

COMPETITION AND RISK-TAKING IN BANKING

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Abstract

This thesis examines the effects of competition on a bank's tendency to exhibit either prudent or risky behaviour when we consider the impact of competition on both deposit and lending rates. In particular, we are interested in evaluating whether one of the main results from Hellman et al. (2000) will still hold when the effects of competition are treated more symmetrically across deposit rates and lending rates. The model presented by Hellman et al. (HMS), which only considers competition in deposit rates, finds that a Pareto improvement can be achieved by combining a capital requirement with a deposit rate ceiling, rather than using a capital requirement in isolation.

With regards to competition in banking, there is a general mechanism that is argued and forms the basis of several papers, among these notably the paper by Hellman et al. The argument is that higher levels of competition erode franchise values, giving a bank with limited liability greater incentive to undertake risky endeavours. Though risk-taking is to some extent a natural and required part of banking, models like that of the HMS show that banks become more inclined to take on higher levels of risk when they are exposed to increasing levels of competition. This is shown to be the case even when the level of risk is inefficient; i.e. when it yields inefficiently low expected returns.

In papers like Allen and Gale (2004) and the mentioned paper by Hellman et al, the relationship between competition and banks behaviour is studied by examining competition for deposits in isolation. The trouble with this approach is that it ignores the rather basic notion that competition also matters for lending rates. In this paper, I will examine whether the same conclusions about competition and risk-taking that are found by HMS can be drawn when we allow competition to influence lending rates.

In order to achieve this purpose, I will propose a model that is an alteration of the HMS-model. This model will maintain the attributes of the HMS-model, but will also incorporate the bank's lending rate as a variable that is susceptible to changes in the overall level of competition in the economy. The motivation for doing this is the criticism by Boyd and De Nicolo (2005) stating that in models like the HMS-model, changes in competition are only mirrored in the deposit market, while implicitly leaving the competition for lending unchanged. This is an unrealistic assumption as competition in the two markets will generally

be tightly linked. It is also a crucial assumption to investigate, as it may be influential towards yielding the positive relationship most commonly found between competition and risk-taking.

The results of the altered HMS-model proposed in this paper, suggest that the effects of competition on bank behaviour are ambiguous. Under certain circumstances restricting competition will create greater incentive for banks to exude prudent behaviour, rather than risky. In others, the incentive for risk-taking can be shown to increase when competition is restricted.

The remaining chapters of this paper are organised as follows. Section 1 reviews some of the theoretical literature concerning competition in banking. Section 2 goes on to give a brief introduction of the HMS-model, before the aforementioned alterations are made to the model in section 3. In section 4, prudential regulation is applied to the model and the results and findings of the model are presented. In section 5 some shortcomings of the model are discussed before, finally in section 6, concluding remarks are presented.

1 The role of competition

There is a large amount of banking literature that studies the relationship between competition on the one side and risk-taking on the other. In much of this literature, there is a general consensus that competition, when coupled with limited liability, can lead the banks to exhibit behaviour that potentially leads to undesirable outcomes. For this reason, there exists considerable theoretical leverage backing the notion that restricting competition in banking, despite its obvious economic costs, can be a necessary evil as it incentivizes banks to abstain from high and inefficient levels of risk.

The abovementioned relationship between competition and risk-taking is prevalent in several articles, among these Hellman et al. (2000), Repullo (2004) and Vives (2010). In these articles we find the well-established argument that the more intense competition in banking is, the less incentivized banks will be to undertake prudent investments. The rationale behind this argument is as follows: The more intense the competition between banks is, the lower the margins earned on intermediation will be as competition drives banks to outbid one another by offering higher and higher rates on their deposits in order to attract customers. When margins are lower, the bank's present discounted value of expected profits (i.e. their franchise value) is lower as well. A small franchise value entails that the benefit to the owners of keeping the bank in business is subsequently low; the amount they stand to lose by making poor investment decisions is close to negligible. This means, when there is limited liability involved, that the owners of the banks will be more inclined to take on undue amounts of risk in order to earn a one-time rent. When this potentially huge upside of risky investment is compared with the negligibly small potential loss of franchise value, it is obvious why the banks would respond with a higher appetite for risk.

Though Hellman et al. and Repullo model competition in different ways; Hellman et al. implicitly, Repullo explicitly, the result is always the same; that more intense competition unambiguously leads to a greater appetite for risk. There are however those who claim this general reasoning to be false, or at least incomplete and that it is the results of theoretical models that do not fully manage to capture all the relevant effects of competition. Among these are Boyd and De Nicolo (2005).

In their paper "The theory of bank risk-taking and competition revisited", the authors voice the argument that much of the theoretical analysis conducted in the area of competition in

banking is fragile, as it fails to take into account certain fundamental risk-incentive mechanisms that operate in the direction of increased risk-taking when competition is restricted. By this, Boyd and De Nicolo are in part referring to the increase in risk-taking that necessarily takes place as lower competition allows banks to increase their lending rates, and in part to the increased moral hazard on the part of the borrowers.

Less intense competition allows banks to operate with higher lending rates than what would be the case with greater competition. This effect increases the bank's margins. Following an argument equivalent to the one in Hellman et al. and Repullo, it is clear that this in itself gives increased incentive for prudent investment. However, when the lending rates are higher it also implies that the risk of bankruptcy by the bank's borrowers increases. In other words, the tendency for the banks loans to be repaid goes down. This rather obvious effect is overlooked in models such as the one by Hellman et al.; where asset returns and success rates are assumed to be given and therefore not affected by the changes in competition.

Boyd and De Nicolo also argue that if the bank's borrowers have limited liability, a higher lending rate will make them more inclined to pursue relatively more risky investments. This tendency would yet again increase the risk of bankruptcy by the bank's borrowers. The mechanism at work here is the same as in the portfolio decision in the Hellman et al. and Repullo; namely that the borrower's margins from prudent investment are reduced when the bank increases its lending rates, thereby making prudent investment less attractive. All else equal, this makes the borrowers more inclined to pursue risky investments in order to maximize their expected returns.

If the two adverse effects in the market for loans dominate the positive effect on bank incentives of earning monopoly rents, then restricting competition will unambiguously increase the risk-taking in the banking sector. Boyd and De Nicolo do not conclude as to which of the abovementioned effects is the dominant one. Thereby, they do not say anything final with regards to the effect of restricting competition in the sector. They make reference to empirical studies and comment that these have shown mixed results on the matter, implying that no certain conclusion can be drawn on this basis either

Though the mechanisms put forward by Boyd and De Nicolo seem quite reasonable, even these can be disputed. While Boyd and De Nicolo argue how lower lending rates reduce the riskiness of the banks loans, Riordan (1993) argues the exact opposite by referring to how

competition will affect banks' incentives to screen borrowers. He argues that the effort a bank devotes to screening loans can be expected to depend positively on the probability of winning a loan and on the return from a successful loan. In his paper, banks compete amongst themselves for a single borrower who selects the loan with the best conditions. When competition is more intense, the likelihood of offering the winning bid is low. When the chances of a positive outcome are low, the banks become dis-incentivized to spend resources on screening the borrower; the more intense competition is, the more likely it is that these screening resources are spent in vain. The screening that takes place in the economy will therefore be slack, implying that more bad loans will be made when competition is more intense. Riordan's point is in this respect the exact opposite of what Boyd and De Nicolo argue.

Though Boyd and De Nicolo and Riordan emphasize contrasting ways in which competition affects risk, the important and undisputable point to take away is that when evaluating the effects of competition on the incentives of banks, results will at best be incomplete, and at worst directly misleading if one concentrates solely on competition in the deposit market. For this reason, the model proposed in section 3, will include the effect of competition on both the deposit rate and the lending rates. In addition to this, the success rate of the loans will depend on the lending rate as implied by Boyd and De Nicolo. The reason for emphasising these effects rather than the one argued by Riordan has to do with the structure of the benchmark HMS-model. In the HMS there is no screening of loans per se, so it seems unnatural to incorporate this in the framework. One can argue that the mechanism argued by Riordan is to some extent present in the model, but that it is dominated by effects put forward by Boyd and De Nicolo.

2 The Hellman-Murdoch-Stiglitz model (HMS)

The purpose of this thesis is to evaluate how competition affects bank behaviour when we consider its impact on both deposit and lending rates. In addition, we want to examine the effect of different policy responses when we allow for such a symmetrical representation of the effects of competition. Since the HMS-model considers the effects of competition on bank behaviour and discusses optimal policy, it is a natural starting point for such an analysis. In their paper, HMS find that a Pareto improvement can be achieved when a capital requirement is combined with a deposit rate ceiling. It will be of particular interest to see if a similar Pareto improvement may still be achieved after the mentioned alterations are made.

In this section, I will present the structure and results of the HMS-model, when no alterations are made. The purpose of this exercise is to provide a benchmark against which to compare the results of the alternative model proposed in section 3.

2.1.1 The Model

In their paper from 2000, Hellman et al. present a dynamic model that examines the relationship between market power, risk-taking and prudential regulation in banking. The model features a representative bank with limited liability that collects deposits and makes an investment after solving a portfolio problem.

Through the choice of its deposit rate, r_i , the bank is able to influence the amount of deposits it attracts, where a higher deposit rate naturally leads to a greater amount of deposits. The market for deposits is characterized by imperfect competition, where competition is represented by how sensitive deposits are to changes in the deposit rate. By allowing for monopolistically competitive deposit markets, the authors are able to study the implications that different levels of competitive pressure have on the banks earnings.

Whatever amount of deposits the bank collects is combined with the own capital, k , it holds, and used to invest in one of two assets. The two assets available to the bank are characterised by given asset prices and given return distributions. The asset referred to as the “prudent asset” has a known return of α that is achieved with full certainty. The second asset, referred

to as the “gambling asset” has also known return distribution of $\{\gamma, \beta\}$, but has uncertainty with regards to which return is achieved. The high return γ is achieved with a probability of θ , while the low return β (for simplicity assumed to be 0) is achieved with the probability $1 - \theta$.

With this set-up, the margin earned on every unit invested is $m_p = \alpha(1 + k) - r_i - \rho k$ when investing in the prudent asset. Where ρ is defined as the opportunity cost of capital and $\rho > \alpha$. When investing in the risky asset, the margin earned is $m_G = \theta(\gamma(1 + k) - r_i) - \rho k$, when taking account of that there is no repayment to depositors when the gamble fails. The risky asset is dominated by the prudent asset in terms of expected returns, $\alpha > \theta\gamma$, making investments in the risky asset inefficient and undesirable from a social point of view. The yield from the risky asset is however higher, provided that the risk-taking is successful, $\alpha < \gamma$.

Since the banks are assumed to be risk-neutral expected profit maximizing entities, their decision to take risk or invest prudently will ultimately depend on which investment option yields the highest expected returns. The authors show that voluntarily holding a positive amount of capital will never be optimal for the banks. This result means that the deposit rate is the only variable the bank can use in order to influence its earnings.

