COMPETITION AND RISK-TAKING IN BANKING INDUSTRY

Rostislav Staněk

Masaryk University, Faculty of Economics and Administration, Department of Economics

Lipová 41a, 602 00 Brno, rostanek@mail.muni.cz

Abstract: The aim of the paper is to investigate the relationship between competition and risk-taking in the banking industry. The paper provides a general theoretical model that incorporates the charter value models and models with contracting problems. In particular, the model contains a moral hazard problem and it enables investments into the risk-free asset. Competition on the loan side of the market is modeled as spatial competition. The model predicts that the relationship between competition and the probability of bank failure is non-monotonic and U shaped. The prediction of the model is verified by the empirical analysis conducted using the data from Czech banking sector. The Herfindahl-Hirschman index is used as a measurement of competition and the Z-score is used as measurement of the probability of bank failure.

JEL Classification: L13, D86, G21, G32

Keywords: Moral hazard, Risk, Bank competition

Introduction

In general, the paper deals with the question: “What is the relationship between competition and risk-taking in the banking industry?” Unfortunately, very different answers can be found in the current economic literature.

A large amount of economic and finance literature predicts a positive relationship between the competition in the banking industry and a bank's risk-taking (Hellmann et al. 2000; Repullo 2004). This relationship is based on the so called charter value model of the bank of Allen and Gale (2004). This model assumes that banks compete in the deposit market and invest into the risk-free asset or into the risky asset. There is no contracting problem in the model, which means that neither moral hazard nor adverse selection occurs. The decision of the bank about the risk of its investment depends on its charter value which further depends on the degree of competition in the market. Let me illustrate the relationship using a simple example. Consider two banks. One of them is a monopoly and the other operates in a competitive market. The monopoly bank obtains a monopoly rent and its charter value is high. The bank that operates in a competitive market obtains zero profit and its charter value is zero. Therefore, the higher the competition in the banking industry, the smaller the charter value of the bank. In the case of default, the bank has to leave the market and it loses its charter value. It is clear that the default is more costly for the bank in the less competitive market. Hence, lower competition induces lower risk-taking and vice versa.

On the other hand, there is another stream of economic literature that predicts negative relationship between the competition in the banking industry and a bank's risk-taking. This relationship is based on the existence of the contracting problem, i.e. it assumes moral hazard or an adverse selection problem on the side of loan applicants. Boyd and De Nicolo(2005) follow the seminal paper of Stiglitz and Weiss (1981) and present the model with adverse selection. This means that the characteristics of the loan contract offered by the bank will affect the composition of the population of firms that apply for the loan. If the adverse selection is present, then the risk of loan default is increasing in the interest rate. This feature of the model creates the connection between risk-taking and competition. Higher competition in the banking industry reduces the interest rate, which attracts borrowers with more safety projects and the risk of loan default decreases.

Boyd and De Nicolo (2009) present a breakthrough model that incorporates both approaches. The model contains the moral hazard on the side of the firms but it also allows for the bank's holding of the risk-free assets. This possibility creates the charter value of the bank. The model assumes that banks compete in Cournot's way on both sides of the market. The model shows that as competition increases, the probability of bank failure can either decrease or increase.

Empirical literature presents mixed findings. Keeley (1990) and Demsetz, Saidenberg and Strahan (1996) present empirical evidence for positive relationship between competition and risk in banking industry. Keeley (1990) finds that deregulation of state branching increased risk-taking measured by capital-to-asset ratio. Demsetz, Saidenberg and Strahan (1996) showed that U.S. banks with greater market power also have the largest solvency ratios and a lower level of asset risk. On the other hand, Jayarante, Strahan (1998) claim that deregulation was followed by reductions in loan losses, which suggests a negative relationship between competition and risk. Neither further literature provides ultimate conclusions (see e.g. De Nicolo 2004).

