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Multistrategic Behaviour of Croatian Banks

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ABSTRACT

The paper analyses whether Croatian banks simultaneously use both price and non-price strategies in producing loans and deposits as their outputs in a monopolistically competitive setting, based on a spatial competition model for the period between 2004 and 2010. Obtained elasticity coefficients of demand for banks' products show that banks rely mostly on their interest rate policies, but also on physical presence in the market in order to maximize their profits, and are also sensitive to similar decisions made by other banks. The comparison between demand elasticities for the pre-crisis and crisis/post-crisis periods shows that demand for loans became more sensitive to the banks' choice of interest rates as economic conditions worsened, while the decrease of deposit interest rates influenced the weakened deposit demand sensitivity to interest rate strategies.

Keywords: monopolistic competition; multistrategic; banking; Croatia

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1. Introduction[1]

The banking industry can generally be characterized as monopolistically competitive. In such a setting, banks have both price and non-price strategies at their disposal that can be used to increase their market power. This paper uses a spatial competition model for Croatian commercial banks that operated between 2004 and 2010 to examine whether banks behave multistrategically, i.e. to what extent do branching decisions and interest rate choices matter for profit maximization in the deposit and loan market.

Banks' branching choices, as well as the size of regional markets for deposits and loans, have been largely neglected in existing analyses of the Croatian banking industry, which provides substantial space for potentially new insights into strategic behaviour of banks and might have further implications for policy makers, especially when it comes to market regulation. Since branching decisions determine banks' location, it is also important to consider all possible factors that might affect the distance between banks' clients and their branches. To the knowledge of the author, this paper also offers the first attempt to directly assess the impact of the increase in quality of transportation infrastructure in Croatia on economic activity that goes beyond the usual focus on tourism or regional development, which is another potential contribution of the paper. The results of the estimated model indicate that interest rate strategies are relatively more important than branching decisions for banks' profit maximization, as evident from the size of the demand elasticity coefficients with respect to own and rival interest rates and the size of the branch network. Throughout the observed period the demand for loans seems to be less price- and branch-elastic than demand for deposits, while during the crisis/post-crisis period the elasticity of demand with respect to interest rates decreased in the case of deposits and increased in the case of loans, under conditions of declining deposit rates and increasing loan rates.

The paper is organized as follows: following the introductory section, the second section provides a summary of relevant literature on the structure of the banking industry and various strategies banks use to gain market power. The third section introduces the spatial competition model used in assessing multistrategic behaviour of Croatian banks. The next two sections provide a description of the data and methods used in the estimation of the model, as well as the results of the estimation of price and branch elasticities of demand for loans and deposits. The final section concludes.

2. The banking industry - from structure to strategies

The flow of main interests in microeconomic research of the banking industry could be summarised as follows: earlier papers focused on analysing the structure of the banking industry, i.e. whether it is justified to consider the market as oligopolistic/monopolistically competitive. In such circumstances it is relevant to determine what methods market players use to obtain market power. In the case of banks, the main strategic variables under

[1] The author wishes to thank Ante Žigman for very useful comments, as well as Gordi Sušić and Ivan Huljak for assistance in obtaining necessary data and helpful suggestions.

consideration were either the level of prices or the level of output. What was subsequently emphasized as characteristic of the banking industry is also the multilocational nature of banks, i.e. the use of the branch network as another possible strategic variable. Various approaches also arose regarding the separability of the loan and deposit market, as well as the treatment of deposits as an input or output. The explanation and examples of aforementioned approaches are given in the following paragraphs.

Models that analyse market players' behaviour and have been used in the assessment of the competitive structure of the banking industry mostly relied on two different approaches: structural and non-structural approach[2]. From the structural approach, focusing on measures of market concentration, it has been concluded that higher market concentration results in higher profits, but two different explanations can stand behind this relationship. According to the structure-conduct-performance (SCP) approach, high market concentration results in non-competitive or collusive behaviour of dominant market players, who set unfavourable prices to their clients in order to maximize their profits. Using this approach, Hannan (1991) and Hannan and Prager (2006), among others, show that banks operating in more concentrated markets pay lower deposit rates and charge higher loan rates. On the other hand, the efficiency-structure approach, introduced by Demsetz (1973) and Peltzmann (1977), treats higher concentration merely as a consequence of higher efficiency: more efficient banks would have higher profits, but also higher market shares, which results in higher market concentration. Therefore, the authors argue that deconcentration and anti-merger measures might harm efficiency if concentration is observed only as a consequence of monopolistic competition in the market.

On the other hand, the non-structural approach focuses on competitive behaviour of market players. This approach, developed under the umbrella of NEIO (New Empirical Industrial Organization) models, uses oligopoly models in which market players attempt to maximize their profits by setting appropriate price or output levels, assuming certain demand and cost function forms. Following a Cournot strategy, each player maximizes his profit by setting an appropriate output level, given the output level of other players, while in a Bertrand strategy he maximizes his profit by setting an appropriate price level, given the price level of other players. However, what can also be relevant in the price/output choice of each player is the perceived response (conjectural variation) of other players to price/output choices made by each player. A market player would then set his price/output level based on his predictions of other players' response to the change of his level of price/output. Iwata (1974) measured the value of conjectural variation in an oligopolistic market, i.e. the ratio of:

- the response of other firms' change in output levels as a reaction to firm A's change in its output level, as perceived by market player A, and
- the initial change in output level by market player A.

A model that considers the oligopolistic nature of the banking industry and banks' conjectures was developed by Berg and Kim (1994), who showed for the Norwegian banking sector in 1988 that each bank expected other banks' response to its initial choice of an output level.

[2] Main conclusions of the two different lines of reasoning within the structural approach can be found in Berger and Hannan (1989). Bikker and Haaf (2002) provide an overview of both the structural and non-structural approaches and results of some of their applications to the European banking industry.