From the expressions for the asset margins, it is plain to see that at some point the deposit rate can become so high that investing in the risky asset is strictly preferred. When competitive pressure drives up the equilibrium deposit rate, reduces margins and effectively erodes the franchise value of the bank, a bank becomes less inclined to invest in the prudent asset. The reason for this is that as competition intensifies the franchise value of the bank declines, leading the value to the owners of owning the bank to decrease correspondingly. This means that the consequence to the owners of taking risk and failing becomes gradually smaller, courtesy of limited liability. On the other hand, the benefit of gambling on the risky asset also falls, but to a lesser degree, as the expected costs of deposits are lower for this asset. This mechanism means that there is some critical deposit rate, given the model parameters, that makes the bank indifferent between investing in the two assets. HMS show that this critical value can be written as:

$$\hat{r}(k) = (1 - \delta) \frac{\alpha - \theta\gamma}{1 - \theta} (1 + k) + \delta[\alpha(1 + k) - \rho k] \quad (1)$$

When the equilibrium deposit rate is greater than this critical value, the bank will prefer investing in the gambling asset in equilibrium. When the equilibrium deposit rate is below this critical value, prudent investment is preferred. This relationship shows how competition comes into effect in the model. Higher levels of competition will, all else equal, lead to a higher optimal deposit rate which reduces the margin on both of the investments. Since the bank maximizes expected profits, changes in the bank's earnings due to varying degrees of competitive pressure will influence the bank's optimal behaviour.

After the critical deposit rate has been established, the authors move on to determine what deposit rate the banks will actually choose. When only the prudent asset is available to the banks, the optimal deposit rate is shown to be:

$$r_p(k) = [\alpha(1 + k) - \rho k] \frac{\varepsilon}{1 + \varepsilon} \quad (2)$$

Where ε is the elasticity of deposits with respect to changes in the deposit rate and is the proxy HMS use for the level of competition. The optimal deposit rate when only the gambling asset is available is:

$$r_G(k) = \left[\gamma(1 + k) - \frac{\rho k}{\theta} \right] \frac{\varepsilon}{1 + \varepsilon} \quad (3)$$

It is easily verified that both of these expressions are both decreasing with the level of own capital and increasing in the level of competition, modelled as a higher value of the elasticity ε . Since the deposit rate the banks will actually choose is increasing with the level of competition, it is clear that at some point competition will be so high that this deposit rate exceeds the critical rate $\hat{r}(k)$. If this happens, gambling on the risky and inefficient asset will arise as the equilibrium outcome. This leads us to proposition 1 in HMS:

“PROPOSITION 1: For sufficiently competitive markets (*i. e.*, $\varepsilon > \bar{\varepsilon}$), the only symmetric equilibrium has banks choosing to hold no capital, pay $r_G(0)$ to depositors, and invest in the gambling asset.” (Hellman et al., 2000, p. 153)

2.1.2 Prudential Regulation

In addition to the effects of competition on earnings, the tendency of the banks to exhibit either prudent behaviour or risky behaviour may be effected by various forms of prudential regulation. The discussion in section 2.1.1 implies that if the competitive pressure for deposits is sufficiently intense, banks will exude risky behaviour in equilibrium and some form of prudential regulation may be warranted. The authors find that the prudent equilibrium outcome can be achieved with the use of a capital requirement or a deposit rate control, but that a combination of the two will always Pareto-dominate solely utilizing a capital requirement in isolation.

Hellman et al. go on to discuss the implications and efficiency of imposing a capital requirement and/or a deposit rate control on the banks. They show that when banks are sufficiently myopic, the critical deposit rate is increasing in the level of own capital. The banks optimal deposit rates, on the other hand, are decreasing in the level of own capital. This means that by imposing a sufficiently large capital requirement, the regulators can force the optimal deposit rate below the critical value, thereby incentivizing the banks to opt for the prudent investment in equilibrium.

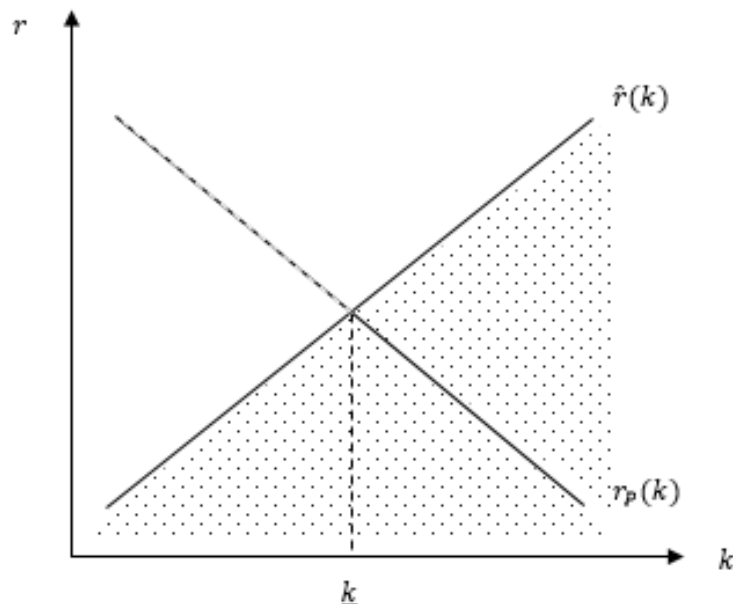


Figure 1: No-Gambling region and competitive equilibria.

The line designated $\hat{r}(k)$ is the no-gambling condition, while the line designated $r_p(k)$ is the equilibrium deposit rate conditional on prudent investment. A capital requirement above \underline{k} moves the banks into the no-gambling region, implying that the prudential equilibrium will be achieved for these levels of capital requirement. For capital requirements below \underline{k} , the prudential outcome is not obtainable, as the optimal deposit rate is so high that gambling is strictly preferred.

When the capital requirement is higher than or equal to \underline{k} , the banks prefer the prudent asset as the downside to the bank from gambling on the risky asset and being unsuccessful is so large that gambling is made unattractive.

Considering the discussion in section 2.1.1., it is quite clear that an adequately low deposit rate ceiling would also be sufficient to induce the prudent outcome, even with no other regulation in place. When imposing a deposit rate ceiling the prudent equilibrium can be achieved by increasing the bank's margins, which results in elevated franchise values. If the deposit rate ceiling is set sufficiently low, the franchise value of the bank increases to the point where profit-maximizing banks prefer to invest in the prudent asset rather than risk losing their franchise value by gambling on the risky asset. In the model, this translates to a deposit rate ceiling $\bar{r} = r_p(0)$ lower than the critical rate $\hat{r}(0)$ producing the prudent outcome.

So far, we have argued that both a policy of either a deposit rate ceiling or a capital requirement in isolation can yield the desired, prudent outcome. The novelty of the HMS-model is however in the potential benefit of combining these two regulatory instruments. According to HMS, the combination of a capital requirement along with a deposit rate control can create a Pareto-improvement over a capital requirement in isolation. It is shown that for any capital requirement that would induce a prudent equilibrium on its own, the corresponding equilibrium deposit rate could be used as the deposit rate ceiling, thereby allowing for a lower capital requirement.

The reason such a Pareto-improvement is possible is related to the relative pay-offs of the two assets. When a bank invests in the risky asset it earns a higher expected margin on each incremental unit of deposits it invests than it does when investing in the safe asset. This difference gives the bank incentive to attract a larger amount of deposits when it opts for risky investment. In order to do this, it will be optimal for the bank to offer a higher deposit rate when pursuing the risky strategy than when pursuing the safe strategy. With an appropriate deposit rate ceiling in place, the banks cannot take advantage of this effect in the same way. This means that imposing the deposit rate ceiling gives the banks reduced incentive to invest in the risky asset. Since the incentive is reduced, the capital requirement need not be as stringent in order to achieve the desired prudent outcome. Therefore, the necessary capital requirement will be lower. This effect is illustrated in Figure 2 below:

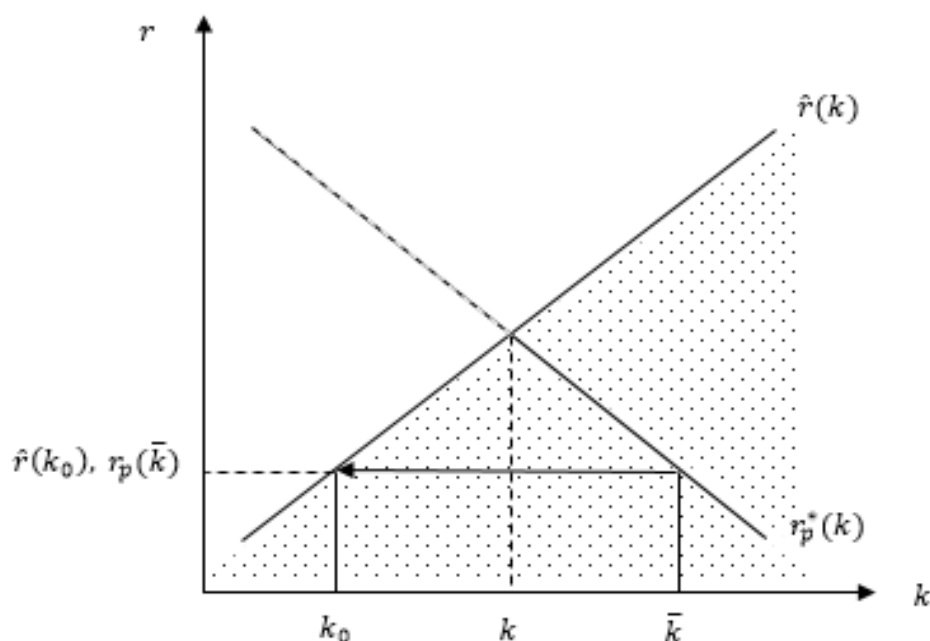


Figure 2: Pareto improvements with deposit rate controls

This figure is equivalent to Figure 2 in the paper by HMS. The line designated $\hat{r}(k)$ is the no-gambling condition, while the line designated $r_p(k)$ is the equilibrium deposit rate conditional on prudent investment and no deposit rate ceiling. The figure shows that a deposit rate ceiling $\bar{r} = r_p(\bar{k})$ yields the same deposit rate at a lower capital requirement than does just a capital requirement on its own.

Figure 2 demonstrates how the combination of these two regulatory instruments can be viewed as a Pareto improvement; all the actors in this stylized economy are left equally well off by this regime, apart from the banks who are actually made better off. The banks are better off on account of the capital they are required to hold being lowered from \bar{k} to k_0 . This implies that they experience lower costs of capital, which is a benefit to the banks. This leads us to proposition 4 in the HMS that states:

“PROPOSITION 4: There always exists a policy regime consisting of both a capital requirement and a deposit-rate control that Pareto-dominates any policy regime that only uses a capital requirement.” (Hellman et al., 2000, p. 156)

The content of this proposition is what we will be examining in the chapters to come. So far, we have seen that proposition 4 must hold when the economy can be represented as in the HMS. However, as I have touched upon earlier, HMS treats competition in banking one-sidedly, implicitly ignoring any effects of competition on lending rates. When we include endogenous lending rates into the model, will this strong result still hold?