Aim and methodology

The aim of this paper is twofold. First, I provide the game-theoretical model that incorporates both links mentioned in the introduction between competition and bank risk-taking. The notion of subgame perfect equilibrium is employed as a solution of the game. The subgame perfect equilibrium is found by backward induction method. The model should allow for a more general and possibly non-monotonic relationship between competition and risk-taking in the baking industry and consequently it should be consistent with various empirical findings. Second, I present a simple empirical analysis of the relationship between competition and risk taking using Czech banking industry data. I use the Herfindahl-Hirschman index as a measurement of the degree of competition and the Z-score for measurement of risk-taking in the banking industry. Consequently, the estimation results are compared with the predictions of the model. The data for the empirical analysis comes from the Czech National Bank time series database ARAD and covers the period from 2002 to 2010. This is the longest period for which all the necessary data are available.

I follow the approach of Boyd and De Nicolo (2009) when creating the model. Hence, the presented model contains the charter value channel as well as the contracting problem. Contrary to the model of Boyd and De Nicolo (2009), I abandon the assumption of Cournot competition and I assume spatial competition a la Salop (1979) on the loan side of the market. There are at least two reasons why this assumption is more appropriate. First, in my view, the interest rate is the main characteristic of the loan. So, it is natural to assume that banks pick up prices rather than quantities. Boyd and De Nicolo (2009) justify their assumption by pointing out that Cournot competition can be seen as shortcut for a two-stage game in which firms choose capacities and they compete through prices (Kreps and Scheinkman, 1983). But this justification is not acceptable because the choice of quantities is already present in the model. Second, Cournot competition assumes that products are homogenous. But it is hard to believe that bank loans are perfect substitutes. A bank usually poses some private information about its customers. This informational barrier creates switching costs for the loan applicants. Therefore, spatial competition is more suitable assumption, because it allows for product differentiation.

Theoretical model

The theoretical model is formally a five period extensive game with simultaneous moves. There are two types of players in the game: banks and entrepreneurs. Banks obtain financial resources and offer a loan contract to an entrepreneur. Each entrepreneur has a project of a fixed size that can be financed only by a bank loan. The timing of the game is defined as follows. At the start of the game the banks attract financial resources. At the next stage, each bank offers a simple debt contract to entrepreneurs. The contract is characterized by the interest rate. In the third period, each entrepreneur can accept or reject the loan contract offered by the bank. The bank allocates the rest of its resources into the risk free asset. In the fourth period, the entrepreneur decides about the effort that they invest into the project. Note that the effort of the entrepreneur is not observable by the bank. Hence, the game contains the moral hazard aspect. At the last stage, the outcome of the project is implemented and the profit is divided according to the contract.

Model environment

I describe the decision making problems of the players backwards. As regards the decision making of the firms, each entrepreneur can manage one project of a fixed size 1. The project can be financed only by a bank. The project yields a revenue $p + e$ where p is the stochastic part and e is the deterministic part that depends on the entrepreneur's effort. If the entrepreneurs lower their effort, then the deterministic part of the profit decreases and the risk of the project, measured by the probability that the revenue falls below some given value, increases. Denote $c(e)$ as the cost of the entrepreneur's effort. For the sake of simplicity, suppose that random variable p has a uniform distribution in the closed interval $[0,P]$. The bank offers a simple debt contract where it sets the lending rate R. The firm obtains some profit $(p+e-R)$ only if the return of the project is at least $(p+e)$. Otherwise, the firm is not capable to pay the lending rate R. In this case the bank becomes a residual claimant of the project and the firm obtains zero profit. Hence, the expected profit of the firm is given by the following expression, where T denotes the transaction costs which will be explained later.

$$\Pi(R) = \int_{R-e}^{P} (p+e-R)\frac{1}{P}dp - c(e) - T = \frac{P}{2} + e - R - \frac{(R-e)^2}{2P} - c(e) - T \ .$$

I impose a standard assumption of concavity on the expected profit function (see e.g. Mas-Colell et al. 1995). Under this assumption, it holds that the second derivative of the expected profit function is less than zero. In this case it means that $1/P-c''(e)<0$. Under the assumption that the firm chooses the level effort in order to maximize its expected profit, we can find the first order condition of this problem:

$$1 + \frac{R-e(R)}{P} - c'(e) = 0 \ .$$

Differentiating the first order condition according tobased on the lending rate, we get the expression for the change in the entrepreneur's effort induced by the change of the lending rate. The change is given by the following expression and it is negative because of the concavity of the expected profit function.

$$e'(R) = 1 - Pc''(e) < 0 \ ,$$

We can see that the entrepreneurs lower their efforts when the lending rate rises. This increases the risk of the project.