Bresnahan (1982) introduced the parameter λ, which serves as a measure of market power: in the case of perfect competition λ equals zero, in the case of perfect cartel it equals one, while values of λ between zero and one imply other possible oligopolistic structures. Lau (1982) explained in which cases of demand and cost functions' estimation it is impossible to identify the λ parameter. A similar parameter, the *H* statistic, was introduced by Panzar and Rosse (1987) in order to differentiate between monopoly (negative values of *H*), monopolistic competition (*H* is between zero and one) and perfect competition (*H* equals one). Models introduced by Bresnahan (1982) and Lau (1982) rely on industry data and the estimation of players' cost function and market demand function. Examples include Shaffer (1993), who analyzed aggregate data on the Canadian banking sector between 1965 and 1989, and found evidence of perfect competition which would not be endangered by deregulation, as the efficiency approach would suggest. Swank (1995) showed that the Dutch loan and deposit markets in the period between 1957 and 1990 can be characterized as oligopolistic. Neven and Röller (1999) used country-level data for seven European countries in the period between 1981 and 1989, and found evidence of banks' collusive behaviour in the provision of household and corporate loans.

Contrary to this, Panzar and Rosse (1987) model uses data on individual market players' revenues and input prices in order to estimate the reduced-form revenue function, and assumes players operate in their long-run equilibrium. Implementing this approach on several European banking industries for the period between 1992 and 1996, De Bandt and Davis (2000) found that the Italian banking industry was monopolistically competitive, while in Germany and France monopolistic competition was present in the case of large banks, and monopoly was characteristic of small banks. On the other hand, Bikker and Groeneveld (2000) concluded that neither of the analyzed European banking industries was monopolistic, using data on all EU member states between 1989 and 1996. The analysis of the Canadian banking sector for the period between 1982 and 1994, presented by Nathan and Neave (1989), showed that banks are more competitive than trust and mortgage companies, but also that monopolistic behaviour is not present in either of the industries.

As for the competitive behaviour of Croatian banks, Kraft (2006) analysed data on all banks that were operating in the period between 1994 and 2004 and found, using the Panzar-Rosse *H* statistic and Lerner indices, that the banking industry could be described as monopolistically competitive, a result very much similar to other European banking industries. Tipurić, Kolaković et al. (2002) analysed the period between 1993 and 2000, and used various measures of market concentration to show that the structure of the Croatian banking industry is oligopolistic, with two dominant large banks, a few medium-sized banks and a decreasing number of small banks, which is a result of market consolidation. A similar result of the dominance of a few market players was obtained in the analysis of the banking industry performed by Babić (1996), who additionally concluded that the regional dispersion of banking activities is focused towards regional and county centres of the country.

The literature presented thus far presumes that market players make either price or output decisions.[3] A newer consideration is also the spatial dimension in which players operate, following the work of Salop (1979) and the uniform distribution of business units along a unit

[3] Another possible non-price strategic variable could be advertising, as shown by Roberts and Samuelson (1988).

circle. In terms of the banking industry, what is analysed are banks' decisions regarding the number and location of bank branches. This flow of research considers the fact that the presence of banks in a variety of locations, i.e. in different regional markets, is another possible source of their market power, so the multimarket characteristic of banks is the main focus of spatial competition models. Barros (1999) used such a model on the Portuguese deposit market for the years 1991 and 1992 in order to determine whether market power arises from collusive behaviour or product heterogeneity, which is a result of various banks' locations. Although collusive behaviour, at the level of bank groups, could not be rejected as a source of higher price margins, decisions on branch networks also influence market competition. The author concludes that banks' branching decisions should also be considered within regulatory measures in the banking industry. Chiappori, Perez-Castrillo et al. (1995) also used the model in order to assess the impact of regulative measures on deposit interest rates, which are treated as the main strategic variable. The authors conclude that such regulation results in an overspread of the branch network and a subsequent fall in loan rates, which then gives incentive to banks to provide tied sales of deposits and loans and to cross-subsidize, thus reducing the efficiency of monetary policy, as reflected by the money market rate. Kim and Vale (2001) considered branching decisions as the main strategic variable of Norwegian banks for the period between 1988 and 1995 in the provision of loans. The authors concluded that banks' own and rival branching decisions are relevant in obtaining a higher market share, and pointed out the influence of the banking crisis on banks' behaviour. Park and Pennacchi (2009) used a spatial model to show that large multimarket banks set lower deposit rates and impose higher loan rates, thus "harming depositors and helping borrowers".

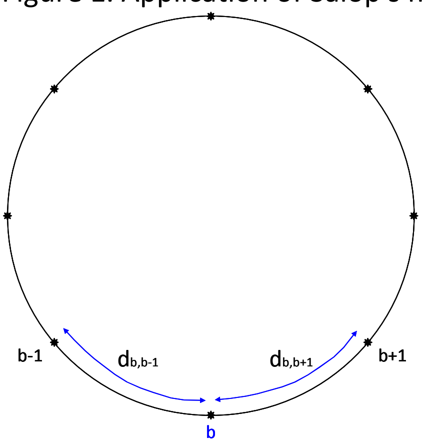
A step forward in spatial competition models was the consideration of banks' multistrategic behaviour. Estrada and Rozo (2006) applied both price and branching strategies on the Colombian deposit market for the period between 1996 and 2005, with the price choices preceding branching choices, and assessed the degree of competitiveness in the deposit market. The simultaneous use of both price and branching decisions was introduced by Kim, Lozano-Vivas et al. (2007) in order to determine whether own and rival strategic choices affect the demand on both the deposit and loan markets.

