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Estimating the intensity of price and non-price competition in banking

Abstract

We model bank oligopoly behavior using price and non-price competition as strategic variables in an expanded conjectural variations framework. Rivals can respond to changes in both loan and deposit market prices as well as (non-price) branch market shares. The model is illustrated using data for Spain which, over 1986-2002, eliminated interest rate and branching restrictions and set off a competitive race to lock-in expanded market shares. Banks use both interest rates and branches as strategic variables and both have changed over time. We illustrate the results using a regional vs. a national specification for the relevant markets.

Keywords: non-price competition, banking, market shares.
JEL Classification: G21, D43, L13.

Introduction

Almost all empirical analyses of competition in banking in Europe and elsewhere focus on indicators of industry price competition to guide their antitrust and merger policies. In addition to long-standing efforts to determine existing and possible future price competition from measures of deposit or loan market structure, direct measures – such as the Panzar and Rosse (1987) H-statistic, loan or deposit interest margins, and Lerner indices – are increasingly relied upon as ancillary information. The H-statistic ranks current competitive behavior on a scale from 1.0 (perfect competition) to less than or equal to 0.0 (monopoly) based upon the degree to which changes in input prices are reflected in contemporaneous changes in unit revenues. While intermediate values can signal more or less competition, there is no guideline regarding the point at which a sufficiently competitive market becomes an insufficient one. As studies by De Bandt and Davis (2000), Bikker and Haaf (2002), Carbó, Humphrey and Rodriguez (2003), Maudos and Pérez (2003) and Carbó, Humphrey, Maudos and Molyneux (2009) all find evidence of (intermediate) monopolistic behavior for European banking markets, this information is most useful only when combined with other indicators of competition.

More direct information is contained in interest margins and Lerner indices which estimate the average mark-up of price over unit cost and so indicate the current level or change in unit profitability. Corvosier and Gropp (2002) analyze the effect of concentration on margins in European banking during the 1990s and find increasing concentration is associated with less competitive pricing of loans and sight deposits but greater price competition for savings and time deposits. Similarly, Fernández de Guevara, Maudos, and Pérez (2005) estimate Lerner indexes for the 1990s and find that market power in major European countries has apparently not declined despite a series of market liberating measures. Finally, Maudos and Fernández de Guevara (2004) illustrate the importance of including deposit and loan production costs in the margin definition while Maudos and Fernández de Guevara (2007) use Lerner indices to determine the social welfare loss attributable to market power.

These price-based indicators of competition have been recently augmented with non-price measures of competitive behavior under the assumption that banks may substitute one for the other in certain instances. For example, Pinho (2000) looks at advertising expenditures and branches as non-price strategic variables for Portugal; Kim and Vale (2001) focus on branches and their effect on loan market competition in Norway; Cesari and Chizzolini (2002) do the same for the deposit markets in Europe, while Barros (1995, 1999) uses differences in regional markets in Portugal as a strategic variable in the bank loan/deposit pricing decision. While Kim and Vale (2001), Canhoto (2004), and Coccorese (2005) focus on rivals' responses in the loan market and Barros (1999) and Pinho (2000) focus on similar responses in the deposit market, we focus on determining their separate effects and relative intensity by looking at both markets simultaneously (rather than in isolation).

Another branch of the literature has analyzed the role of collateral as an additional dimension of non-price competition. For example, Besanko and Thakor have analyzed the impact of collateral on

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credit rationing under different market structures while Bester (1985) illustrates the contemporaneous trade-off between loan collateral requirements and interest rates. In contrast, we focus on the trade-off between interest rates and branching network competition, a relationship which is not contemporaneous with loan or deposit pricing (which can occur in days) since the planning and arranging for opening a branch office clearly takes time (a year or more).