In the period before, the banks are on the move. Each bank can invest into a risky loan or into a risk-free asset. L denotes the part of the portfolio invested into the risky loan and $(F-L)$ denotes the part of the portfolio invested into the risk-free asset. The return of the risk-free asset is r. Obviously, the bank's expected profit depends on the realization of the random variable p. I assume that the realization of the random variable p is the same for all projects, which means that p represents some kind of systemic risk. If $p>R-e$, then no firm defaults and the bank receives the profit

$$RL + r(F - L) - FI \ .$$

On the contrary, if it holds that $p<R-e$, then all firms default and the bank becomes a residual claimant of the projects which gives the profit

$$\max\{0, L(p + e) + r(F - L) - FI\}.$$

In the baseline model of Boyd and De Nicolo (2009) the banks compete in Cournot's way on both sides of the market. I abandon this assumption on the loan side of the market for reasons stated in the previous section. Instead of that I consider Salop's (1979) circular city model of price competition. The idea of the model is simple. Each entrepreneur is in some sense close to a particular bank. This means for example that the bank has some private information about creditworthiness of the entrepreneur and therefore the debt contract of this bank is ceteris paribus more favorable for the entrepreneur. Specifically, the entrepreneurs are located uniformly on a circle with perimeter equal to one. Density is unitary around the circle. Suppose that there are N banks in the market. The banks are located equidistant from one another on the circle. The position of banks represents the differentiation of their products. To apply for a loan the entrepreneur has to spend transaction costs t for a unit of distance. Each entrepreneur chooses the bank loan that gives them the highest expected profit given the transaction costs T and the lending rate of each bank R. So, the demand for loans of a particular bank is given by $L(R)$. Each bank chooses its lending rate R_i and the amount of resources F_i in order to maximize its expected profit taking into account the best response function of the entrepreneurs. The best response function of the entrepreneur can be written as $e(R)$. The expected profit of the bank can be stated in the following way.

$$\int_{R_i - e(R_i)}^{P} (R_i L(R) + (F_i - L(R))r - F_i I)\frac{1}{P}dp + \int_{p^*}^{R_i - e(R_i)} ((e(R) + p)L(R) + (F_i - L(R))r - F_i I)\frac{1}{P}dp$$

After some algebra the expected profit of the bank can be stated as the net interest profit minus the loss given by the possibility of entrepreneur's default.

$$(R_i - r)L(R) + (r - I)F_i - L(R)\int_{p^*}^{R-e(R)} \frac{p}{P}\,dp$$

Now I can define the probability of bank failure. Denote *p** as the stochastic part of the profit, i.e. realization of the random variable *p*, such that the bank's profit is zero. From the above stated expression for the bank's profit in the case of the entrepreneur's default, we get

$$p^*(R,F) = r - \frac{(r-I)F}{L(R_i)} - e(R_i)\,.$$

Thus p* is the threshold value of bank failure. The higher is the threshold, the higher is the probability of default and the risk-taking in the banking industry. Under the assumption of uniform distribution of random variable *p*, the probability of default can be stated as *p*/P*.