As can be seen from the literature overview, an important feature of many models was the separability of the deposit and loan markets, which was justified by price-taking behaviour of banks in the securities/money market (Barros, 1999: 337) and the additive property of management costs of loans and deposits (Neven and Röller, 1999: 1063). Another important consideration is the appropriate treatment of deposits, since a long-lasting dispute in the banking literature evolves around whether they should be treated as an input or output. As pointed out in a comprehensive literature overview provided by Berger and Humphrey (1997), the output feature of deposits is that they are a part of services which banks provide to their clients. According to the production approach, deposits and loans should then be treated as outputs, with labour and capital used as inputs. On the other hand, deposits represent banks' financial inflow that serves as an input for other banking activities, such as providing loans or investing in securities. This line of reasoning is supported in the intermediation approach, where deposits are treated as an input, along with labour and physical capital. When the production approach is followed and both deposits and loans are treated as an output, banks are then considered as multi-output market players.

3. The model

The model developed in this paper is based on a multistrategic, multimarket and multi-output approach to banks' activities. Following the works of Salop (1979), Barros (1999) and Kim et al. (2007), a spatial model is considered in which bank branches (denoted by b) are located uniformly around a unit circle. The representative bank i operates in k regional markets and has $n_{i,k}$ branches in each of these markets. At branch b_i the relevant interest rate is r_b^D in the case of deposits and r_b^L in the case of loans. Neighbouring branches $b-1$ and $b+1$ can also belong to bank i or to other banks, commonly denoted by j. Each of these banks has $n_{j,k}$ branches in each regional market, so the total number of branches in each region equals $n_k = n_{i,k} + \sum_{j \neq i} n_{j,k}$. Interest rates in branch b_i's neighbouring branches are r_{b-1}^D and r_{b+1}^D in the case of deposits, and r_{b-1}^L and r_{b+1}^L in the case of loans. The distance between branches is denoted by $d_{b,b-1}$ and $d_{b,b+1}$.

Figure 1. Application of Salop's model to bank branch distribution



Source: Adjusted from Salop (1979)

Two important restrictions are imposed upon the model:

- the interest rate on deposits and loans is uniform across regions, so no potential regional differentiation among interest rates is supposed[4];
- for reasons of estimation simplification, branches are supposed to be symmetrically distributed along the unit circle, which means that, for each regional market k, $d_{b,b-1} = d_{b,b+1} = \dfrac{1}{n_k}$.

When potential clients are choosing between branches, they are doing so based on several determinants:

- distance, resulting from the location of both the client and the branches,

[4] This restriction very likely does not hold in the case of Croatian banks, since experience shows that in some regions (e.g. Istria) interest rates are significantly lower than in other regions, marked by higher client risk factors (e.g. Eastern Croatia). Unfortunately, bank data on regional interest rates is not currently available, so it is impossible to quantify these differences for the purpose of the model estimation.

– interest rate,
– transportation costs τ which clients incur, related to distance.

Indifference in the choice between two branches is achieved

– between branches b and $b-1$ when the client's location is $\frac{1}{2}d_{b,b-1}+\frac{r_b^D-r_{b-1}^D}{2}\cdot\frac{1}{\tau}$ in the case of deposits or $\frac{1}{2}d_{b,b-1}-\frac{r_b^L-r_{b-1}^L}{2}\cdot\frac{1}{\tau}$ in the case of loans,
– between branches b and $b+1$ when the client's location is $\frac{1}{2}d_{b,b+1}+\frac{r_b^D-r_{b+1}^D}{2}\cdot\frac{1}{\tau}$ in the case of deposits or $\frac{1}{2}d_{b,b+1}-\frac{r_b^L-r_{b+1}^L}{2}\cdot\frac{1}{\tau}$ in the case of loans.

If branch b belongs to bank i, the probability that branch $b-1$ or $b+1$ also belongs to bank i is $\frac{n_{i,k}-1}{n_k-1}$, while the probability that it belongs to another bank is $\frac{n_k-n_{i,k}}{n_k-1}$.
Therefore, assuming that in each branch the volumes of deposits and loans amount to δ_b and λ_b, respectively, with $\sum_b \delta_b=\delta_i$ and $\sum_b \lambda_b=\lambda_i$ at the level of bank i, the demand for deposits at bank i is equal to

$$D_{i,k}=n_{i,k}\cdot\delta_{i,k}\cdot\left(\frac{1}{n_k}+\frac{\frac{n_k-n_i}{n_k-1}r_i^D-\sum_{j\neq i}\frac{n_k-n_{i,k}}{n_k-1}r_j^D}{\tau_k}\right), \qquad (1)$$

while demand for loans at the same bank amounts to

$$L_{i,k}=n_{i,k}\cdot\lambda_{i,k}\cdot\left(\frac{1}{n_k}-\frac{\frac{n_k-n_{i,k}}{n_k-1}r_i^L-\sum_{j\neq i}\frac{n_k-n_{i,k}}{n_k-1}r_j^L}{\tau_k}\right). \qquad (2)$$

Banks attempt to maximize their profits, which are defined at the level of bank i as

$$\Pi_i=D_i\cdot R_{D,i}+L_i\cdot R_{L,i}-C_i(D_i,L_i), \qquad (3)$$

where $R_{D,i}=r^m(1-\varphi)+\varphi\cdot p-r_i^D$ and $R_{L,i}=r_i^L-r^m$. The interest rate r^m is the money market rate and represents the opportunity cost of alternative funding possibilities, φ is the monetary policy reserve requirement rate, and p is the monetary policy reserve remuneration rate.