Potentially, there is a four-way trade-off between changing a bank's deposit or loan prices versus altering market shares through non-price de novo branch entry or acquisition since either of these two actions can have a corresponding price or non-price response by rivals at a regional or national level. Although Kim and Vale (2001) specify that all rivals' responses occur in a national market for loans and Coccorese (2005) specifies a national market for only the largest banks in Italy, we illustrate our results using first a regional and then a national specification for the relevant deposit and loan markets. As branching is a mid- to long-term decision variable, rivals are expected to react with a lag of one period but clearly can react contemporaneously in responding to interest rate changes.

Our model is illustrated using data for the Spanish banking system during 1986-2002. In anticipation of expanded competition following Spain's entry into the European Union in 1986, restrictions on bank interest rates and geographical controls on branching were removed. This permitted banks to set deposit and loan rates in response to market conditions and to compete for deposit market share and loan relationships using branches as an additional strategic variable to its pricing decisions. As a result, price and non-price behavior is intertwined and we provide a way to assess their relative importance as well as to determine the effect of rivals' responses by estimating conjectural variation parameters for interest rates and branches.

Our model and its empirical specification is presented in Section 1 while Section 2 briefly notes key price and non-price features of the Spanish banking sector and outlines the data and empirical approach to implement the model. Empirical results are discussed in Section 3 while a summary and conclusions are presented in the last section.

1. A model of price and non-price competition

1.1. Basic Relationships. Using Kim and Vale (2001)´s model as a starting point, we develop a model where banks can compete with rivals in prices for deposits and loans as well as branches (our non-price variable)[1]. There are n banks (i = 1,…, n) and the markets for deposits (D) and loans (L) are characterised by competition in prices and product differentiation while banks are price-takers in the purchased funds or money market (M). With product differentiation, the demand for loans (l_{it}) and supply of deposits (d_{it}) at time t is a function of the bank's own (r^l_{it}, r^d_{it}) and its rivals´ (r^l_{iRt}, r^d_{iRt}) interest rates on these banking outputs[2], the size of its own (b_{it}) and rivals' (b_{iRt}) branch network, and a vector of exogenous factors which may influence the overall demand of loans and deposits (z^l_{it}, z^d_{it}):

$$l_{it} = l(b_{it}, b_{iRt}, r^l{}_{it}, r^l{}_{iRt}, z^l{}_{it}), \tag{1}$$

$$d_{it} = d(b_{it}, b_{iRt}, r^d{}_{it}, r^d{}_{iRt}, z^d{}_{it}). \tag{2}$$

Loans made by bank i are expected to decrease with increases in its own interest rate ($\partial l_{it}/\partial r^l_{it} < 0$) and expansions of rivals' branch networks ($\partial l_{it}/\partial b_{iRt} < 0$) but rise with growth in its own branch network ($\partial l_{it}/\partial b_t > 0$) and increases in rivals' loan rates ($\partial l_{it}/\partial r^l_{iRt} > 0$). Similarly, deposits at bank i are expected to rise with its own interest rate ($\partial d_{it}/\partial r^d_{it} > 0$) and growth in its branch network ($\partial d_{it}/\partial b_{it} > 0$) but fall with increases in rivals' deposit rates ($\partial d_{it}/\partial r^d_{iR} < 0$) and branch network growth ($\partial d_{it}/\partial b_{iRt} < 0$).

Bank production or operating cost c_{it} (which excludes interest expenses) depends on the level of loan and deposit outputs[3] and the price of its factor inputs w_{it} (which excludes interest rates):

$$c_{it} = c(l_{it}, d_{it}, w_{it}). \tag{3}$$

Profits (π_{it}) are determined from the difference between interest income and financial and operating costs:

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[1] There are three important differences w.r.t. Kim and Vale´s model: a) we include deposits and consequently financial costs; b) we allow competition in branches and also in loan and deposit interest rates; and c) we introduce conjectural variations in interest rates.

[2] The demand for loans and supply of deposits for a specific bank depends on the interest rates of the *(n-1)* rival banks. With the aim of reducing the number of parameters to be estimated, we replace the *(n-1)* individual rivals' interest rates by a single condensed measure. This measure can be computed as a weighted average of the *(n-1)* rivals' interest rates: $r_{iRt} = \sum_{j \neq i}^{n-1} w_j r_{jt}$, where w are the weights.