Finally, I have to describe financing of the banks. Denote *S* as the total amount of resources obtained by all banks in the industry. There is an upward slopping supply of these resources provided by non-banks subjects or by the central bank. The inverse supply of these resources is given by the following equation where *I* is the interest rate paid by the bank.

$$I = I(S)$$

Equilibrium and the prediction of the model

I redirect my attention to the symmetric subgame perfect equilibrium. To obtain symmetric equilibrium I have to compute the demand for loans of the particular bank when it offers the lending rate R_i while other banks offer the lending rate *R*. Assuming the symmetric equilibrium, the bank *i* has two effective competitors, namely the bank *i-1* and the bank *i+1*. The entrepreneur located between bank *i* and the bank *i+1* is indifferent when applying for the loan from bank *i* and the bank *i+1* if and only if her profit net of transaction cost is the same. That is, if

$$\Pi(R_i) + tx = \Pi(R) + t\left(\frac{1}{N} - x\right),$$

where *x* denotes the distance from the bank *i*. Taking into account the symmetry of the market area of the bank, the bank faces the demand of

$$L(R_i, R) = \frac{1}{N} + \frac{\Pi(R_i) - \Pi(R)}{t}$$

Note that the demand function $L(R_i,R)$ decreases in R_i, because $\Pi(R_i)$ also decreases in R_i. Moreover, it can be shown that an increase in the number of banks reduces the equilibrium lending rate.

In the equilibrium, each bank chooses R and F that is the best response to the other banks' strategies. Because of the symmetry of the equilibrium we can find the best response function of one bank and suppose that $R=R_i$. The equilibrium is characterized by the following conditions where the subscript denotes the derivative by the stated variable:

$$L+(R-r)L_R = L_R \int_{p^*}^{R-e(R)} \frac{p}{P}\,dp + \frac{L(R)}{P}((1-e_R)(R-e(R)) - p^* p_R^*)$$

$$r - I - I_F F = 0$$

The equilibrium of the model has some interesting features. It can be seen from the second condition that the amount of resources used to finance loans is independent of the amount of loans. It also shows that the deposit rate is the risk-free rate minus the market power rent on the deposit side of the market. The first condition determines the lending rate. It shows that the lending rate is such that the marginal revenue obtained by increasing the lending rate is equal to the sum of two terms on the right-hand side of the equation. The first term reflects that the bank is exposed to lower risk, because it holds lower amount of loans. Hence, it can be seen as a change in the expected loss given by the probability that the entrepreneur will default. The second term can be interpreted as change in the market power rent. We can see that this market power rent disappears when the number of banks increases and the market share of one bank $L(R)$ goes to zero.

The main prediction of the model concerns the relationship between competition and risk in the banking industry. Competition is measured by the number of banks. Risk-taking is measured by the probability of the failure of the bank, which is given by the threshold value p^*. A higher threshold value represents a higher probability of bank failure. What is the change in the equilibrium threshold value induced by the change in the number of the banks? It is clear that in the symmetric equilibrium each bank has an equal market share. So, after substituting second equilibrium condition and the equations $L=1/N$ and $F=S/N$ into the expression for p*, we get expression for the threshold in the symmetric equilibrium.

$$p^* = r - \frac{I_F S}{N} - e(R)\,.$$

At the first sight, we can see that the equilibrium threshold value is increasing in the lending rate. By differentiating this expression by N, we obtain more interesting expressions regarding how the probability of bank failure changes as the number of banks changes.

$$\frac{\partial p^*}{\partial N} = \frac{I_F S}{N^2} - e_R R_N \,.$$

The first term in the expression is positive, because I_F is positive by the assumption that inverse supply of deposits increases. The second term is also positive, because I showed that both e_R and R_N are negative. Hence, the whole expression can be either positive or negative. The sign of the whole expression depends on the strength of the charter value effect and the moral hazard effect. The moral hazard effect is given by the product of e_R and R_N. It can be interpreted in a simple way. When more banks enter the market, the equilibrium lending rate decreases. A lower lending rate induces entrepreneurs to invest more effort into their projects. If the moral hazard is sufficiently strong, then the threshold value of bank failure decreases when the number of firms increases. The charter value is given by the market power on the deposit side of the market. Hence, the charter value effect describes the change in the charter value of the bank. As the number of banks increases, the market power on the deposit of the market goes down as well as the charter value of bank. If the charter value effect prevails, then the threshold value of bank failure increases as the number of firms increases. Moreover, we can see that:

$$\lim_{N \to \infty} p_N^* = -e_R R_N \,,$$

This means that the moral hazard effect prevails when the number of firms goes to infinity. This fact creates the main prediction of the model. In a very competitive market the moral hazard effect should be stronger than in a market with a low level of competition.