The cost function can be estimated using the transcendental logarithmic (translog) cost function form. The translog cost function for output Q and W inputs with prices $P_i, i=1..W$ can be defined using the second-order Taylor series approximation method as

$$\log(C) = \alpha_0 + \alpha_Q \log(Q) + \frac{1}{2}\alpha_{QQ}\left(\log(Q)\right)^2 + \sum_{i=1}^{W} \alpha_{iQ} \log(Q)\log(P_i) + \\ + \sum_{i=1}^{W} \alpha_i \log(P_i) + \frac{1}{2}\sum_{i=1}^{W}\sum_{j=1}^{W} \alpha_{ij} \log(P_i)\log(P_j), \quad (4)$$

while cost share equations are equal to

$$\omega_i = \frac{\partial \log(C)}{\partial \log(P_i)} = \alpha_i + \alpha_{iQ} \log(Q) + \alpha_{ii} \log(P_i) + \sum_{j \neq i} \alpha_{ij} \log(P_j). \quad (5)$$

Several restrictions that apply to the equations above regard

- homogeneity of degree one in prices of inputs, so $\sum_i \alpha_{iQ} = 0$, $\sum_i \alpha_i = 1$ and $\sum_j \alpha_{ij} = 0, \forall i$,
- symmetry, so $\alpha_{ij} = \alpha_{ji}$.

Marginal costs for each output Q can be derived as

$$MC_Q = \frac{\partial \log(C)}{\partial \log(Q)} \cdot \frac{C}{Q} = \left(\alpha_Q + \alpha_{QQ} \log(Q) + \sum_i \alpha_{iQ} \log(P_i)\right) \cdot \frac{C}{Q} \quad (6)$$

Since each bank uses three strategic variables (deposit interest rate r_i^D, loan interest rate r_i^L and size of the branch network n_i), the three relevant first-order conditions for profit maximization are

$$\frac{\partial \Pi_i}{\partial r_i^D} = \frac{\partial D_i}{\partial r_i^D} R_{D,i} - D_i - \frac{\partial C_i}{\partial D_i} \cdot \frac{\partial D_i}{\partial r_i^D} = 0, \quad (7)$$

$$\frac{\partial \Pi_i}{\partial r_i^L} = \frac{\partial L_i}{\partial r_i^L} R_{L,i} + L_i - \frac{\partial C_i}{\partial L_i} \cdot \frac{\partial L_i}{\partial r_i^L} = 0 \text{ and} \quad (8)$$

$$\frac{\partial \Pi_i}{\partial n_i} = \frac{\partial D_i}{\partial n_i} R_{D,i} + \frac{\partial L_i}{\partial n_i} R_{L,i} - \frac{\partial C_i}{\partial D_i} \cdot \frac{\partial D_i}{\partial n_i} - \frac{\partial C_i}{\partial L_i} \cdot \frac{\partial L_i}{\partial n_i} = 0. \quad (9)$$

In similar papers (Barros (1999) and Kim et al. (2007)) volumes of regional deposits and loans, as well as transportation costs, were unknown, so the model required simultaneous estimations of all three first-order conditions. However, in this case the data on regional volumes of deposits and loans (δ_k and λ_k, respectively) are available, so they can be used in order to estimate the unknown transportation costs.

The rearrangement of Equation 9, using first derivatives of deposit and loan demand with respect to the size of own branch network (provided in Table 1.), gives

$$\frac{\partial D_i}{\partial n_i}\cdot\left(R_{D,i}-MC_{D,i}\right)=-\frac{\partial L_i}{\partial n_i}\cdot\left(R_{L,i}-MC_{L,i}\right) \tag{10}$$

$$\begin{gathered}\left[\delta_k\cdot\left(\frac{n_{j,k}}{n_k^{\;2}}+\frac{1}{\tau_k}\cdot\frac{(n_k-2)n_{j,k}(r_i^D-r_j^D)}{(n_k-1)^2}\right)\right]\cdot\left(R_{D,i}-MC_{D,i}\right)=\\-\left[\lambda_k\cdot\left(\frac{n_{j,k}}{n_k^{\;2}}-\frac{1}{\tau_k}\cdot\frac{(n_k-2)n_{j,k}(r_i^L-r_j^L)}{(n_k-1)^2}\right)\right]\cdot\left(R_{L,i}-MC_{L,i}\right)\end{gathered} \tag{11}$$

The only unknown variable in Equation 11, regional transportation costs τ_k, can be substituted with the equation

$$\tau_k=\beta_0+\beta_1\cdot area_k+\beta_2\cdot urban_k+\beta_3\cdot hway_k+\varepsilon_k\,. \tag{12}$$

As in Barros (1999) and Kim et al. (2007), transportation costs in each region are estimated using the area of the region in square kilometres ($area_k$) and the percentage of urban population ($urban_k$) as explanatory variables. Another variable that was added to the estimation of transportation costs was the quality of transportation infrastructure, proxied by the kilometre length of the highway network ($hway_k$) in each region. This variable captures the effects of transportation infrastructure projects undergone in Croatia since early 2000s, which were especially intensive during the observed period.[5] The improvement of transportation infrastructure quality might affect distance between clients and branches or the speed at which this distance is crossed, influencing also the costs incurred by clients.