3 Introducing competition in lending

The HMS-model delivers some clear implications on how varying degrees of competition for deposits affect banks' incentives to take on risk. However, it is unclear how much to read from these results when considering that the model fails to take into account the effects that competition might have on bank lending. To see whether the policy implications of the HMS still stand when we no longer study competition for deposits in isolation, we will in this chapter suggest a model, an extension of HMS, that incorporates the effects of competition on lending rates.

The rationale behind seeking to include competition in lending into the HMS-model, is simply that without it, we cannot truly paint the full picture of how competition influences banks' incentives and behaviour. Since many papers concerning competition in banking draw conclusions on optimal policies responses, it is important that light is shed on all relevant effects before costly policies are put in place.

As mentioned, one objection that can be put forward against the HMS-model is its asymmetric treatment of competition in lending and competition for deposits. Though the authors never mention competition in lending per se in their article, it does not mean that some implicit assumptions aren't being made. As yields on assets are assumed to be completely fixed while deposit rates vary depending on the level of deposit competition, the setup of the model entails that competition for deposits and competition in lending are implied to be completely unrelated. This implicit conclusion seems rather unnatural. Consider the number of banks as an example. It is generally implied that a larger number of banks corresponds to more intense competition than does a smaller number of banks. If the number of banks is increasing, and thereby creating more competition, why should this only affect deposit rates and not lending rates? The number of banks collecting deposits and extending loans has increased by the same amount, why should not competition in both increase by (roughly) the same amount? In order to overcome these odd implications of the HMS, we will consider different ways to include the effects of competition on lending into the model.

3.1.1 First attempt: Fixed deposits and competition in lending rates

A first attempt at integrating a more realistic lending decision by the banks can be conducted as follows. We maintain much of the original setup of the HMS-model, but add on a few

additional features and restrictions. We maintain the assumption that banks are required to make the binary choice of investing its deposits and own capital in either the prudent asset or in the risky asset. We restrict the model by taking the deposit rate to be given and thereby also the size of a bank's deposits are given. In addition, we assume that the yields on both the prudent asset and on the risky asset are decreasing functions of an exogenously given parameter that represents the level of competition. Shocks to this parameter will cause the asset yields to shift, resulting in changes in the banks' margins and franchise value. For simplicity, we assume that changes in the level of competition affect the yields equally. A positive shift would for instance imply that competition in lending was increasing. All else equal, the consequence of this would be that banks would have to offer lower lending rates to maintain the size of their lending portfolio. In doing this, margins earned on lending would go down, reducing franchise values and thereby making the banks more prone to take on risk.

With this proposed setup, more intense competition would make extending risky loans relatively more attractive. To see this, consider a state where prudent lending and risky lending are equally desirable to the banks. If we assume the same margins on lending as in the HMS we see that the impact on the margins of increased competition is as follows:

$$\Delta m_p = (1 + k)\Delta\alpha \quad (4)$$

$$\Delta m_g = \theta(1 + k)\Delta\gamma \quad (5)$$

We see that the margin on risky lending will fall more than the margin on safe lending whenever $|\theta(1 + k)\Delta\gamma| > |(1 + k)\Delta\alpha|$, or when $|\theta\Delta\gamma| > |\Delta\alpha|$. However, since $\theta < 1$ and since we assume that competition affects these yields symmetrically, $\Delta\alpha = \Delta\gamma$, it is clear that this will never hold. We can never have $|\theta\Delta\alpha| > |\Delta\alpha|$ and therefore the margin on prudent lending will always be reduced to a greater extent than the margin on risky lending. This implies that an equally large reduction in both the yield on prudent lending and safe lending would work in favour of risk-taking. This result is acquired as the expected return falls less when considering risky lending than when considering prudent lending. Thus, in this model, a higher level of competition unambiguously leads banks to take on more risk in an unregulated equilibrium.

This simple model illustrates that competition in lending rates has a similar effect as competition for deposits; namely reduced franchise values and increased incentive to take on risk. Though a simplistic model like this gives us an indication of the effects of competition in lending in isolation, it is susceptible to the same criticism as HMS; namely that competition in lending and in deposits are related, something that is not reflected in this type of model. In the second attempt, we will try to account for this relationship as well.

3.1.2 Second attempt: Competition in deposit rates & lending rates

As a second attempt we could remove the assumption that deposits are fixed and propose a model that is identical to the HMS, in all respects but one; namely that the yields are assumed to be functions of the competition for deposits, ε . Competition for deposits is defined as the elasticity of the deposits in response to a percentage change in the deposit rate and is as such seemingly unrelated to competition in lending rates. However, it seems reasonable to assume that whatever is driving the changes in this elasticity, would also be influencing competition in lending rates in a similar way. Thus, we can defend using ε as a proxy for competition in lending as well as for competition for deposits. As before, we assume that a positive shift in this parameter makes the yields on both assets go down.

We can analyse the effects competition has on this system from the equilibrium conditions in the HMS. Consider first the critical deposit rate as given in HMS:

$$\hat{r}(k) = (1 - \delta) \frac{\alpha - \theta\gamma}{1 - \theta} (1 + k) + \delta[\alpha(1 + k) - \rho k] \quad (6)$$

Employing that the lending rates are now functions of the level of competition, and assuming that competition affects the yields symmetrically, i.e. that $\frac{\partial\alpha}{\partial\varepsilon} = \frac{\partial\gamma}{\partial\varepsilon}$, we find that the critical value goes down when competition increases:

$$\frac{\partial\hat{r}(k)}{\partial\varepsilon} = \frac{\partial\alpha}{\partial\varepsilon} (1 + k) < 0 \quad (7)$$

In isolation this means that the range of deposit rates that yield the prudent outcome is reduced, implying that risky lending has become relatively more favourable. When we take into account that the optimal deposit rate is always increasing in competition, it is clear that a

higher level of competition unambiguously leads to a greater incentive for risk-taking, also in this model.

So far the proposed models do not contradict the findings in the HMS; where increased competition leads to more risk-taking. If anything, they reinforce this notion by showing that competition not only reduces franchise value through higher deposit rates, it also does it by decreasing lending rates; implying a double whammy on the margin on intermediation.

Though the second proposed model improves on some aspects, for instance on the fact that competition in loans and deposits are related, it is still lacking (at least) one critical aspect in order to give a meaningful discussion about the effects of competition. This critical aspect is the fact that the success rate of the loans the banks extends is dependent on the lending rate the bank offers. As argued by Boyd and De Nicolo, when borrowers have to pay higher lending rates, the chance that they will not be able to repay goes up. All else equal, this means that banks are taking on less risk when competition is high and lending rates are correspondingly low. The implications of this is that we cannot realistically operate with an exogenous success rate, θ , in our model.

The rest of this chapter will be used to establish and examine a model that both captures the fact that competition in deposits and lending are two sides of the same coin, while also taking into account how changes in the lending rates affect the risk profile of the banks. This third suggested model is yet again the HMS-model with some additional modifications. The main point of departure from the HMS is related to the return on risky lending. While risky lending still yields an uncertain return, with lower expected return than safe lending, these lending rates now depend on the level of competition. When the level of competition changes, not only the yields will change, but also the success rate of the investment.

3.2 The model

As in the standard model, we consider a bank that is assumed to operate for T periods. In each period the bank competes for deposits by offering the deposit rate r_i while the other banks offer the deposit rate r_{-i} . We denote the total amount of deposits bank i is able to acquire $D(r_i, r_{-i})$, where the volume of deposits is increasing in the bank's own deposit rate and decreasing in the rate of competing banks. This implies that we have $D_1 > 0$ and $D_2 < 0$.

After deposits have been raised, the bank is faced with the problem of choosing its lending portfolio. As in the standard model, we assume that the bank can invest both the deposits it collects and whatever amount of own capital it holds. The banks can choose to invest its means in one of two ways. It may either lend to safe borrowers, which yields a return that is achieved with full certainty; or it may lend to risky borrowers.

When the bank extends loans to safe borrowers, the bank offers a lending rate $\alpha(\varepsilon)$ which is paid to the bank with full certainty. These loans can be seen as loans extended to sound institutions, governments and households with a high degree of creditworthiness. If the bank chooses to extend loans to risky borrowers it offers the lending rate $\gamma_i(\varepsilon) > \alpha(\varepsilon)$.

The first point of departure from the standard model is related to the yield on these two assets. Whereas in the standard model the yields were given outside the model, in this modified version the rates of return will depend on the level of competition between banks. As proposed in the second attempt, we will use ε as the proxy for competition in lending as well as for competition for deposits, as these are likely to be closely linked. As before, we assume that a positive shift in this parameter, indicating an increase in the level of competition in general, will make the yields on lending go down.

$$\frac{\partial \gamma(\varepsilon)}{\partial \varepsilon} < 0$$

$$\frac{\partial \alpha(\varepsilon)}{\partial \varepsilon} < 0$$

The second departure from the standard model is related to the probability of a successful investment outcome. When the banks choose a higher lending rate, the probability that the loan is repaid, $\theta(\gamma_i)$, will go down. This is due to the higher interest payments increasing the chances that borrowers will be unable to repay their loans. This alteration implies that we have the following relationship between lending rate and success rate; $\theta'(\gamma_i) < 0$. The loan is unsuccessful and is defaulted on with probability $1 - \theta(\gamma_i)$. When the borrowers default on their loans, the salvage value achieved by the banks is equal to β . However, for simplicity going forward, we will assume that $\beta = 0$.

It goes without saying that the mechanism where a higher lending rate leads to a greater risk of default is present both when considering risky loans and when considering the so-called

“safe loans”. However, to justify not taking this effect into consideration when discussing the safe loans, we will assume that the borrowers of these loans have high enough creditworthiness that they are able to repay their loans at any reasonable lending rate. Thus, we will neglect this effect when considering the safe loans.

In the standard HMS-model it is assumed that the expected return from the risky asset is strictly lower than the expected return on the safe asset. We will maintain this assumption here too, implying that $\alpha > \theta(\gamma_i)\gamma_i$, making risky lending inefficient at any lending rate. We also maintain the assumption that if the risk-taking is successful, the bank earns a higher private return, implying that $\gamma_i > \alpha$. The opportunity cost of capital is ρ and is assumed to be exogenous and strictly greater than the return on safe lending ($\rho > \alpha$). It is assumed that the demand for loans at any interest rate is always large enough so that the banks are able to lend out all their funds.