Empirical analysis

In this section I perform a simple empirical analysis of the relationship between competition and risk-taking in the Czech banking sector. This section can be also seen as an attempt to verify or falsify the prediction of the above presented model. As mentioned in the introduction, the empirical findings of the current literature are confusing. The findings are different because various authors use different measures of competition and risk-taking. So, it is important to choose the right measurement of competition and risk-taking in the banking sector. In this respect, the theoretical model helps us because the measurement of competition and risk-taking is clearly determined by the model.

The standard measurement of competition is either the Herfindahl-Hirschman index or the Lerner index. Ceteris paribus the Herfindahl-Hirschman index is positively associated with the Lerner index. But Herfindahl-Hirschman index has several advantages in our model. First, it is more closely related to the number of firms which is the measure of competition in the model presented above. Second, contrary to the Lerner index, the Herfindahl-Hirschman index is observable and directly computable. The computation of the Herfindahl-Hirschman index is given by the following formula where N is the number of banks and s_i is the market share of the firm i.

$$HHI = \sum_{i=1}^{N} s_i^2$$

The value of the index ranges from zero to 10,000. A higher value of Herfindahl-Hirschman index indicates a more concentrated industry and a less competitive industry. For the purpose of this paper, I use the Herfindahl-Hirschman index published by the Czech National Bank in the ARAD time series. The data are on monthly basis and they cover the period from 2002 to 2010.

The risk-taking in the banking sector is understood as a probability of bank failure. The probability of bank failure can be measured by the Z-score. Z-score is defined by the following expression where ROA is the return to assets ratio, EA is the equity to assets ratio and σ(ROA) is the standard deviation of the return to assets ratio.

$$Zscore = \frac{ROA + EA}{\sigma(ROA)}.$$

The higher the Z-score, the lower is the probability of bank failure. Theoretical explanation of why Z-score measures the probability of failure can be found in Boyd and Hewitt (1993). Calculation of the Z-score is based on the aggregate data for the whole banking sector published by the Czech National bank in the ARAD time series. Specifically, I used the data from the time series Interest rates of MFIs and Balance sheet of commercial banks. Hence, the Z-score does not express the probability of failure of the particular bank but the risk of the whole banking sector.

Now I can estimate how the Z-score depends on the Herfindahl-Hirschman index. The theoretical model predicts that the relationship between competition and risk does not need to be monotonic. Hence, the model includes also the square of the Herfindahl-Hirschman index to allow for this non-monotonicity. Moreover, the model predicts that probability of bank failure is negatively correlated with the lending rate. Therefore, I also add the bank interest rate on loans by non-financial corporation as a proxy for the lending rate. Finally, we can ask if the probability of bank failure can or cannot be explained by a macroeconomic variable, such as GDP. Therefore, the equation also contains the gross domestic product index in constant prices. The estimated equation is the following:

$$\ln(Zscore) = \alpha_0 + \alpha_1 \ln(HHI) + \alpha_2 \ln^2(HHI) + \alpha_3 \ln(R) + \alpha_4 \ln(GDP)$$

The results of the estimation are presented in the table. We can see that all the coefficients are statistically significant on a 1 % level except the GDP coefficient. Moreover, the coefficients have the expected sign. The relationship between the lending rate and Z-score is negative, which suggests the presence of moral hazard effect. The relationship between Z-score and the Herfindahl-Hirschman index is non-monotonic. Because the coefficient α_1 is negative and the coefficient α_2 is positive, we obtain a non-linear U-shaped relationship between the measurement of concentration and the probability of bank failure.