[3] The value of deposits are both an indicator of a pure "funding" input as well as a "service" output because deposit services (payment, safekeeping) are not fully priced to users but instead are to a large degree traded in kind for the payment of a substantially below market rate of return. Thus a bank with more deposits is simultaneously providing more payment/safekeeping services to depositors.

$$\pi_{it} = r^l{}_{it} l_{it}(b_{it}, b_{iRt}, r^l{}_{it}, r^l{}_{iRt}, z^l{}_{it}) + M_{it}\,\bar{r}_t - r^d{}_{it} d_{it}(b_{it}, b_{iRt}, r^d{}_{it}, r^d{}_{iRt}, z^d{}_{it})$$
$$-c_{it}(l_{it}, d_{it}, w_{it}) = (r^l{}_{it} - \bar{r}) l_{it}(b_{it}, b_{iRt}, r^l{}_{it}, r^l{}_{iRt}, z^l{}_{it}) + (\bar{r}_t - r^d{}_{it}) d_{it}(b_{it}, b_{iRt}, r^d{}_{it}, r^d{}_{iRt}, z^d{}_{it}) \quad (4)$$
$$-c_{it}(l_{it}, d_{it}, w_{it})$$

where $M = l - d$ is the net position in the money market, and $\bar{r}_t$ is the money market rate.

Banks maximize the discounted flow of profits:

$$V_{i0} = \sum_{t=0}^{\infty} \beta_t \pi_{it}, \quad (5)$$

where β is the discount factor. As in Kim and Vale (2001), we assume that banks use a feedback (Markow) strategy. At period t they set control variables (b_{it}, $r^l{}_{it}$, $r^d{}_{it}$) based on the information available at that time on the number of branches and interest rates of rival banks. As price is a short-term decision variable and branches are a mid-term one, banks are assumed to expect their rival to react with a lag of one period. However, it is assumed that banks react contemporaneously in setting interest rates. We use an approximation to feedback equilibrium which ignores repercussions that occur two or more periods ahead.

To maximize profits, a bank determines the number of branches and loan and deposit interest rates from:

$$\frac{\partial V_{it}}{\partial b_{it}} = \left(r^l{}_{it} - \bar{r}_t - \frac{\partial c_{it}}{\partial l_{it}} \right) \frac{\partial l_{it}}{\partial b_{it}} + \left(\bar{r}_t - r^d{}_{it} - \frac{\partial c_{it}}{\partial d_{it}} \right) \frac{\partial d_{it}}{\partial b_{it}} +$$
$$\beta_t \left[\left(r^l{}_{it+1} - \bar{r}_{t+1} - \frac{\partial c_{it+1}}{\partial l_{it+1}} \right) \frac{\partial l_{it+1}}{\partial b_{iRt+1}} \frac{\partial b_{iRt+1}}{\partial b_{it}} + \left(\bar{r}_{t+1} - r^d{}_{it+1} - \frac{\partial c_{it+1}}{\partial d_{it+1}} \right) \frac{\partial d_{it+1}}{\partial b_{iRt+1}} \frac{\partial b_{iRt+1}}{\partial b_{it}} \right] = 0 \quad (6)$$

$$\frac{\partial V_{it}}{\partial r^l{}_{it}} = l_{it} + \left(r^l{}_{it} - \bar{r}_t - \frac{\partial c_{it}}{\partial l_{it}} \right) \left(\frac{\partial l_{it}}{\partial r^l{}_{it}} + \frac{\partial l_{it}}{\partial r^l{}_{iRt}} \frac{\partial r^l{}_{iRt}}{\partial r^l{}_{it}} \right) = 0, \quad (7)$$

$$\frac{\partial V_{it}}{\partial r^d{}_{it}} = -\left[d_{it} + \left(\bar{r}_t - r^d{}_{it} - \frac{\partial c_{it}}{\partial d_{it}} \right) \left(\frac{\partial d_{it}}{\partial r^d{}_{it}} + \frac{\partial d_{it}}{\partial r^d{}_{iRt}} \frac{\partial r^d{}_{iRt}}{\partial r^d{}_{it}} \right) \right] = 0. \quad (8)$$