The per period profit of the bank when it chooses extend safe loans is $\pi_p = m_p D(r_i, r_{-i})$, where $m_p = \alpha(\varepsilon)(1 + k) - \rho k - r_i$ is the effective profit margin that the bank earns on each unit of deposit, net of its cost of capital. When the bank chooses to extend risky loans, per period profit is $\pi_g = m_g D(r_i, r_{-i})$, where $m_g = \theta(\gamma_i(\varepsilon))(\gamma_i(\varepsilon)(1 + k) - r_i) - \rho k$ is the margin on risk-taking. These margins are similar to the one’s in the HMS, with the aforementioned alterations; first of all, both the asset returns – or lending rates – are assumed to be functions of the level of competition in the economy, ε . Second of all, the probability that an investment is successful is a function of the risky lending rate and therefore also dependent on the level of competition in the economy.

Notice how the risky margin illustrates where moral hazard comes into the picture. From the definition of the margin we see that deposits are only repaid when the borrower does not default. This implies that the “expected costs of every unit deposits”, θr_i , when extending risky loans is lower than the expected costs of deposits when extending safe loans, r_i . The expected costs of deposits when extending risky loans will be increasing with the success rate. This means that the banks like risk-taking as more risk implies lower expected costs of deposits. If the risk-taking indeed fails, the banks do not compensate the depositors in any way.

As mentioned, banks are assumed to be risk-neutral, profit maximizing entities. They therefore seek to maximize their expected discounted profits, $V = \sum_{t=0}^T \delta^t \pi_t$. Following

Diamond (1989) we will look at the limit as $T \rightarrow \infty$. This entails that banks will choose strategies corresponding to the infinitely repeated static Nash equilibrium.

The sequence of the stage game is as follows: Banks simultaneously choose their level of own capital and their deposit rate, while the lending rate follows from the level of competition in the economy. The level of own capital and the deposit rate are chosen in order to maximize expected discounted profits. Depositors then choose the bank in which they wish to place their funds. After the banks have chosen their level of own capital and deposits are collected, the banks extend loans to either safe or risky borrowers. Once the portfolio decision is made, returns are realized, and the regulatory authorities inspect the balance sheet of the banks. If the bank has negative equity and thereby cannot repay its depositors in full, the bank's franchise is revoked.

3.3 Competitive equilibria

In the standard HMS-model we saw that, under certain conditions, banks were incentivized to choose the risky asset as an equilibrium outcome. In this section we will determine whether the banks might still choose to take risk in equilibrium. If risk-taking is never chosen as an equilibrium outcome, then no prudential regulation would ever be necessary. In this section we will determine under which conditions, if any, the banks would choose to extend risky loans in equilibrium.

There are two stages to the bank's investment process. In the first stage, the bank uses its deposit rate to attract deposits. When the bank has acquired its deposits, the second stage is to invest its means by extending either risky loans, or safe loans. The investment decision the bank makes will depend on the lending rates in the economy.

Following HMS, the bank's choice of asset class is unobservable to depositors and regulators. As the bank is a risk-neutral, profit maximizing entity, the bank will extend safe loans only if the expected discounted profit from extending these loans exceeds that of the expected discounted profit of extending loans to the risky borrowers. This will be the case as long as $V_p \geq V_g$, where V_p is defined as $\frac{1}{1-\delta} [m_p D(r_i, r_{-i})]$ and is the expected discounted profits when extending safe loans, and V_g is defined as $\frac{1}{1-\theta(y_i)\delta} [m_g D(r_i, r_{-i})]$ and is expected discounted profits from risky lending.

If we tweak the expression $V_p \geq V_g$ slightly, we obtain the same result found in the standard HMS; namely that the banks will be incentivized to extend safe loans as long as the one period expected additional rent on risk-taking ($\pi_g - \pi_p$) is smaller than the lost franchise value if the banks risk-taking should fail:

$$\pi_g - \pi_p \leq \delta(1 - \theta(\gamma(\varepsilon)))V_p \quad (8)$$

The only difference between this condition and the one in the HMS is that the probability of failure varies with the banks risky lending rate. Should this condition above not hold true, the banks will prefer to extend risky loans in an unregulated equilibrium. Using the constraint, we can determine a critical level for the deposit rate:

$$\hat{r}(k, \varepsilon) = (1 - \delta) \frac{\alpha(\varepsilon) - \theta(\gamma(\varepsilon))\gamma(\varepsilon)}{1 - \theta(\gamma(\varepsilon))} (1 + k) + \delta[\alpha(\varepsilon)(1 + k) - \rho k] \quad (9)$$

Provided that the equilibrium deposit rate is less than or equal to this critical value, $r_i \leq \hat{r}(k, \varepsilon)$, the bank will prefer to extend safe loans in equilibrium, rather than extending loans to the risky borrowers. Should the bank's deposit rate be such that it exceeds this critical threshold, the bank will prefer to extend risky loans in equilibrium. Notice that, as in the HMS, this critical level is determined in such a way that the bank has no incentive to extend risky loans at the lending-decision stage. The bank is thus determining whether to extend safe loans or risky loans, conditional on having a fix pool of deposits to invest and therefore also a fixed deposit rate.

Later we will show that it is never optimal for the banks to hold capital, regardless of the type of loans they choose to extend. Thus, in an unregulated scenario, where there is no capital requirement, the critical value that makes safe lending preferred to risky lending will be when:

$$\hat{r}(0, \varepsilon) = (1 - \delta) \frac{\alpha(\varepsilon) - \theta(\gamma(\varepsilon))\gamma(\varepsilon)}{1 - \theta(\gamma(\varepsilon))} + \delta[\alpha(\varepsilon)] \quad (10)$$

3.3.1 Equilibrium with safe lending

In the previous section, we demonstrated that the portfolio decision of the bank will depend on the interest rates that arise in equilibrium. Thus, to determine what state of the world will arise, we need to determine the various interest rate responses of the bank. In this section we will focus on how the bank competes in the market for deposits and the bank's portfolio decision.

Following HMS, we will begin with the assumption that if a competitive equilibrium with no risk-taking exists, then this is the equilibrium that will be chosen by the banks. If the bank intends to invest in the safe asset, then it will choose:

$$(r_p, k_p) = \arg \max_{r,k} \{V_p(r, r_{-i}, k)\} \quad (11)$$

In other words, the bank will choose the deposit rate and level of own capital that maximizes the expected discounted profits, taking the deposit rate offered by other banks as given. This implies that the bank solves the following problem:

$$\text{Max}_{(r,k)} \left\{ \frac{1}{1-\delta} (\alpha(\varepsilon)(1+k) - r_i - \rho k) D(r_i, r_{-i}) \right\} \quad (12)$$

Taking the derivative with respect to the deposit rate r_i and solving for the profit maximizing deposit rate conditional on prudent lending we find:

$$r_p(k) = [\alpha(\varepsilon)(1+k) - \rho k] \frac{\varepsilon}{\varepsilon + 1} \quad (13)$$

Where we have defined the level of competition as the elasticity of deposits with respect to a change in the deposit rate, $\varepsilon = \frac{r}{D} \frac{\partial D(r_p, r_{-p})}{\partial r_p}$. This is equivalent to the definition used in the HMS.

In determining the optimal level of own capital, we observe that $\frac{\partial V_p}{\partial k} = -\frac{1}{1-\delta} [(\rho - \alpha)D(r_p, r_{-p})] < 0$. This implies that increasing a bank's own capital will only reduce the bank's expected profits, and thus the bank will always seek to minimize the amount of own capital it invests. In the competitive equilibrium the bank therefore chooses $k_p = 0$, which implies that the optimal lending rate will be:

$$r_p(0) = \alpha(\varepsilon) \frac{\varepsilon}{\varepsilon + 1} \quad (14)$$

This is a similar equilibrium deposit rate as the one found by HMS. From the expression it can be shown that more intense competition works in opposing ways on the equilibrium deposit rate (as $\frac{\partial \alpha}{\partial \varepsilon} < 0$), but we will assume the deposit rate is increasing the level of competition, $\frac{\partial r_p}{\partial \varepsilon} > 0$. We see that also in this modified model, when competition becomes increasingly intense, the deposit rate will approach the lending rate and the margin on safe lending becomes arbitrarily small. Thus, we get the well-known result where increasingly higher levels of competition for deposits lead to a steadily decreasing margin and therefore a steadily decreasing franchise value from safe lending.

However, as we saw earlier, the outcome where only safe lending takes place, will only arise as the equilibrium provided that the optimal deposit rate is lower than the critical deposit rate, i.e. when r_p is lower than \hat{r} . If the optimal deposit rate when extending safe loans is higher than the critical lending rate, the banks would earn a strictly greater return by extending risky loans. Thus we know that if the equilibrium deposit rate $r_p > \hat{r}$, no equilibrium where all banks choose to extend safe loans can exist.

3.3.2 Equilibrium with risky lending

In the following, we will sketch the case where the bank can only extend risky loans. In this scenario, the bank chooses (r_g, k) in order to maximize:

$$(r_g, k_g) = \arg \max_{r,k} \{V_g(r_i, r_{-i}, k)\} \quad (15)$$

In this setting the bank must choose its optimal deposit rate and level of own capital to maximize its expected discounted profits. The maximization problem can be expressed as follows:

$$\text{Max}_{(r_i, k)} \left\{ \frac{1}{1 - \theta(\gamma(\varepsilon))\delta} (\theta(\gamma(\varepsilon))(\gamma(\varepsilon)(1 + k) - r_i) - \rho k) D(r_i, r_{-i}) \right\} \quad (16)$$

Maximizing the objective function with respect to the deposit rate, we find that the optimal deposit rate when the bank extends risky loans is given as:

$$r_g = \frac{\varepsilon}{1 + \varepsilon} \left[\gamma(\varepsilon)(1 + k) - \frac{\rho k}{\theta(\gamma(\varepsilon))} \right] \quad (17)$$

If we consider the unregulated case, where $k = 0$, we see that as the level of competition approaches infinity, the deposit rate approaches the risky lending rate. Thus, higher levels of competition, as measured by the size of ε , reduce the margin on risky lending just as it did the margin on safe lending. As before we assume that more intense competition leads to a higher deposit rate, implying $\frac{\partial r_g}{\partial \varepsilon} > 0$.

Maximizing equation (16) with respect to the amount of own capital yields:

$$\frac{1}{1 - \theta(\gamma_i)\delta} (\theta(\gamma_i)\gamma_i - \rho)D(r_i, r_{-i}) < 0 \quad (18)$$

Since the maximum expected return from risky investment is $\theta(\gamma_i)\gamma_i < \alpha$ and we have assumed that $\alpha < \rho$, it follows that $\theta(\gamma_i)\gamma_i < \rho$ and that $\frac{\partial V_g}{\partial k} < 0$. This result implies that increasing a bank's capital will only reduce the bank's expected discounted profits when it extends risky loans. Therefore, the bank will always seek to minimize the amount of own capital it invests. In the competitive equilibrium the banks therefore choose $k_g = 0$, which implies that the optimal lending rate will be:

$$r_g = \gamma(\varepsilon) \frac{\varepsilon}{1 + \varepsilon} > 0 \quad (19)$$

Notice that regardless of whether the bank chooses the safe or the risky asset, profit maximization will always entail that banks hold no own capital voluntarily.