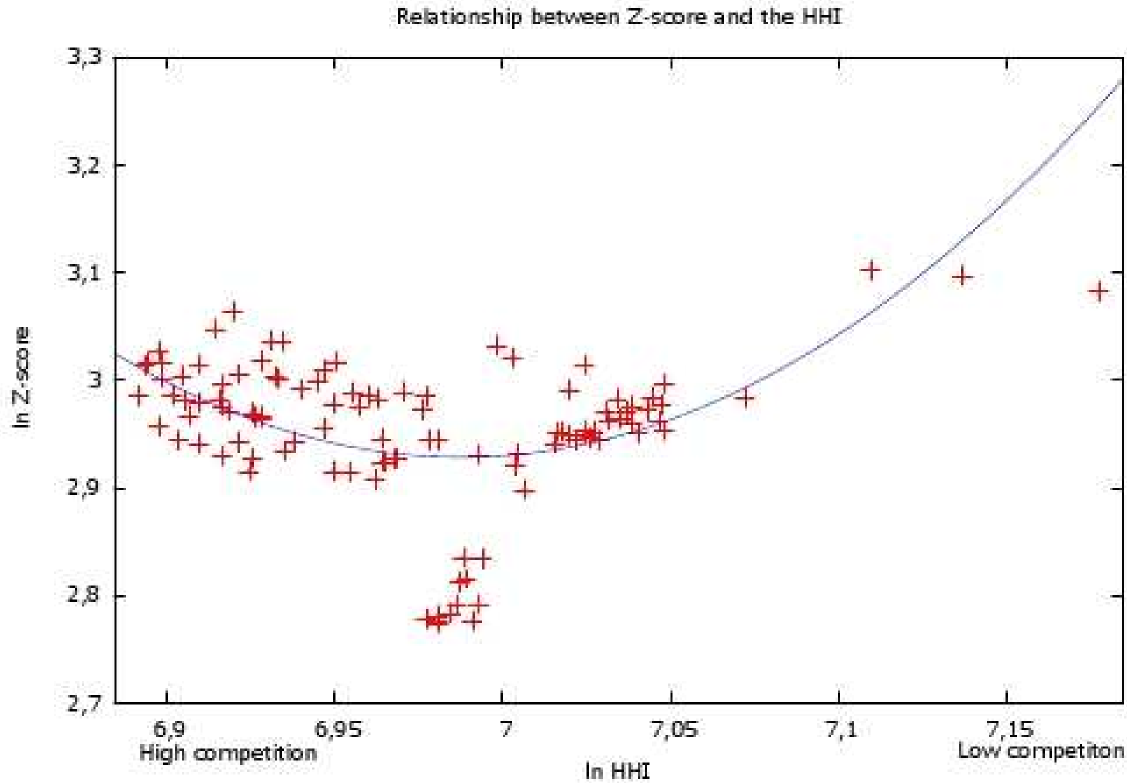
Table.1 Estimation of coefficients

	Coefficient	*Standard deviation*	*T-ratio*	*P-value*
Constant	444.603	55.529	8.007	$1.88 \cdot 10^{-12}$
Ln HHI	-126.410	15.835	-7.983	$2.11 \cdot 10^{-12}$
Ln HHI square	9.0488	1.132	7.994	$1.99 \cdot 10^{-12}$
Ln R	-0.2444	0.043	-5.678	$1.27 \cdot 10^{-7}$
Ln GDP	0.0389	0.186	0.2093	0.8347

Source: Author's calculation

The Z-score dependence on the Herfindahl-Hirschman index can be seen in figure 1. The crosses represent individual observations. The natural logarithm of the Herfindahl-Hirschman index and natural logarithm of the Z-score are captured on the axes. The lower the logarithm of the Herfindahl-Hirschman index, the greater is the competition in the industry. The theoretical model predicts that the moral hazard effect gets stronger when the market is highly competitive, i.e. when the Herfindahl-Hirschman index is low. In this case, the probability of bank failure should decrease when the competition rises. Figure 1 shows that this prediction is met by the empirical analysis. Imagine that we are on the left-hand side of the graph, where the market is competitive. If the competition increases further, the Z-score rises and the probability of default decreases. On the contrary, an increase in competition reduces the Z score on the right-hand side of the graph.