The terms in parentheses reflect the interest margin on loans $(r^l - \bar{r})$, deposits $(\bar{r} - r^d)$, and their associated marginal operating costs ($\partial c_{it}/\partial l_{it}$, $\partial c_{it}/\partial d_{it}$). Own-price derivatives of demand for loans and deposits are, respectively, $\partial l_{it}/\partial r^l{}_{it}$ and $\partial d_{it}/\partial r^d{}_{it}$, while $\partial l_i/_t\partial r^l{}_{iRt}$ and $\partial d_{it}/\partial r^d{}_{iRt}$ represent rivals' price derivatives for the same two banking service outputs (loans and deposits).

$\partial b_{iRt+1}/\partial b_{it}$, $\partial r^l{}_{iRt}/\partial r^l{}_{it}$ and $\partial r^d{}_{iRt}/\partial r^d{}_{it}$ capture the effect from rival banks´conjectured reaction (conjectural variations or conduct parameters). Conjectural variations may also be interpreted as a measure of the departure from Nash behavior. In the case of interest rates, a zero value for these terms would imply that bank i completely ignores rival banks in making its decisions (Nash behavior, where firms act taking rivals' prices as given) and a unit value means that bank i believes that rival banks exactly match its decisions (cartel behavior). When $\partial r_{iRt}/\partial r_{it} < 0$, conduct is more competitive than Nash behavior with prices approaching marginal costs as $\partial r_{iRt}/\partial r_{it} \rightarrow -\infty$. Collusive behavior is consistent with $\partial r_{iRt}/\partial r_{it} > 0$ suggesting that firms achieve market power through collusion.

1.2. Empirical specification. In estimating the above model, the loan demand and deposit supply functions are specified as log-linear relationships:

$$\ln l_{it} = \phi^l_b \ln b_{it} + \phi^l_{bR} \ln b_{iRt} + \phi^l_r \ln r^l{}_{it} + \phi^l_{rR} \ln r^l{}_{iRt} + z^l{}_{it}, \quad (9)$$

$$\ln d_{it} = \phi^d_b \ln b_{it} + \phi^d_{bR} \ln b_{iRt} + \phi^d_r \ln r^d{}_{it} + \phi^d_{rR} \ln r^d{}_{iRt} + z^d{}_{it}, \quad (10)$$

where ϕ^l_b, ϕ^d_b (ϕ^l_{bR}, ϕ^d_{bR}) are the elasticity effects from bank i's own (rivals') branches while ϕ^l_r, ϕ^d_r (ϕ^l_{rR}, ϕ^d_{rR}) are the loan and deposit elasticities from bank i's own (rivals') loan and deposit interest rates.

As shown in the Appendix, the derivatives of the loan demand (9) and deposit supply (10) functions with respect to branches and interest rates for use in (6), (7) and (8) along with the marginal operating costs of loans (*mcl)* and deposits (*mcd)* from a standard translog cost function can be included in equations (6) to (8) to express the profit maximization FOC as:

$$\left(r^l_{it} - \bar{r}_t - mcl_{it}\right)\frac{l_{it}\phi^l_{\ b}}{b_{it}} + \left(\bar{r}_t - r^d_{\ it} - mcd_{it}\right)\frac{d_{it}\phi^d_{\ b}}{b_{it}} = \\ -\beta_t\alpha^b\left[\left(r^l_{\ it+1} - \bar{r}_{t+1} - mcl_{it+1}\right)\frac{l_{it+1}\phi^l_{bR}}{b_{iRt+1}} + \left(\bar{r}_{t+1} - r^d_{\ it+1} - mcd_{it+1}\right)\frac{d_{it+1}\phi^d_{bR}}{b_{iRt+1}}\right] \quad (11)$$