3.3.3 Effects of competition on equilibrium outcome

So far, the results in the model bare close resemblance to those in the HMS. However, since competition now affects the success rate of risky lending in addition to all the yields, it is not obvious what the net effect of competition will be in the model. For instance, if it turns out that increased competition reduces the margin on risky lending to a greater extent than the margin on safe lending, it may imply that higher levels of competition spur greater incentive to extend prudent loans, not lower.

In order to work out if this might be the case and to evaluate the “robustness” of *Proposition 1*; we begin with the expression for the critical value for the deposit rate and examine how it is affected by an increase in the level of competition. In order to make the expressions that follow as general as possible, we will include k in the expressions, keeping in mind that $k = 0$ in the unregulated equilibrium:

$$\frac{\partial \hat{r}}{\partial \varepsilon} = \frac{1+k}{1-\theta} \left[\left(\frac{1-\delta}{1-\theta} \theta'(\alpha-\gamma) - (1-\delta)\theta \right) \frac{\partial \gamma}{\partial \varepsilon} + (1-\theta\delta) \frac{\partial \alpha}{\partial \varepsilon} \right] \quad (20)$$

We see that the critical deposit rate is ambiguous when we do not assume anything about the relative size of $\frac{\partial \gamma}{\partial \varepsilon}$ and $\frac{\partial \alpha}{\partial \varepsilon}$. However, as an initial simplification, if we assume as we have done before that $\frac{\partial \gamma}{\partial \varepsilon} = \frac{\partial \alpha}{\partial \varepsilon}$ we get:

$$\frac{\partial \hat{r}}{\partial \varepsilon} = \frac{1+k}{1-\theta} \left[\left(\frac{1-\delta}{1-\theta} \theta'(\alpha-\gamma) + (1-\theta) \right) \frac{\partial \gamma}{\partial \varepsilon} \right] < 0 \quad (21)$$

Hence \hat{r} is strictly decreasing as the level of competition increases. This means that the range of equilibrium deposit rates that yield the prudent outcome is narrowing as competition increases. Considering only this effect in isolation, it is clear that higher levels of competition are reducing the incentive to extend prudent loans. To determine whether the net effect of more intense competition is higher risk-taking, we must also consider the how competition influences the optimal deposit rate:

$$\frac{\partial r_p}{\partial \varepsilon} = \frac{1}{1+\varepsilon} \left[\frac{r_p}{\varepsilon} + \varepsilon \frac{\partial \alpha}{\partial \varepsilon} (1+k) \right] \quad (22)$$

We assume that this expression is positive. This means that if the equilibrium prudent deposit rate was initially below \hat{r} , a higher level of competition will bring the two rates closer. If the equilibrium prudent deposit rate was initially above \hat{r} , a higher level of competition will increase the gap. Thus, we can conclude that when competition becomes more intense and the yields on both assets decrease by the same amount, this unambiguously raises a bank’s incentive to take on risk. This mechanism is illustrated in the figure below:

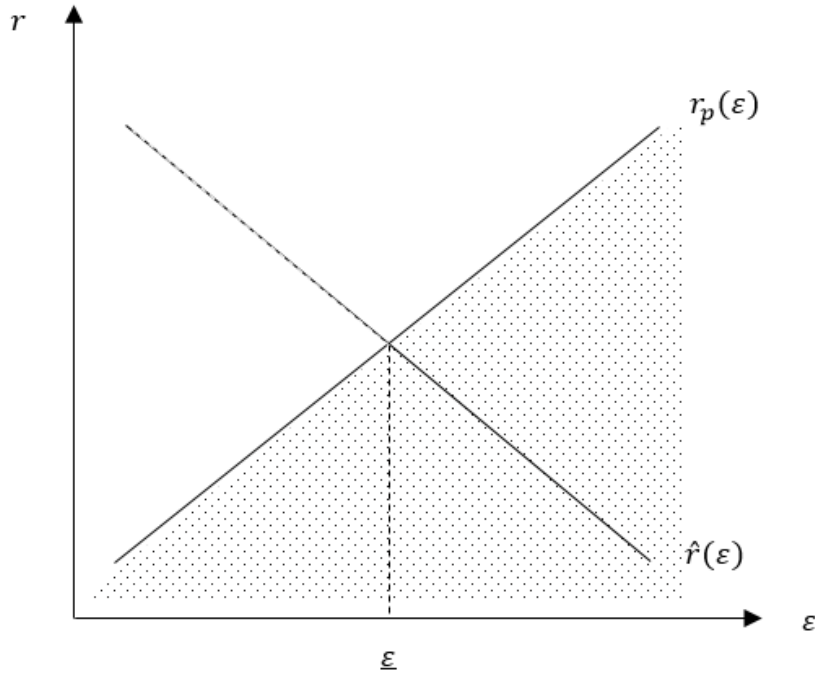


Figure 3: The critical level of competition

The line denoted $\hat{r}(\varepsilon)$ is the no-gambling condition, while the line denoted $r_p(\varepsilon)$ is the equilibrium deposit rate conditional on prudent investment. The figure illustrates when the equilibrium outcome will be prudent or risky, depending on the level of competition. For levels of competition above $\underline{\varepsilon}$ the optimal deposit rate is above the critical deposit rate, leading to risk-taking in equilibrium. The opposite is true for levels of competition below $\underline{\varepsilon}$.

As the figure demonstrates, as the critical deposit rate is decreasing with competition, while the optimal response is increasing, at some point the level of competition will be so high that the optimal deposit rate is above the rate that makes the banks indifferent. This means that at a sufficiently high level of competition, banks will prefer risk-taking in equilibrium. From what has been demonstrated so far, it seems that proposition 1 from the standard HMS, stating that when markets are sufficiently competitive (*i. e.*, $\varepsilon > \underline{\varepsilon}$), the only symmetric equilibrium has banks choosing to hold no capital, and investing in the risky asset, still holds.

However, this result rests critically on the assumption that $\frac{\partial \gamma}{\partial \varepsilon} = \frac{\partial \alpha}{\partial \varepsilon}$. When this constraint holds, it can be shown that $\frac{\partial m_g}{\partial \varepsilon} = \theta' \frac{\partial \gamma}{\partial \varepsilon} (\gamma(\varepsilon)(1+k) - r(\varepsilon)) + \theta \frac{\partial m_p}{\partial \varepsilon}$, which implies that $\left| \frac{\partial m_g}{\partial \varepsilon} \right| < \left| \frac{\partial m_p}{\partial \varepsilon} \right|$. This means that the margin on risky lending is falling to a lesser degree than the margin on safe lending when we impose $\frac{\partial \gamma}{\partial \varepsilon} = \frac{\partial \alpha}{\partial \varepsilon}$. However, should we not impose this assumption; can we ever obtain a situation that contradicts the finding that greater competition leads to increased incentive for risk-taking?

When we do not assume anything about the relative changes in the yields due to a change in competition, we see that competition affects the margins in the following way:

$$\frac{\partial m_g}{\partial \varepsilon} = \theta' \frac{\partial \gamma}{\partial \varepsilon} (\gamma(\varepsilon)(1+k) - r(\varepsilon)) + \theta \left(\frac{\partial \gamma}{\partial \varepsilon} (1+k) - \frac{\partial r}{\partial \varepsilon} \right) \quad (23)$$

$$\frac{\partial m_p}{\partial \varepsilon} = \frac{\partial \alpha}{\partial \varepsilon} (1+k) - \frac{\partial r}{\partial \varepsilon} < 0 \quad (24)$$

If we use the fact that the critical value is determined from a state with a given deposit rate so that $\frac{\partial r}{\partial \varepsilon}$ is the same in each margin, we get:

$$\frac{\partial m_g}{\partial \varepsilon} = \frac{\partial \gamma}{\partial \varepsilon} \theta' (\gamma(\varepsilon)(1+k) - r(\varepsilon)) + \left[\frac{\partial \gamma}{\partial \varepsilon} - \frac{\partial \alpha}{\partial \varepsilon} \right] \theta (1+k) + \theta \frac{\partial m_p}{\partial \varepsilon} \quad (25)$$

From this expression we see that if $\frac{\partial \gamma}{\partial \varepsilon} \theta' (\gamma(\varepsilon)(1+k) - r(\varepsilon)) + \left[\frac{\partial \gamma}{\partial \varepsilon} - \frac{\partial \alpha}{\partial \varepsilon} \right] \theta (1+k)$ is sufficiently negative we will have $\left| \frac{\partial m_g}{\partial \varepsilon} \right| > \left| \frac{\partial m_p}{\partial \varepsilon} \right|$. This would imply that the margin on risky lending is reduced to a greater extent by more intense competition than the margin on safe lending. In isolation, this would mean that increased competition would work in favour of making the banks more incentivized to choose the safe asset. In order to achieve this result, we see from equation (25) that $\left| \frac{\partial \gamma}{\partial \varepsilon} \right| > \left| \frac{\partial \alpha}{\partial \varepsilon} \right|$ is a necessary condition, i.e. that the lending rate on risky investment is more negatively affected by competition than the prudent lending rate is. This means that if changes in the level of competition for some reason affects the yield on risky lending to a greater extent than the yield on safe lending, competition may actually work in favour of the prudent lending. This would imply that prudent lending becomes relatively more attractive for banks as competition increases.