The rearrangement of Equations 7 and 8, using first derivatives of deposit and loan demand with respect to relevant interest rates (shown in Table 1.), gives the demand functions for deposits and loans

$$D_i=\sum_k\left(R_{D,i}-MC_{D,i}\right)\cdot\frac{\delta_k\cdot n_{i,k}\cdot n_{j,k}}{(n_k-1)\cdot\tau_k}\ \text{and} \tag{13}$$

$$L_i=\sum_k\left(R_{L,i}-MC_{L,i}\right)\cdot\frac{\lambda_k\cdot n_{i,k}\cdot n_{j,k}}{(n_k-1)\cdot\tau_k}\,. \tag{14}$$

Demand for outputs, i.e. deposits and loans, of one specific bank depends not only on the strategic variables used by that bank in particular, but also on strategic choices of other banks. Therefore, the key variables are the relevant bank's interest rates r_i^D and r_i^L and its branch network size n_i, as well as the rival banks' interest rates r_j^D and r_j^L (calculated as weighted averages of other banks' interest rates on deposits and loans) and their branch network size n_j. In order to estimate the efficiency of multistrategic behaviour of banks and

[5] The size of the highway network increased by nearly 80% in the period between 2004 and 2010. Such improvements surely had spill-over effects on the quality of transportation infrastructure (construction of connecting roads and local road infrastructure, decreased traffic congestion, etc.).

their sensitivity to multistrategic behaviour of other banks, elasticity coefficients of demand can be calculated, using the obtained results of transportation costs estimation (Equations 11 and 12) and inserting demand functions for deposits and loans (Equations 13 and 14) into demand elasticity coefficients presented in Table 1.

Table 1. Demand elasticity coefficients

DEPOSITS
Bank *i*'s interest rate on deposits
$El_{D_i,r_i^D} = \frac{r_i^D}{D_i} \cdot \frac{\partial D_i}{\partial r_i^D} = \frac{r_i^D}{D_i} \cdot \sum_k \frac{n_{i,k} \cdot n_{j,k} \cdot \delta_k}{(n_k - 1) \cdot \tau_k} > 0$
Bank *j*'s interest rate on deposits
$El_{D_i,r_j^D} = \frac{r_j^D}{D_i} \cdot \frac{\partial D_i}{\partial r_j^D} = \frac{r_j^D}{D_i} \cdot \sum_k - \frac{n_{i,k} \cdot n_{j,k} \cdot \delta_k}{(n_k - 1) \cdot \tau_k} < 0$
Bank *i*'s branch network
$El_{D_i,n_i} = \frac{n_i}{D_i} \cdot \frac{\partial D_i}{\partial n_i} = \frac{n_i}{D_i} \cdot \left[\delta_k \left(\frac{n_{j,k}}{n_k^{\ 2}} + \frac{1}{\tau_k} \cdot \frac{(n_k - 2) \cdot n_{j,k} (r_i^D - r_j^D)}{(n_k - 1)^2} \right) \right] > 0$
Bank *j*'s branch network
$El_{D_i,n_j} = \frac{n_j}{D_i} \cdot \frac{\partial D_i}{\partial n_j} = \frac{n_j}{D_i} \cdot \left[\delta_k \left(- \frac{n_{j,k}}{n_k^{\ 2}} + \frac{1}{\tau_k} \cdot \frac{(n_k - 1 - n_{j,k})(r_i^D - r_j^D)}{(n_k - 1)^2} \right) \right] < 0$
LOANS
Bank *i*'s interest rate on loans
$El_{L_i,r_i^L} = \frac{r_i^L}{L_i} \cdot \frac{\partial L_i}{\partial r_i^L} = \frac{r_i^L}{L_i} \cdot \sum_k - \frac{n_{i,k} \cdot n_{j,k} \cdot \lambda_k}{(n_k - 1) \cdot \tau_k} < 0$
Bank *j*'s interest rate on loans
$El_{L_i,r_j^L} = \frac{r_j^L}{L_i} \cdot \frac{\partial L_i}{\partial r_j^L} = \frac{r_j^L}{L_i} \cdot \sum_k \frac{n_{i,k} \cdot n_{j,k} \cdot \lambda_k}{(n_k - 1) \cdot \tau_k} > 0$
Bank *i*'s branch network
$El_{L_i,n_i} = \frac{n_i}{L_i} \cdot \frac{\partial L_i}{\partial n_i} = \frac{n_i}{L_i} \cdot \left[\lambda_k \left(\frac{n_{j,k}}{n_k^{\ 2}} - \frac{1}{\tau_k} \cdot \frac{(n_k - 2) \cdot n_{j,k} (r_i^L - r_j^L)}{(n_k - 1)^2} \right) \right] > 0$
Bank *j*'s branch network
$El_{L_i,n_j} = \frac{n_j}{L_i} \cdot \frac{\partial L_i}{\partial n_j} = \frac{n_j}{L_i} \cdot \left[\lambda_k \left(- \frac{n_{j,k}}{n_k^{\ 2}} - \frac{1}{\tau_k} \cdot \frac{(n_k - 1 - n_{j,k})(r_i^L - r_j^L)}{(n_k - 1)^2} \right) \right] < 0$

Source: author's calculations

4. Data

The model is applied on 32 commercial banks that were operating in the period between the first quarter of 2004 and the last quarter of 2010. Since some banks underwent processes of mergers and acquisitions between 2004 and 2009, data on those banks were added up.[6] Banks that underwent liquidation procedures were excluded from the model.[7] The main sources of banks' data are their profit and loss accounts and balance sheets, reported to the Croatian National Bank (CNB) on a quarterly basis. Additionally, data from other reports to the CNB were used, such as the monthly report on interest rates on new and renewed loans and deposits, the quarterly report on the regional distribution of deposits and loans, and the semi-annual report on the number of branches in 20 Croatian counties.[8]

Interest rates used in the model were quarterly weighted averages of monthly interest rates on loans denominated in foreign currency and on foreign currency deposits, since these categories of loans and deposits make up the majority of all approved loans or received deposits.[9] It can be argued that the use of actual instead of implicit interest rates has several advantages: interest rates on new and renewed deposits and loans are available at a higher data frequency; such interest rates are more observable from both the banks' and clients' point of view rather than banks' statements data.