$$\frac{\left(r^l_{\ it} - \bar{r}_t - mcl_{it}\right)}{r^l_{\ it}} = \frac{-1}{\left(\phi^l_{\ r} + \phi^l_{\ rR}\dfrac{r^l_{\ it}}{r^l_{\ iRt}}\alpha^l_{\ r}\right)}, \quad (12)$$

$$\frac{\left(\bar{r}_t - mcd_{it} - r^d_{\ it}\right)}{r^d_{\ it}} = \frac{1}{\left(\phi^d_{\ r} + \phi^d_{\ rR}\dfrac{r^d_{\ it}}{r^d_{\ iRt}}\alpha^d_{\ r}\right)}, \quad (13)$$

where $\alpha_b = {\partial b_{iRt+1}}/{\partial b_{it}}$, $\alpha^l_r = {\partial r^l_{iRt}}/{\partial r^l_{it}}$, $\alpha^d_r = {\partial r^d_{iRt}}/{\partial r^d_{it}}$ are the conduct parameters (conjectural variations). Observe that $\left(\dfrac{r^l_{\ it} - \bar{r}_t - mcl_{it}}{r^l_{\ it}}\right)$ and $\left(\dfrac{\bar{r}_t - md_{it} - r^d_{\ it}}{r^d_{\ it}}\right)$ are expressions of the Lerner Index of market power for loans and deposits, respectively[1].

In empirical implementation, the translog cost function is first estimated to determine the marginal operating costs[2] which are then used in jointly estimating the first order conditions for the number of branches (11) and loan (12) and deposit (13) interest rates with the market shares[3]. Exogenous influences (z_{it}) specified in the demand for loans (9) and supply of deposits (10) include the size of the market for loans and deposits. For each bank this variable is constructed as a weighted average of the market size of the provinces where the bank has branches, using as weights the relative importance of each province in terms of that bank's branches. Our results do not change if a linear time trend is added to (9) and (10) to account for economic expansion over the period.

2. Spanish banking: competitive background and data description

2.1. Spanish banking during 1986-2002. The most important actions to deregulate Spanish banking were taken in the 1980s. Controls on domestic interest rates and restrictions on branching and foreign bank entry were effectively removed over 1986-1989 in preparation for European integration and regulatory harmonization. Although commercial banks already had the power to branch outside their regions, savings banks did not. After branching restrictions were lifted, savings banks rushed to enter new markets by opening new branches and merging with and acquiring other institutions inside and outside of their regions. This completely altered the domestic competitive environment.

The variation in aggregate loan and deposit interest rates for Spain over 1986-2002 is shown in Figure 1. During this period both commercial and savings banks adopted aggressive pricing strategies seeking to increase their market share of deposit accounts. As the initial emphasis was on attracting deposits during the late 1980s, both deposit and loan rates were relatively high, only to fall during the 1990s as pressure to expand loans – along with reduced inflation – resulted in significant reductions in loan and deposit rates and bank interest margins (left axis). The fall in interest rates led depositors to expand into mutual funds and other off-balance sheet savings instruments which, unlike the U.S., are almost exclusively offered by banking firms. Even so, deposits grew by over 160% in real terms during this period.