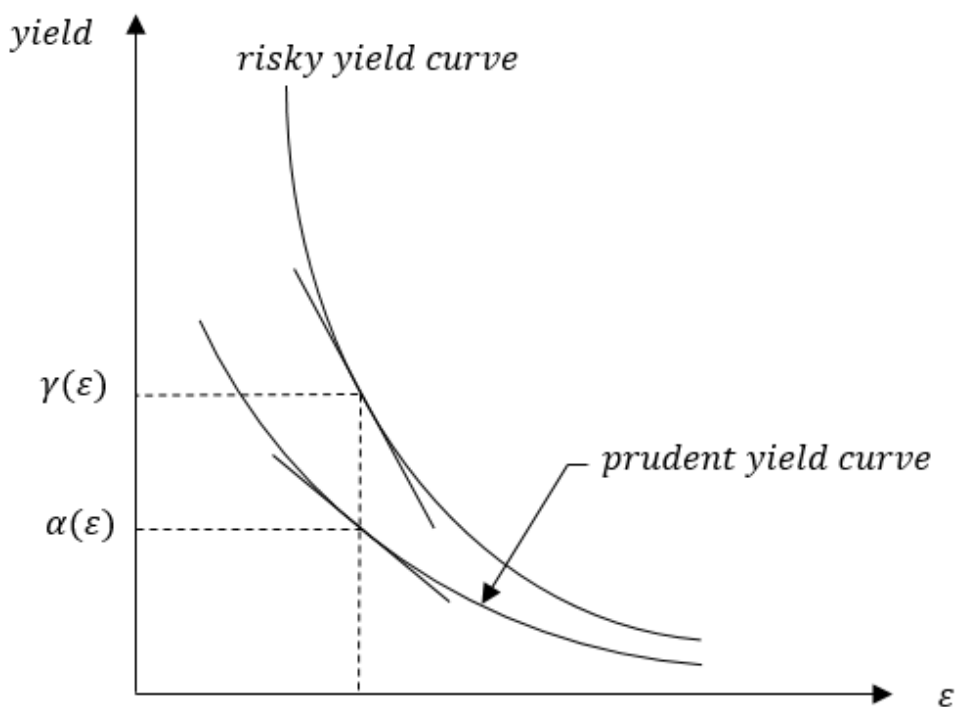


Figure 4: Yield curves

Figure 4 gives a likely representation of the relationship between the yields and the level of competition. We see that when the prudent yield curve is strictly below the risky yield curve, as is assumed, the yield on risky loans will be falling to a greater degree than the yield on prudent loans as competition increases. This implies that we may well have situations where increased competition lead to greater incentive to extend prudent loans.

Is it reasonable to assume that the yield on risky lending is affected more negatively by competition than the yield on safe loans? Considering that the yield on safe loans is lower than that of risky loans, banks have less to “work with” when it comes to the safe loans. The degree to which banks are able to cut costs and similar to reduce the prudent lending rate as competition increases is likely to be small. The banks have more leeway when it comes to the risky lending rate, simply due to it being higher than the prudent rate. It is therefore not unlikely that the relationship between competition and yields may be represented as in Figure 4 above. Since the yield curve for prudent loans is strictly below that of risky loans, the yield on risky loans will be falling at a higher rate than the yield on prudent loans for any level of competition.

In the previous paragraphs, we saw that the condition $\left| \frac{\partial \gamma}{\partial \varepsilon} \right| > \left| \frac{\partial \alpha}{\partial \varepsilon} \right|$ was necessary in order to achieve an outcome where banks gain greater incentive to extend safe loans as competition intensifies. This condition is however not in itself sufficient to ensure that such an outcome is possible. In order to obtain the outcome, where more intense competition gives greater incentive towards safe investment, the following two conditions must be met:

- i. $\frac{\partial \hat{r}}{\partial \varepsilon} > 0$
- ii. $\frac{\partial \hat{r}}{\partial \varepsilon} > \frac{\partial r_p}{\partial \varepsilon}$

Condition i. can be shown to be true under certain assumptions, while condition ii. will hold under certain parameter values. Consider again how the critical deposit rate depends on the level of competition:

$$\frac{\partial \hat{r}}{\partial \varepsilon} = \frac{1+k}{1-\theta} \left[\left(\frac{1-\delta}{1-\theta} \theta' (\alpha - \gamma) - (1-\delta)\theta \right) \frac{\partial \gamma}{\partial \varepsilon} + (1-\theta\delta) \frac{\partial \alpha}{\partial \varepsilon} \right] \quad (26)$$

If the expression inside the square brackets can be shown to be positive, then $\frac{\partial \hat{r}}{\partial \varepsilon} > 0$. In order for this to be the case we must have that:

$$\left(\frac{\theta'}{1-\theta} (\alpha - \gamma) - \theta \right) \frac{\partial \gamma}{\partial \varepsilon} > - \left(\frac{1-\theta\delta}{1-\delta} \right) \frac{\partial \alpha}{\partial \varepsilon} \quad (27)$$

If this condition is to hold, we must have that $\theta > \frac{\theta'}{1-\theta} (\alpha - \gamma)$ and, as before, $\left| \frac{\partial \gamma}{\partial \varepsilon} \right|$ must be sufficiently larger than $\left| \frac{\partial \alpha}{\partial \varepsilon} \right|$. If we assume that these conditions are met, the results translate to $\frac{\partial \hat{r}}{\partial \varepsilon} > 0$. When this is the case, it means that the more intense competition is, the higher the equilibrium deposit rate must be in order to make risky lending preferred to safe lending. Thus, the higher the level of competition, the larger the range of deposit rates that imply prudent lending.

In addition to this, we still have:

$$\frac{\partial r_p}{\partial \varepsilon} = \frac{1}{1+\varepsilon} \left[\frac{r_p}{\varepsilon} + \varepsilon \frac{\partial \alpha}{\partial \varepsilon} (1+k) \right] \quad (28)$$

Which we assume to be positive, due to the traditional effects of competition. The combination of these two results is illustrated in the figures below:

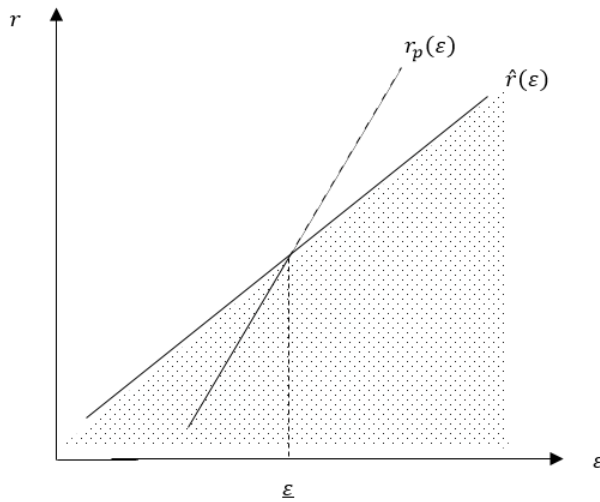


Figure 5A: Increasing critical deposit rate I

In this figure, competition increases the optimal deposit rate to a greater extent than it does the critical deposit rate. Therefore, for a sufficiently high level of competition and above, risky lending is preferred in equilibrium

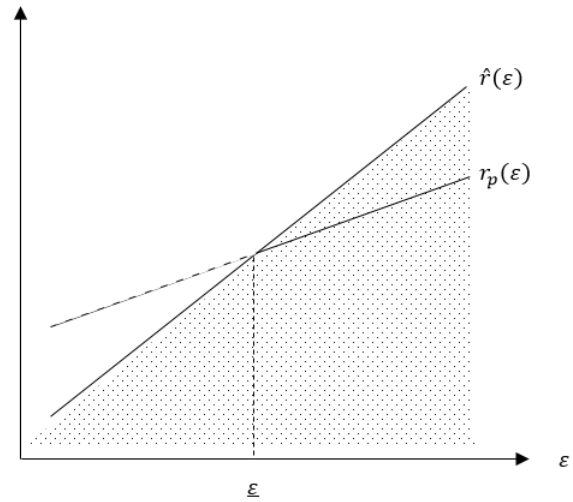


Figure 5B: Increasing critical deposit rate II

In this figure, increased competition has a greater effect on the critical deposit rate than on the optimal rate. Therefore, for a sufficiently high level of competition, $\underline{\varepsilon}$ and above, safe lending is preferred in equilibrium.

The figures above show that there are two possible outcomes when $\frac{\partial \hat{r}}{\partial \varepsilon} > 0$. In the scenario depicted in Figure 5A, $r_p(\varepsilon)$ is steeper than $\hat{r}(\varepsilon)$. In this figure, though the necessary condition $\frac{\partial \hat{r}}{\partial \varepsilon} > 0$ is met, as competition becomes more intense banks will eventually find risky lending optimal. This is because when $\frac{\partial r_p}{\partial \varepsilon} > \frac{\partial \hat{r}}{\partial \varepsilon}$, higher levels of competition increases the optimal deposit rate more than the critical rate. When competition becomes sufficiently intense, the optimal deposit rate will surpass the critical rate, implying that risky investment is the banks optimal response.

The results depicted in Figure 5B however, show that *Proposition 1* in HMS may not always hold. Figure 5B illustrates that when condition i. and ii. are fulfilled, we find that when competition becomes sufficiently high (*i.e.*, $\varepsilon > \underline{\varepsilon}$), the only symmetric equilibrium has banks choosing to hold no capital, and extending safe loans. The result illustrated in Figure 5B we will refer to as the “counter outcome”.

As touched upon before, a higher level of competition leads to a lower margin on safe lending, reducing the banks incentive to extend this kind of loans. However, competition also leads to a lower margin on risky lending, by lowering the optimal risky lending rate and increasing the deposit rate. As the optimal risky lending rate is falling, the probability that the loan is repaid is increasing, implying that the probability that the bank must repay the

depositors is increasing as well. This means that these costs are to a greater extent being internalized by the bank, thereby reducing the benefit to the bank of limited liability. In isolation, this cost-effect contributes towards making the banks less incentivized to take on risk as competition increases. When the benefit of risky lending is falling more than the benefit of prudent lending as competition increases, we may get the result illustrated in Figure 5B.

4 Prudential regulation

We have seen that some levels of competition will lead banks to opt for imprudent and inefficient levels of risk. Therefore, we can argue that for certain levels of competition, prudent regulation may be warranted. In the current framework, whether or not a given level of competition will produce risk-taking in equilibrium will depend on the relative influence that competition has on the yields on lending. In some cases, whenever the level of competition is above the critical level that we have called $\underline{\epsilon}$, risk-taking will take place. However, in the “counter outcome”, lending will be both prudent and efficient if the level of competition is sufficiently intense.

The notion that sufficiently intense competition can lead to an efficient unregulated outcome may be surprising as it is rather contrary to the result that we generally find when discussing the effects of competition. Bearing this result in mind, we will now look at the effect the prudential regulation proposed by HMS would have on equilibrium behaviour. Imposing the proposed regulation may not make sense in the counter framework, but the intention is to see what the effect of the proposed regulation will be if the economy can be described as in the alternative model.

Given the alterations that have been made to the model, it is natural to also analyse the effect of a third regulatory instrument as well; namely a lending rate control. In the following section we will discuss both the effect that a minimum capital requirement, a deposit rate control and a lending rate control have on equilibrium behaviour.

4.1 Imposing a capital requirement

The logic behind applying a minimum capital requirement in the altered model is the same as in the standard HMS. When the bank is bound to invest own capital it is forced to bear some of the down-side risks of its lending decision. The intended effect is that it will make risky investment less attractive and thereby align the bank’s preferences with those of the regulators. If the own capital causes the downside from risky lending to be sufficiently large, the banks will choose to extend safe loans in equilibrium instead.

To implement a policy of capital requirements that eliminates risky lending as a competitive equilibrium, the capital requirement must induce an outcome where no profitable deviation to

risk-taking is profitable to any bank. In the standard HMS, the level of capital that ensured a prudential outcome was the one that secured that the expected discounted profit from risk-taking, when everyone else invested prudently, was less than the expected discounted profit from prudent investment.