Quarterly regional volumes of deposits and loans include domestic demand, savings and term deposits, as well as the net value of all approved loans, according to the residence of the clients. These volumes are available at the level of 20 Croatian counties, as is the number of branches of each bank. Semi-annual data on the number of branches were interpolated in order to obtain quarterly data. Since there are only a few banks whose activities span over all Croatian counties, the regions were instead defined as Croatian NUTS II regions – the Northwestern region (consisting of 5 counties), the Central and Eastern region (consisting of 8 counties) and the Adriatic region (consisting of 7 counties).

Marginal costs of deposits and loans were estimated using costs of labour and physical capital. Labour costs are defined as personnel expenses, while capital costs comprise expenses on asset depreciation and other administrative expenses. The price of labour was calculated as the ratio of personnel expenses to the number of employees, and the price of capital was defined as the ratio of expenses on asset depreciation and other administrative expenses to the value of fixed assets.

For the purpose of setting first-order conditions of profit maximization, the reserve requirement rate and remuneration rate were used as a proxy for the influence of monetary

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[6] *Varazdinska banka* (2004) and *Dresdner Bank* (2005) were taken over by *Zagrebacka banka*. *Dubrovacka banka* (2004) joined *OTP Bank*. *Privredna banka Laguna* (2005) joined *Privredna banka*. *Pozeska banka* (2006) was taken over by *Podravska banka*. *Slavonska banka* (2009) joined *Hypo Alpe-Adria Bank*. During the observed period some banks also underwent changes of ownership.

[7] *Primus banka* and *Krizevacka banka*.

[8] Zagreb County and City of Zagreb are treated as one county.

[9] At end-2010 loans denominated in foreign currency made up nearly 60% of all approved loans to the non-banking sector, whereas about three quarters of all savings and time deposits of the non-banking sector were foreign currency deposits.

policy regulation on banks' choice of interest rates. For the period between August 2004 and October 2008 the reserve requirement rate also included the marginal reserve requirement, which was used to limit the amount of foreign currency loan activities. The remuneration rate was set as the weighted average of remuneration rates on domestic and foreign currency parts of reserve requirements. The relevant interest rate that represents the Croatian money market conditions and, for the purposes of the model, the opportunity cost of alternative forms of investments, as opposed to loans, is the government securities rate (interest rate on one-year domestic currency treasury bills).

Data on the area and the percentage of urban population of each Croatian county, necessary for the estimation of transportation costs, were available from the 2000 Census data collected by the Central Bureau of Statistics, while the relevant data source on the size of completed highway construction projects were annual reports from the Croatian Association of Toll Motorways Concessionaires.

5. Estimation method and results

The model is estimated in two stages. In the first stage the translog cost function and cost share equations are estimated in order to obtain marginal costs of deposits and loans, which then enter the second stage, where transportation costs are estimated. This allows for the calculation of demand elasticity coefficients with respect to interest rates and the size of the branch network, which indicate whether interest rates and the branch network are used as banks' strategic variables.

The translog cost function[10] and cost share equations were estimated jointly, using the full information maximum likelihood (FIML) method under the assumption of normally distributed residuals. Since the sum of cost shares is equal to unity, one cost share equation has to be removed from the estimation in order to avoid a singular covariance matrix. The FIML method is invariant to the choice of the equation that is excluded from the estimation. For the purposes of estimating the model, the equation that was excluded from the estimation was the share equation for capital. Additionally, homogeneity in input prices and symmetry were imposed.

The relevant equations, estimated at the bank level for each output separately, are

$$\log(C_i) = \alpha_0 + \alpha_1 \log(Q_i) + \frac{1}{2}\alpha_2 \left(\log(Q_i)\right)^2 + \alpha_3 \log(P_{L,i})\log(Q_i) + (-\alpha_3)\log(P_{K,i})\log(Q_i) +$$

$$+ \alpha_4 \log(P_{L,i}) + (1-\alpha_4)\log(P_{K,i}) + \frac{1}{2}\alpha_5\left(\log(P_{L,i})\right)^2 + \frac{1}{2}\alpha_6\left(\log(P_{K,i})\right)^2 +$$

[10] An alternative form of the cost function that has been extensively used in the literature is the Fourier flexible function form, which adds to the translog form the trigonometric terms of the logarithm of output, previously adjusted and expressed in radians. The Fourier function form was therefore also used in the first stage of the estimation and results were compared with those obtained using the translog function form. Coefficients of the trigonometric terms were insignificant, and the information criteria (Akaike, Schwarz, Hannan-Quinn) also pointed to an, albeit very slight, advantage of the translog cost function form.

$$+\left(-\frac{1}{2}\alpha_5 - \frac{1}{2}\alpha_6\right)\log(P_{L,i})\log(P_{K,i}) + \varepsilon_1 \text{ and} \tag{15}$$

$$\omega_{L,i} = \alpha_4 + \alpha_3 \log(Q_i) + \alpha_5 \log(P_{L,i}) + (-\frac{1}{2}\alpha_5 - \frac{1}{2}\alpha_6)\log(P_{K,i}) + \varepsilon_2 , \tag{16}$$

where C_i are total labour and capital costs for bank i, Q_i is the bank i's quantity of output, and P_L and P_K are bank i's prices of labour and capital, respectively.