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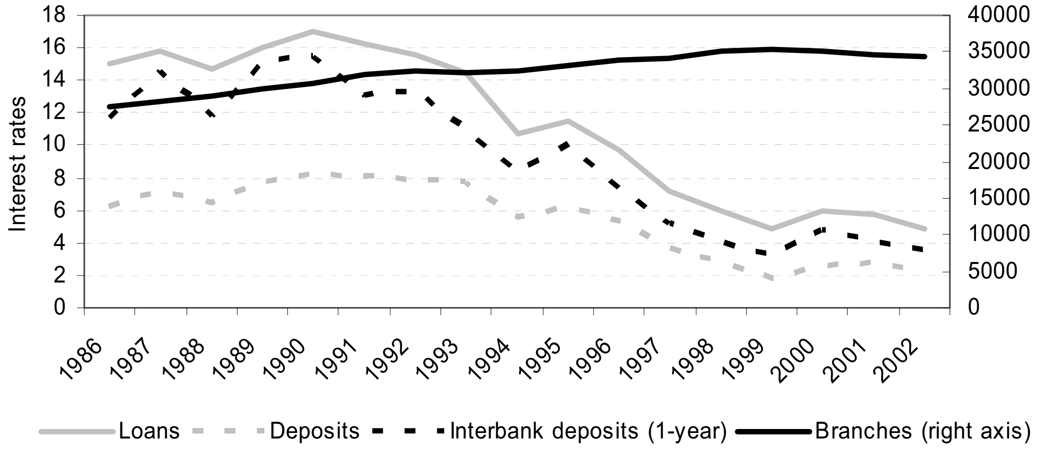
[1] See Freixas and Rochet (1997).

[2] Given output demand, costs are minimized in order to maximize profits regardless of actual market structure. Therefore, the estimation in a first stage of the cost function separately from first order conditions is reasonably consistent with the assumption of some degree of market power implicit in the model.

[3] The parameters to estimate are: α_b and α^l_r, α^d_r (conjectural variation in branches and interest rates, respectively), ϕ^l_b, ϕ^d_b (elasticities of loan and deposit demand w.r.t. own branches), ϕ^l_{bR}, ϕ^d_{bR} (elasticities of rival branches), θ^l_b, θ^d_b (elasticities of total market demand (size)), and ϕ^l_r, ϕ^d_r (the relative loan and deposit interest rate elasticities).



Source: Bank of Spain.

Fig. 1. Interest rates and number of bank branches in Spain

Figure 1 also shows the overall change in the number of branch offices which rose by 25% over 1986-2002 (right axis). However, savings and commercial banks adopted different non-price branch strategies since branches at savings banks rose by 84% but fell by 15% at commercial banks. Fuentelsaz and Gomez (2001) note that savings banks initially adopted a defensive strategy prior to the lifting of branch restrictions by first expanding the number of branches in their own territory and then later doing the same outside their regional area once this was permitted.

Even though the evolution of interest rates between savings and commercial banks was quite similar, savings banks increased their share of deposits in total funding by 28% over 1986-2002 (from 43% in 1986 to 54% in 2002) while commercial banks reduced their share by 39% (falling from 53% to 32%)[1]. Commercial banks also experienced a reduction in their share of the loan market so that by 2002 savings and commercial banks have almost equal shares. As savings and commercial bank interest rates were similar over the period, the gains made by savings banks in the deposit and loan markets are likely primarily due to non-price (branch) competition[2].

2.2 Data and Empirical Approach. Our unbalanced panel data covers more than 90% of bank assets in Spain and contain 2,194 observations over a 17-year period. Banks with missing data needed for estimating our model and some where data errors seemed quite likely were excluded from the sample[3]. Data are from reported balance sheet and profit and loss accounts of commercial and savings banks published by the AEB (*Asociacion Española de Banca*) and the CECA (*Confederacion Española de Cajas de Ahorros*)[4].

As actual bank interest rates are not reported, yearly averages of loan (deposit) interest rates for each bank were estimated from ratios of loan revenues (deposit expenses) including fee income (expenses) to outstanding loan (deposit) values. This gives an average (not marginal) interest rate but, as our model is based more on the evolution of these prices than on their absolute level, this difference should not have a significant impact on our findings[5].

Marginal operating costs are calculated from estimating a translog cost function (17) where c_i is each bank's operating costs while the input prices (w) are w_1= price of labor (personnel costs / number of employees) and w_2= price of capital (operating

[1] Other funding sources account for the fact that the deposit portion of the funding shares do not add to 100%.