In the current approach, we can formulate a similar condition. In order for deviation to risky lending not to be profitable, and thus ensuring that a capital requirement of k will implement a no-risk-taking equilibrium, it must be the case that $Max_r \{V_g(r, r_p, k)\} \leq V_p(r_p, r_p, k)$. Define \bar{k} as the minimum level of capital that satisfies this constraint. We know that a capital requirement that satisfies this constraint must exist, as for a sufficiently large k , the bank bears enough of the costs from risk-taking that the incentive for taking risk is reduced and the bank's returns will be strictly higher when extending safe loans. If the desire for risk-taking is reduced with the increase of the capital requirement, we must have that $\frac{\partial \hat{r}}{\partial k} > 0$. To see whether this is the case, consider:

$$\frac{\partial \hat{r}}{\partial k} = \frac{1 - \delta}{1 - \theta(\gamma)} [\alpha - \theta(\gamma)\gamma] - \delta[\rho - \alpha] \quad (29)$$

As in the standard HMS we see that $\frac{\partial \hat{r}}{\partial k} > 0$ need not necessarily be the case, and will depend on the farsightedness of the banks. We will assume, as does HMS, that the banks are sufficiently myopic so that $\frac{\partial \hat{r}}{\partial k} > 0$, implying that increased capital is making risky lending relatively less attractive due to the capital at risk effect.

If we can show that $\frac{\partial r_p}{\partial k} < 0$, then we can conclude that a sufficiently high level of capital can induce a prudent outcome where only safe lending takes place. Taking the derivative of the optimal prudent lending rate with respect to the capital requirement leads to the following expression:

$$\frac{\partial r_p}{\partial k} = \frac{\varepsilon}{1 + \varepsilon} [\alpha - \rho] \quad (30)$$

This expression is unambiguously negative. We can therefore conclude that a sufficiently high level of capital will lead to an outcome where safe lending is strictly preferred and will be the equilibrium outcome.

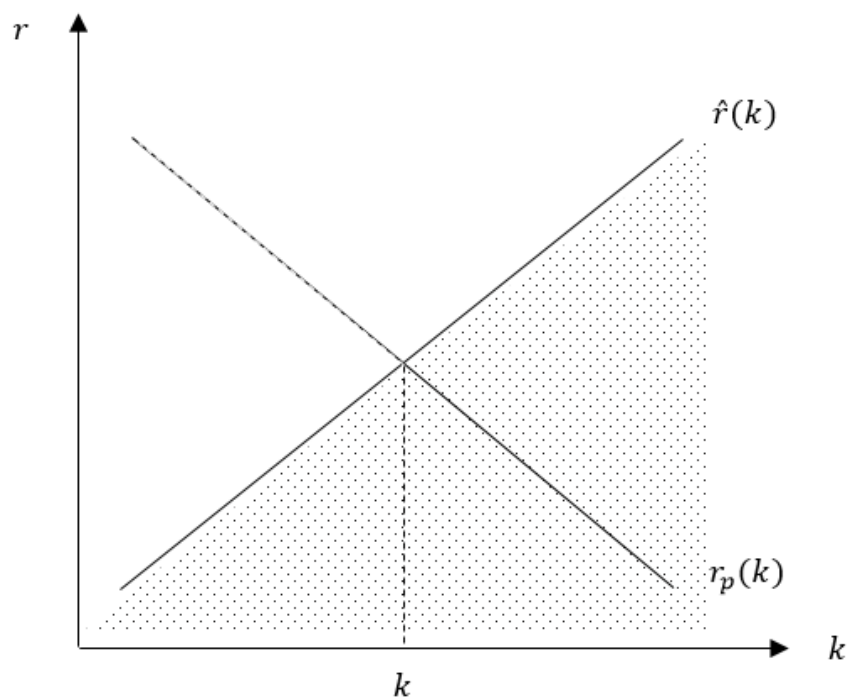


Figure 6: No-Risk-taking region and competitive equilibria.

The line designated \hat{r} is the no risk-taking condition, while the line designated r_p is the equilibrium deposit rate, conditional on prudent lending. A sufficiently high capital requirement can produce the efficient outcome by lowering the optimal deposit rate to the point where safe lending is preferred. In the figure, a capital requirement of \underline{k} and above will achieve this.

This is the same result as derived in HMS. The reason for this result is due to the similar way in which the capital requirement enters into the two models. In the alternative model, the lending rates are assumed not to be affected by changes in the capital requirement. The capital requirement only affects the deposit rates and therefore enters the alternative model in exactly the same way as in the HMS. In this respect, nothing has changed relative to that of the standard model and therefore it is not surprising that we obtain the same result. In the alternative model it is the changes in the level of competition that drive the results that diverge from the standard model.

4.2 Imposing a deposit rate ceiling

In the HMS we saw that a high level of competition for deposits could deteriorate franchise value to the point where banks preferred investing in the risky asset. We saw that prudential bank behaviour could be restored by putting a ceiling on the deposit rate, thereby creating enough franchise value for the banks to discourage them from risk-taking.

In the analysis in the previous section we found that a higher level of competition has a similar effect in the modified model; greater competition reduces franchise values through lower margins on both safe and risky lending. The direction in which increased competition moves the banks preferences will however depend on the relative sizes in these margin reductions. Depending on the assumptions, the benefit of risky lending can fall to a greater or lesser extent than the benefit of safe lending. Thereby driving the result that more intense competition may lead to a prudent unregulated outcome, or a risky one, depending on these assumptions.

Bearing this result in mind, it is not entirely clear how a deposit rate ceiling will influence the equilibrium outcome in the alternative model. Remember that the rationale behind imposing a deposit rate ceiling is that it works in the same way as restricting competition; increasing franchise value and thus making risk-taking relatively less attractive. When we find in the “counter outcome” that sufficiently high competition actually produces the prudent outcome, how will a policy that attempts to mimic the effects of restricting competition impact banks incentives?

An important point to consider in this sense is the point argued by HMS, page 156-157 of their paper; namely that though a deposit rate control mimics competition, restricting competition and imposing a deposit rate ceiling are not one and the same. In the modified version of the model, limiting competition for example through barriers to entry, affect both the deposit rate, the lending rate and the success rate of risky lending. Imposing a deposit rate control only affects the deposit rate in both the standard HMS and in the altered model.

Since imposing a deposit rate control in the altered model will neither affect the lending rates nor the success rate, the effects of a deposit rate control will be exactly the same as in the standard HMS. A sufficiently low deposit rate ceiling that lowers the equilibrium deposit rate will increase the franchise value to the point where the value at risk is so large that the banks do not wish to take risk. This is the same in the altered model as in the standard model. Thus, a sufficiently low deposit rate ceiling can always produce the prudent and efficient outcome.

4.3 Capital requirement and deposit rate control

The main finding of the HMS-model is that a Pareto improvement can be achieved if, instead of using the capital requirement in isolation, a policy of a capital requirement is combined

with a deposit rate control. HMS show us that by using a combination of these instruments, the prudent outcome is achieved with a lower capital requirement and an unchanged deposit rate; making banks better off while leaving depositors equally well off, thereby implying a Pareto improvement. To verify if this combination of policies will entail a Pareto improvement in the modified model, we must add the condition that borrowers are not made worse off either.

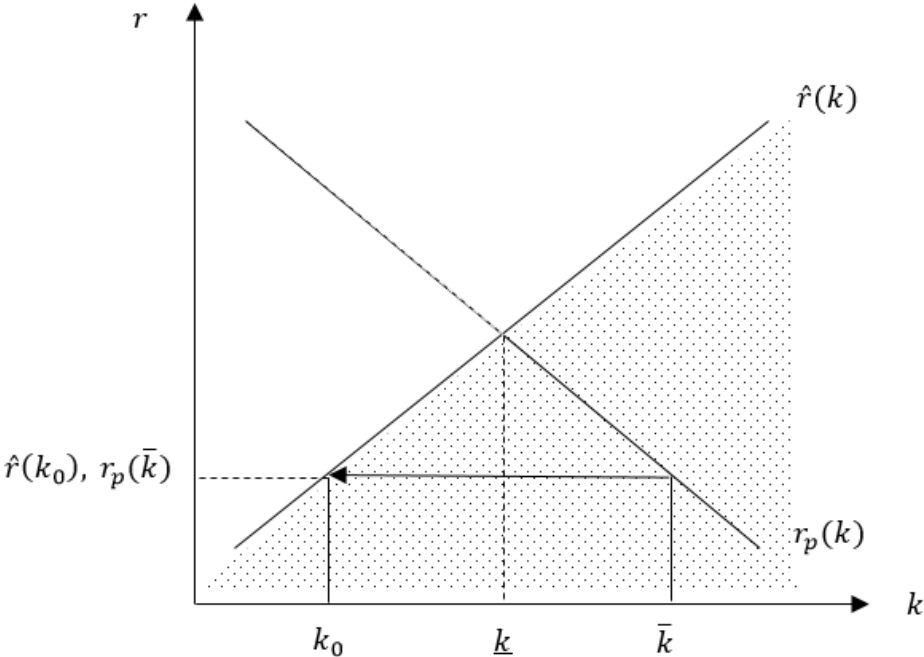


Figure 7: Pareto improvements with deposit-rate controls

The line denoted $\hat{r}(k)$ is the no gambling condition, whereas the line denoted $r_p(k)$ is the equilibrium deposit rate the banks choose, conditional on prudent investment. The figure shows how imposing a deposit rate ceiling of $\bar{r} = r_p(\bar{k})$ yields a Pareto improvement over using the capital requirement \bar{k} in isolation. With the deposit rate ceiling in place, the regulators can reduce the capital requirement to k_0 , implying a Pareto improvement as banks are better off, while regulators, depositors and borrowers are indifferent.

In the previous sections, we saw that a capital requirement and a deposit rate ceiling could separately produce an efficient and prudent outcome. Considering these results, it is clear that this must also be the case under the current framework. Again, since neither a capital requirement nor a deposit rate ceiling influence the lending yields or the success rate in the modified model, we obtain the same result here as in the HMS. If a capital requirement is needed to obtain the prudent outcome, adding on the addition of a deposit rate ceiling at the equilibrium deposit rate will improve the outcome, or at least not make it worse. Since lending rates in this model are unaffected by changes in the capital requirement and the deposit rate, borrowers are also equally well off under this regulatory policy. This implies that

also in the modified model we find that the combination of deposit rate control and capital requirement yield a Pareto improvement over a capital requirement in isolation.

4.4 Imposing a lending rate control

With the changes made to the yields on lending in the altered model, a third policy instrument is natural to consider; namely a lending rate control. As we argued earlier that a deposit rate ceiling could create franchise value by increasing the banks' earnings, a lending rate floor can, in theory, work in the same way. All else equal, imposing a binding floor on the lending rate will increase a banks' earnings through increasing the margin on their loans. This creates additional franchise value. As before, if the franchise value at risk exceeds the one-period expected gain from risk-taking, the bank will choose to lend prudently in equilibrium. If imposing a lending rate floor increases the franchise value when extending safe loans to a greater degree than the rent on risky lending increases, then imposing a sufficiently high lending rate floor would induce safe lending in equilibrium.