From these two equations, marginal costs can be obtained as

$$MC_{Q,i} = \frac{C_i}{Q_i}\left[\alpha_1 + \alpha_2 \log(Q_i) + \alpha_3 \log(P_{L,i}) + (-\alpha_3)\log(P_{K,i})\right]. \tag{17}$$

Table 2. Results of the first estimation stage

Parameters	DEPOSITS	LOANS
α_0	12.264 (2.442)	4.515 (2.399)
α_1	-0.717 (0.238)	0.079 (0.231)
α_2	0.072 (0.012)	0.032 (0.011)
α_3	-0.009 (0.002)	-0.010 (0.002)
α_4	0.561 (0.040)	0.483 (0.038)
α_5	0.051 (0.009)	0.068 (0.009)
α_6	-0.015 (0.011)	-0.061 (0.013)
Adj. R^2		
Translog cost equation	0.9148	0.8925
Labour share equation	0.0913	0.1070
N	1792	1792

Note: Standard errors are reported in parentheses.
Source: author's calculations

For the estimation of transportation costs, a panel approach was again implemented, using the method of generalized least squares (GLS) with cross-section[11] weights that accounts for cross-section heteroskedasticity. It is expected that transportation costs are positively correlated with the area of each region, since covering larger distances implies higher costs ($\beta_1 > 0$). A larger percentage of urban population implies that branches might be located closer to that population, so transportation costs could be lower ($\beta_2 < 0$). Higher quality of transportation infrastructure, approximated by a larger highway network, reduces distance or the time at which a distance has to be crossed between clients and branches, resulting in lower expected transportation costs ($\beta_3 < 0$).

[11] Each cross section refers to individual banks' data for each of the three NUTS II regions.

Table 3. Results of the second estimation stage

Parameters	TRANSPORTATION COSTS
β_0	-11.44 (1.78)
β_1	15.8** (3.39**)
β_2	0.21 (0.02)
β_3	-8.09* (1.51*)
Adj. R^2	0.0451
N	2655

Note: parameters marked with * are multiplied by 10^{-3}, and parameters marked with ** are multiplied by 10^{-5}. Standard errors are reported in parentheses.
Source: author's calculations

As can be seen from Table 3., variables that explain the movements of transportation costs are all significant, with expected signs of the parameters in the case of the size of regions and the quality of transportation infrastructure.

The model was estimated not only for the entire period under observation, but also for the pre-crisis period (from the first quarter of 2004 to the second quarter of 2008) and the crisis/post-crisis period (from the third quarter of 2008 to the last quarter of 2010) separately. The separation between periods was determined by the outbreak of the global financial crisis and its immediately following spill-over effect on the Croatian financial sector, i.e. the temporary withdrawal of households' deposits. The separation between the crisis and post-crisis period remains vague, since identical conclusions cannot be made when analysing the financial and real sector developments. On the one hand, throughout 2010 banks have been in a position of excess liquidity, similar to conditions that prevailed before the crisis. However, there has been limited improvement in overall economic activity and, consequently, banks' lending activity, especially towards the sector of households, which can be associated with unfavourable both demand- and supply-driven conditions.

Table 4. Estimated demand elasticity coefficients

Coefficients	Overall period	Pre-crisis period	Crisis/post-crisis period
Deposits			
Own interest rate	0.4212	0.5261	0.2277
		(0.0279)	
Rival interest rate	-0.3952	-0.4896	-0.2191
		(0.0316)	
Own branch network	0.0668	0.0919	0.0249
		(0.2776)	
Rival branch network	-0.0033	-0.0056	-0.0007
		(0.0006)	
Loans			
Own interest rate	-0.2702	-0.2003	-0.4113
		(0.0160)	
Rival interest rate	0.2791	0.2079	0.4242
		(0.0207)	
Own branch network	0.0253	0.0216	0.0307
		(0.5713)	
Rival branch network	-0.0009	-0.0010	-0.0006
		(0.0361)	

Note: numbers in parentheses denote the statistical significance of differences between means.
Source: author's calculations

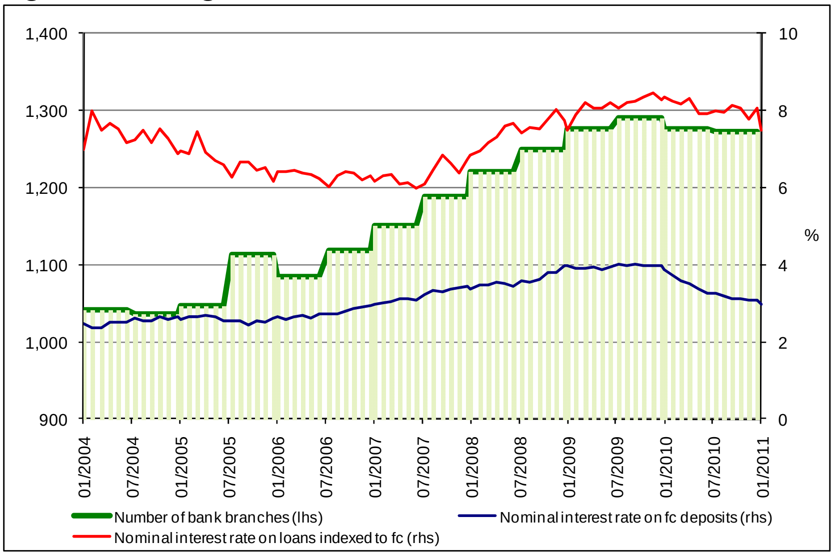
As results indicate, demand for deposits and loans is more sensitive to the banks' choice of interest rates than the change of the branch network size. In the case of deposits, banks' sensitivity to rivals' pricing decisions is somewhat lower than gains from the use of own strategies, while this difference is much more evident when it comes to branching decisions. In the case of loans, banks' sensitivity to rivals' pricing decisions is slightly more pronounced than gains from the use of own pricing strategy, with a similar conclusion regarding branching decisions as is the case for deposits.

A comparison of price elasticities of demand for deposits and loans leads to the conclusion that demand for loans is less sensitive to price changes than demand for deposits. Several possible explanations might stand behind such a result. The significance of loans in financing consumption or investments might be more pronounced than the significance of deposits in saving decisions, i.e. loans have fewer substitutes available than deposits. Furthermore, a significant proportion of borrowers might be taking out new loans only in order to refinance existing loans, thus contributing to a more price-inelastic loan demand. Also, the inherent nature of loan and deposit contracts makes borrowers less flexible in adjusting contract terms to possible interest rate changes. A similar result is found in the case of demand elasticity with respect to the size of the branch network, which means that physical presence in the market is more relevant for branch choices of depositors than borrowers.