[2] Recent regulatory initiatives, such as the Financial Services Action Plan (FSAP) of the European Commission, have the potential to affect bank price and non-price competition. FSAP seeks to promote greater integration of wholesale and retail financial activities in Europe and this can affect deposit pricing since wholesale (purchased) funds are funding substitutes for deposits. As well, FSAP seeks to encourage the development and use of new technologies in delivering financial services which can reduce the competitive benefits of having a physical (branch) presence in the competition for market shares.

[3] Banks with missing data plus those with input prices and/or computed loan and deposit interest rates that were outside the interval of +/- 2.5 times the relevant standard deviation were dropped from the sample. These problems affected 36 banks. Banks with extreme values likely reflect errors in the reported data and typically were associated with small foreign banks.

[4] Data on deposits, loans, and branches are collected from the balance sheet of each bank. Information on financial and operating (personnel and other operating) expenses are collected from the profit and loss account of each bank.

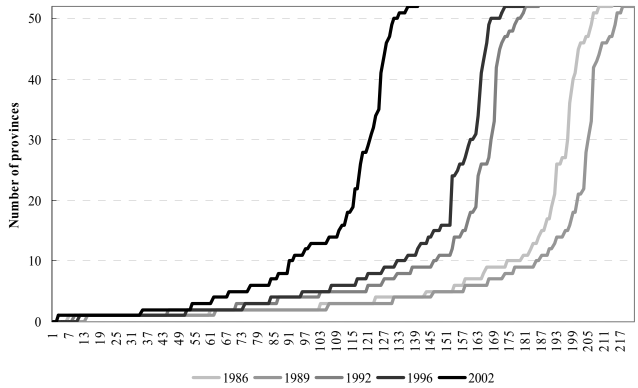
[5] Some support here is seen from the fact that when we compute the aggregate ratio of bank loan revenues plus fee income to the value of loans outstanding, the evolution of this series over time closely approximates that of the market interest rate cited by the Bank of Spain. However, if fee income is excluded from this aggregate ratio, the correspondence weakens. The money market interest rate is assumed to be equal to the one-year interbank interest rate (source: Bank of Spain).

costs except personnel costs / fixed assets)[1]. A time dummy variable is specified to capture the effect of technical change. Symmetry and linear homogeneity in input prices restrictions are imposed. Individual fixed effects have been introduced to capture the effect of other variables specific of each bank.

Data on rivals' interest rates and branches are computed in two ways. As has been done in Kim and Vale (2001) and Coccorese (2005), we assume that rivals' responses occur in a national market framework so rivals' interest rates are computed from the weighted average of the *(n-1)* rivals' interest rates. Similarly, the rivals' branch network response to changes by bank *i* is determined by the sum of all bank branches in the country, excluding those of bank *i*.

However, except for some very large corporate loans and money market institutions, the intensity of competition (and consequent rivals' response) may be stronger and better locally identified within regional markets[2]. If bank *i* is in region *p*, then the number of rival bank branches would be the total number of branches in region *p* minus the number of branches bank *i* has in region *p*. This represents better the actual rivals of any bank *i*, whether bank *i* has branches nationwide or is only located in the region being considered. Specifically, if bank *i* has branches nationwide, only those branches in region *p* would be considered in this calculation. The calculation procedure used is shown in more detail in the Appendix (which also contains a table of the mean values of our data by year). The same logic applies to determining the rivals' loan and deposit interest rates. That is, bank *i*'s rivals' loan and deposit interest rates in region *p* will be a weighted average of interest rates of only those rival banks with branches in the same region.[3]

Rival banks can be identified in each of 52 provinces using data on the regional distribution of branch offices provided by AEB and CECA[4]. As Figure 2 shows, in the last year of our sample (2002), 16% of banks have branches in more than half of the 52 provinces[5]. Only the four largest banking entities (three commercial banks – BBVA, BSCH and Banesto, and one savings bank – "la Caixa") have a presence in all provinces. At the other extreme, 34 commercial and saving banks have branches in only one province. With such differences in branch distribution, it is important to use a regional (provincial) approach to the measurement of rivals' branch network and interest rates.



Source: AEB and CECA.