Fig.1 Dependency of Z-score on the HHI



Source: Author's calculation

Conclusion

The paper provides a general theoretical model that allows for non-monotonic relationship between the competition and the probability of bank failure. The paper follows the approach of Boyd and De Nicolo (2009). However, there are important differences. The banks set prices instead of quantities and the bank loans are not homogeneous in this model. In spite of these differences, the model makes similar predictions as Boyd and De Nicolo (2009). Hence, the predictions can be taken as robust. The model predicts a U-shaped relationship between competition and the probability of bank failure. The positive part of the relationship (a higher competition leads to a higher probability of default) is based on the charter value of the bank that is modeled by the difference between the risk-free rate and the interest rate paid by the bank to its creditors. The negative part of the relationship is explained by contracting problems, namely by moral hazard. The model predicts that the moral hazard effect has a stronger impact when the degree of competition is high.

The empirical findings gained through the data from the Czech banking industry verify the predictions of the model in two ways. The relationship between the interest rate and the probability of default, measured by the Z-score, was positive. This fact has two different interpretations. First, a bank requires higher risk premium when the probability of default is higher. Second, there is a moral hazard problem and firms are willing to take more risky projects when the interest rate is higher. We cannot fully discriminate between these explanations. However, the U-shaped relationship between competition, measured by the Herfindahl-Hirschman index, and the probability of failure indicates that there was a contracting problem in the Czech banking sector between 2002 and 2010.

References

Allen, F. and D. Gale (2004) Competition and Financial Stability. *Journal of Money, Credit and Banking*, 36, 453-480.

Boyd, J. H., and G. De Nicolò (2009). Bank Competition, Risk and Asset Allocations. *IMF Working paper*, 09/143, 2009.

Boyd, J. H., and G. De Nicolò (2005) The Theory of Bank Risk Taking and Competition Revisited. *Journal of Finance,* 60, 1329-1343.

Boyd, S. G. and R. Hewitt (1993). Bank holding company mergers with nonbank financial firms: Effects on the risk of failure. *Journal of Banking and Finance* 17, 43–63.

Czech National Bank (2011). *ARAD Data series system*. Available at WWW: <http://www.cnb.cz/docs/ARADY/HTML/index_en.htm>

Demsetz, R.S., M. R. Saidenberg and P. E. Strahan, (1996). Banks with something to lose: The disciplinary role of franchise value. *FRBNY Economic Policy Review*, 1-14.

De Nicolò B., P. Bartholomew, J. Zaman and P. Zephirin (2004). Bank Consolidation, Internationalization and Conglomeration: Trends and Implications for Financial Risk. *Financial Markets, Institutions & Instruments*, 13, 173-217.

Hellmann, T. F., K. C. Murdock, and J. E. Stiglitz (2000). Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough? *American Economic Review*, 90, 147-165.

Jayaratne, J. and P. E. Strahan (1998). Entry restrictions, industry evolution, and dynamic efficiency: evidence from commercial banking. *Journal of Law and Economics*, 41, 239-273.

Keeley, M.C. (1990). Deposit insurance, risk and market power in banking. *American EconomicReview*, 80, 1183-1200

Kreps, D. and J. Scheinkman (1983). Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes. *Bell Journal of Economics,* 14, 326-337.

Mas-Colell A., M. D. Whinston and J. R.Green (1995). *Microeconomic theory,* Oxford university press, New York, 1995.

Repullo, R. (2004) .Capital Requirements, Market Power, and Risk-Taking in Banking. *Journal of Financial Intermediation*, 13, 156-182.

Salop S. (1979). Monopolistic competition with outside goods. *Bell Journal of Economics,* 10, 141-156

Stiglitz, J. E. and A. Weiss, (1981). Credit Rationing in Markets with Imperfect Information. *American Economic Review*, 71, 393-410.

DOI 10.5817/FAI2012-1-1