However, imposing a lending rate restriction is different from imposing a deposit rate restriction. This is because a binding lending rate restriction does not only influence the lending yields themselves, but also the success rate and the deposit rates. Let us first consider a lending rate floor that only binds the prudent lending rate, such that the lending rate floor $\bar{\alpha}$ is:

$$\alpha(\varepsilon) < \bar{\alpha} < \gamma \quad (31)$$

4.4.1 Binding prudent lending rate

As before, if the equilibrium deposit rate is higher than the critical deposit rate, the banks will prefer risky investments in equilibrium. To study the effects of imposing a lending rate floor that only binds the prudent rate, we can consider the effects on $r_p(k)$ and $\hat{r}(k)$ of an exogenous increase in α - one that is not brought about due to a change in competition.

$$\Delta \hat{r}(k) = (1 + k) \left(\frac{1 - \delta\theta}{1 - \theta} \right) \Delta \alpha > 0 \quad (32)$$

$$\Delta r_p(k) = (1 + k) \frac{\varepsilon}{1 + \varepsilon} \Delta \alpha > 0 \quad (33)$$

The expressions show us that for a given capital requirement, an increase in the prudent lending rate leads to a higher critical deposit rate; implying a larger range of equilibrium deposit rates that produce the prudent outcome. However for the given capital requirement, the optimal prudent deposit rate will also be higher and may thus exceed the increase in the critical lending rate.

If we consider a situation where the banks are exactly indifferent between risky and prudent investment, we can conclude that a binding lending rate floor, $\alpha(\varepsilon) < \bar{\alpha} < \gamma$, will produce the prudent outcome provided that $\frac{\Delta \hat{r}(k)}{\Delta \alpha} > \frac{\Delta r_p(k)}{\Delta \alpha}$. We see that this must be the case since, $\frac{1 - \delta \theta}{1 - \theta} > \frac{\varepsilon}{1 + \varepsilon}$. Therefore, we can conclude that a sufficiently high, binding prudent lending rate floor could produce the prudent outcome, irrespective of the capital requirement.

4.4.2 Binding prudent lending rate and risky lending rate

To study the effects of imposing a lending rate floor that binds both the risky and the prudent lending rate, we can again consider the effects on $r_p(k)$ and $\hat{r}(k)$ of an exogenous increase in α and γ , where we use that when the policy binds both we have $\alpha = \gamma$.

$$\Delta \hat{r}(k) = \frac{1 + k}{1 - \theta} [(\delta(1 - \theta) + 1)\Delta \alpha - \theta \Delta \gamma] > 0 \quad (34)$$

We know that this expression must be positive since $\Delta \alpha$ must be strictly greater than $\Delta \gamma$, as $\alpha < \gamma$ to begin with. This means that a policy that is binding for both lending rates increases the range of deposit rates that makes safe lending preferable, for a given k . In isolation this works toward making the banks more prone to safe lending.

$$\Delta r_p(k) = \frac{\varepsilon}{1 + \varepsilon} (1 + k) \Delta \alpha > 0 \quad (35)$$

The optimal deposit rate is also higher, for a given k , when the lending rate policy binds. Again, in order to determine whether or not this policy is giving increased incentive towards prudent investment we must consider the relative change in the critical deposit rate vs. the prudent deposit rate. In order for the policy to work in the desired direction, eventually

leading to a prudent equilibrium outcome, we need $\Delta\hat{r}(k) > \Delta r_p(k)$. This will be the case as long as:

$$\Delta\gamma < \frac{1}{\theta} \left[1 + (1 - \theta) \left(\delta - \frac{\varepsilon}{1 + \varepsilon} \right) \right] \Delta\alpha \quad (36)$$

Which may or may not be the case, depending on the various parameter values. If this inequality holds, then a policy that binds both rates will push the banks in the direction of prudent lending. If it does not hold, the opposite will happen.

Thus far, we have seen that a binding prudent lending rate will create greater incentive to extend safe loans. We have also seen that a policy that binds both rates can also create greater incentive for safe lending, but it need not. It may in fact do the exact opposite as a policy that binds the risky lending rate gives, in isolation, increased incentive to opt for risky loans.

4.4.3 Combining a lending rate floor with a capital requirement

In the HMS and in the revised model we have seen that a deposit rate control, in form of a deposit rate ceiling, in combination with a capital requirement, can lead to a Pareto improvement when compared to using the capital requirement in isolation. In this section, we will evaluate whether the same will hold when we consider a combination of a lending rate floor and a capital requirement.

HMS consider what the equilibrium deposit rate would be and use this to determine what size the capital requirement should be in order to achieve the prudent outcome. They then look at what happens when they impose this equilibrium deposit rate as the deposit rate ceiling, thereby leaving it unchanged, but prohibiting banks from going above this. HMS find that by doing this, they create a greater incentive toward safe investment and can therefore lower the capital requirement. A lower capital requirement can be used as it is no longer only the capital requirement that is used to produce the prudent outcome – the deposit rate ceiling takes some of the job.

As we have seen that a binding lending rate floor can produce the prudent outcome, it is interesting to see if it is possible to achieve the Pareto improvement when imposing a lending rate floor equal to the equilibrium rate and a capital requirement that is sufficient to induce the prudent outcome. It is, however, quite evident that this floor will have no effect on the

equilibrium outcome. This is because the banks are in no way inclined to go below this lending rate and when the floor doesn't bind, no additional franchise value is generated. Thus, this policy has no effect and as a consequence, the capital requirement cannot be lowered.

A lending rate ceiling on the other hand, might work. As before, a sufficiently high capital requirement will induce prudent lending in equilibrium. Assume that the lending rate that corresponds to this level of capital is imposed as a lending rate ceiling. By imposing this ceiling, the bank's return when extending successful risky loans is no higher than when extending safe loans; thus any incentive to take on risk is eliminated. This means that not only can we reduce the capital requirement when we impose this ceiling, we can eliminate it all together. The lending rate ceiling in itself effectively eliminates the option of the risky asset, thereby inducing the prudent outcome at any level of capital requirement.

Such a policy reduces the capital requirement while leaving the lending rate unchanged, leaving borrowers equally well off while improving the situation for banks. The lower capital requirement also increases the deposit rate, which means that depositors are better off, but makes the banks worse off. Thus, there may be a Pareto improvement from this policy if the benefit to the banks of a lower capital requirement outweighs the negative effect of a higher deposit rate.

5 Comments

The purpose of altering the HMS-model was to include the effect of competition on lending rates into the model. We were able to achieve this by making the yields on lending functions of ε . By making the success rate a function of the risky lending rate, we were also able to model how competition ultimately affects the degree of risk-taking as well. Though these additions help to give a more complete representation of competition on the system, the model still has several shortcomings.

For one, by making the lending rates solely functions of the level of competition, we overlook the fact that the lending rates are likely to depend on the deposit rate and capital requirement. Seeing as an increase in the deposit rate would increase the lending rate, while a decrease would decrease the lending rate, this simplification might not be of great importance, as the net effect on margins may be small or negligible. None the less, the fact that the lending rate is completely disconnected from the deposit rate is important as it is the reason we obtain the results in section 4.2 and 4.3; namely that a capital requirement and a deposit rate restriction work, in the new framework, exactly the same way as they did in HMS. The reason for not making the yields a function of the deposit rate is therefore not an economic one, but a practical one – endogenous yields proved very difficult to work with in the given framework. A model that manages to incorporate the relationship between deposit rates and lending rates in a seamless way would be a clear improvement to this model.

A second assumption that has been critical for the results is the assumption that the success rate on safe loans is independent of the lending rate. Though this may be reasonable within a certain range of lending rates, the success rate would undoubtedly be affected to a certain degree, especially if the lending rate became very high. When the most realistic scenario has the success rate of both loans decreasing as the yields increase, it might not make sense to distinguish between the two types of loans. It might make more sense to consider only one type of loan; one that becomes more risky as the lending rate increases. However, an approach like this has its own hurdles to overcome; namely determining when the bank is taking on too much, or even too little risk. Given appropriate assumptions, it is likely that this hurdle could be overcome by pinpointing the interest rates that maximize expected returns, using this as a critical value in determining excess or inadequate levels of risk.

6 Concluding remarks

In this thesis, I have studied banks' incentives to exude either risky or prudent behaviour when competition affects not only deposit rates, but lending rates and success rates as well. In order to accomplish this, I have altered the HMS-model to include the way in which competition affects yields on loans and subsequently the chances that the loans are repaid; two features that are lacking in the original model. By including these additional features, I find that some of the conclusions of the HMS still hold, while others do not. Among those that do not hold is the proposition that a higher level of competition unambiguously leads to a greater incentive for risk-taking. The alternative model shows that, in some cases, the opposite holds true. In this respect, I found what Boyd and De Nicolo suggested in their paper; namely that more intense competition may give banks increased incentive to extend prudent loans.

This result, and others, rest heavily on the assumptions of the model. Though these assumptions need not be inherently implausible, they are most certainly not the only way to describe the manner in which an economy works. With this in mind, the main purpose of this theoretical exercise has not been to draw a final conclusion about the impact of competition on a bank's behaviour, but simply to highlight that the effects are plentiful and may not be as evident as many papers, including the HMS, imply them to be.

Seeing as the effects of competition on the behaviour and incentives of banks are so numerous, it is understandably difficult to capture all the relevant effects in one and the same framework. It is therefore no wonder that many articles on the subject limit their focus one-sidedly to either competition in deposit rates or in lending rates. As demonstrated here and in other literature, the consequences of competition are sensitive to both the model framework and to what part of intermediation one considers. For this reason, examining the link between competition and bank behaviour may not be well represented by such one-sided approaches. In particular, as touched upon in this paper, some of the results acquired in such a way may in fact cease to hold when competition is allowed to work in a broader way on the system.

In section 3.3.3. I showed how under certain conditions, the higher the level of competition, the more prone banks would be to extending prudent loans; in other words the exact opposite result to what is found by HMS. However, it was also clear that given other conditions, the

link between competition and bank behaviour corresponded perfectly with HMS. Implying that the results found by HMS may yet be valid, even considering the new framework. The point I have attempted to make with this thesis, is not that the findings of HMS are necessarily wrong, but simply that if one does not know all the effects of competition, one runs the risk that imposing restrictions on competition will lead to undesired and unforeseen outcomes. With this consideration in mind and seeing as there are economic costs to both borrowers and depositors of restricting competition, we can draw the modest conclusion that using interest rate controls and restrictions on competition as regulatory instruments should be exercised with caution.

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