/n$ makes it impossible to know a priori whether condition (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 $\varphi$ is decreasing in $r'$, and by the Implicit Function Theorem, that $\partial r'/\partial\left(\frac{t}{n}\right) < 0$. Hence, $\varphi$ 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 $\bar{r} \leq r^* \leq \bar{r}/\theta$, 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 $t/n \geq \theta\gamma - \bar{r}$, 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:[16]

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

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

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

[16] 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.

In that case

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

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 power, 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 $\Pi^P$ and $\Pi^G$ 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 $\delta$ of the deposit rate, the total deposits of 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 $\pi^G$, 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 $\delta$.

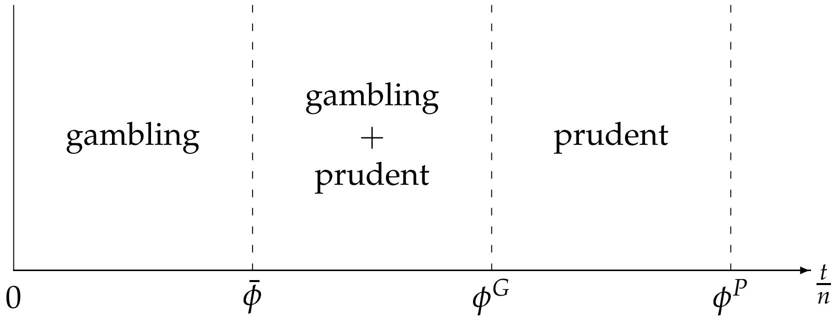


Figure 1: Characterisation of equilibria

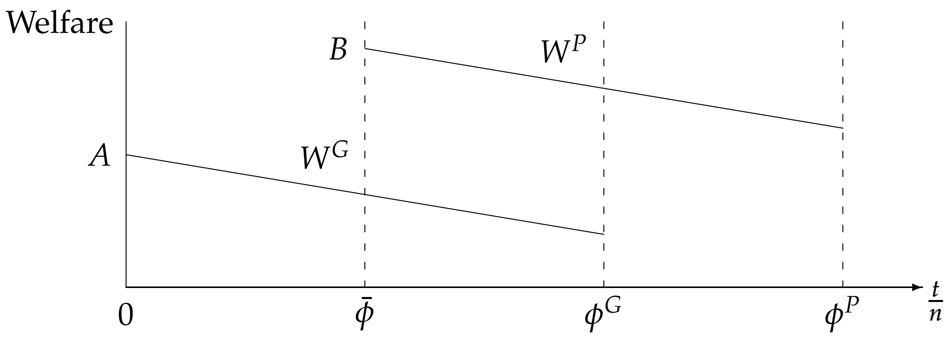


Figure 2: Social welfare and market power

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