The analysis of pre-crisis and crisis/post-crisis elasticity coefficients points to the following conclusions:

- on the deposit side, demand became less sensitive to both changes in own prices and the size of the branch network, although the change in own branching decisions does not seem to be as significant. Also, in the crisis/post-crisis period banks were less sensitive to rivals' pricing and branching decisions. It should nevertheless be mentioned that during the crisis/post-crisis period the threshold of insured deposits was increased substantially[12], motivating depositors to turn more to smaller banks, which usually offer higher interest rates than their larger counterparts. In that sense, larger banks were facing increased competition from their smaller-sized rivals, and this is reflected in higher demand elasticity coefficient faced by large banks[13] with respect to rival's interest rates when rivals are identified as small banks, rather than all the remaining banks. The demand elasticity coefficient increases to -0.5194.
- on the loan side, demand became more sensitive to changes in own interest rates, with a low significance of the change in importance of own branching decisions. Banks' sensitivity to rivals' pricing decisions also increased, while it decreased in the case of rivals' branching decisions. Since the crisis/post-crisis period was marked by an increase in loan rates, more restrictive banks' behaviour towards potential clients and their reluctance to provide loans to less desirable clients, as well as worsened economic conditions, results indicate that the average client was more selective in his choice of a potential bank, since lower interests rates would push him more towards one bank or pull him more strongly away towards other banks.

Figure 2. Strategic variables of Croatian banks



Source: CNB

The crisis/post-crisis period brought about a notable change in the influence of banks' pricing strategies on demand for banks' outputs. This can be explained by looking at the developments of the main strategic variables during the observed period. As can be seen

[12] In October 2008 the minimum amount of insured deposits was increased from HRK 100,000 to HRK 400,000.

[13] Large banks included are *Erste Bank*, *Hypo Alpe-Adria Bank*, *Privredna banka Zagreb*, *Raiffeisen Bank*, *Société Générale – Splitska banka* and *Zagrebacka banka*. All other banks excluding *HPB*, *OTP Bank* and *Volksbank* are considered as small-sized rivals.

from Figure 2., the spread between loan and deposit interest rates increased steadily during 2009 and 2010 as a result of an increase in loan interest rates, which can largely be attributed to banks' higher financing costs, followed by a subsequent decrease in deposit interest rates. Results of an inelastic deposit demand in the period of the late-1990s' banking crisis and recession were also found by Kraft and Galac (2007), which was mostly due to higher risk of depositing funds connected with relatively high deposit rates and willingness of clients to deposit their funds even at lower deposit rates. In this case of a crisis/post-crisis period, it is likely that deposits were considered as a safer alternative to other types of investments, despite the decrease of deposit interest rates. When it comes to loans, increased loan interest rates motivated borrowers to react more strongly to potential price changes, especially since unfavourable economic conditions had a marked impact on the ability of borrowers to finance existing or new debt.

Although results indicate that branching decisions are less important than the use of pricing strategies, it should be noted that only a few banks operate in the majority of regional markets, i.e. Croatian counties, therefore only several banks behave as truly multimarket banks[14]. When results for only such banks are considered, the demand elasticity coefficients with respect to own branching decisions between 2004 and 2010 increase to 0.1096 in the case of deposits and 0.1140 in the case of loans, while coefficients remain relatively low with respect to rivals' branching decisions. This implies that market regulators should also pay attention to branching decisions made by multimarket banks, since the spread of their branch network is a significant source of market power. It is precisely these banks that make up the majority of all bank branches in Croatia[15], whose number increased steadily during the most of the observed period.

6. Conclusion

Croatian banks simultaneously use interest rates and branching decisions as strategic variables in order to maximize their profits on the deposit and loan market, as can be concluded from a spatial competition model implemented on Croatian commercial banks for the period between 2004 and 2010. Banks do not only make own decisions regarding their price levels and branch network, but are also sensitive to similar decisions made by other banks.

The level of interest rates is relatively more important as a strategic variable in the case of both deposits and loans than is physical presence in the market, although the significance of the latter is more pronounced for banks that can be characterized as multimarket banks. This is shown by the estimated demand elasticity coefficients, which also indicate that demand is relatively more price- and branch-elastic in the case of deposits. During the crisis/post-crisis period the elasticity of demand with respect to own and rival interest rates

[14] During the observed period only eight banks had branches in at least 16 out of 20 Croatian counties: *Banka kovanica*, *Croatia banka*, *Erste Bank*, *Hypo Alpe-Adria Bank*, *Privredna banka Zagreb*, *Raiffeisen Bank*, *Société Générale – Splitska banka* and *Zagrebacka banka*.

[15] The share of the number of branches of eight multimarket banks in the total number of branches of Croatian commercial banks amounts to 64.5% for the period between 2004 and 2010.

decreased in the case of deposits and increased in the case of loans. While the former could be related to less attractive alternative investment opportunities even under conditions of declining deposit rates, the latter might be a result of a more significant role of repayment risk for both the banks and borrowers during the period of decreasing economic activity and higher loan interest rates, with the importance of loans in consumption/ investment/ refinancing decisions still remaining high.

Estimation results also provide evidence of the importance of improved transportation infrastructure quality, i.e. its effect on reducing distances or the time required to cross distances between banks and clients and on transportation costs incurred by clients. Furthermore, the results indicate a possible implication of banks' strategic choices on implemented regulatory policies. Since it has been shown that branch networks are relevant in gaining market power, monitoring and possible regulation of branching decisions might be considered, especially in the case of multimarket banks.

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