Fig. 2. Number of provinces in which each bank has branches

As shown earlier in Figure 1, the evolution of loan interest rates over time follows a downward pattern similar to the money market rate but falling even further. The same pattern applies to deposits, with the net result that the spread between money market purchased funds and deposits is quite small toward the end of our period. While the estimated marginal operating costs of loans in Figure 3 has also fallen over time – dropping by two-thirds – the marginal operating cost of deposits is rising. As a result, the ratio of loan to deposit marginal cost falls dramatically from 5.6 in 1986 to 0.3 in 2002. Several things could explain this evolution of marginal costs. On the loan side, improvements in the evaluation of loan risk (credit scoring) can lower loan operating expenses while mortgage loans – which are cheaper to initiate and service – make up a larger share of loan portfolios (rising from 21% of all loans in 1986 to 55% in 2002). On the deposit side, the (smaller) rise in deposit marginal operating costs is associated with the shift of non-bank deposits in the balance sheet (which decreased from 50% in 1986 to 37% in 2002) to mutual funds. In addition, there was an 8 percentage point increase in the relative share of sight deposits, which have

[1] Loans and deposits appear in the translog cost function as outputs. Branches do not appear in the cost function despite its impact on costs because of the strong collinearity between deposits (and loans) and branches.

[2] Others papers also define local banking markets as relevant to assess banking competition. See, for example, Berger and Hannan (1989 and 1998) and Hannan and Prager (2004).

[3] As noted in the text, the exception would be for very large corporate loans where the market may be considered more national than regional in scope. Unfortunately, data are not available by loan size in Spain (nor distinguished between corporate and consumer categories) so data on the value of large corporate loans are not available. Deposit competition is clearly local in nature rather than nationwide.

[4] We are assuming that a bank's business is distributed proportionally to its branches across the different provinces. As Carbó and Rodriguez (2004) show, this is quite reasonable since a high percentage of commercial and savings banks concentrate over 90% of their business only in one region. Other studies have used a distribution of branch offices over 52 provinces in Spain to compute indices of concentration, market size, etc.

[5] Figure 2 uses information on all Spanish commercial and savings banks, which have decreased from 214 in 1986 to 140 in 2002.

higher payment processing expenses than time or savings deposits. Finally, as branching restrictions were dropped for savings banks, they likely over-expanded their branch networks to gain market share (which added to operating expenses).

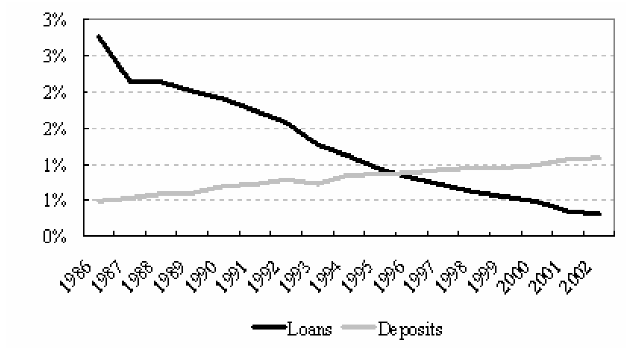


Fig. 3. Operating marginal costs

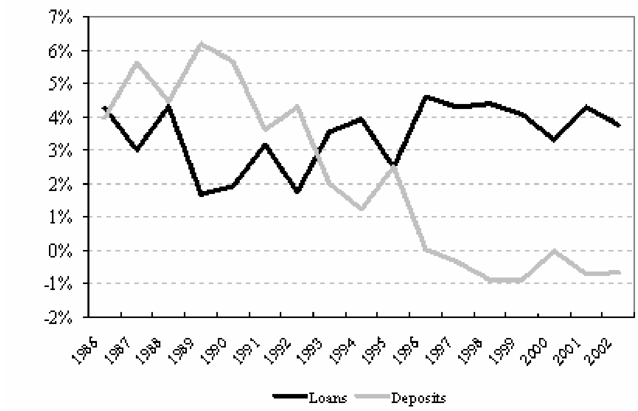
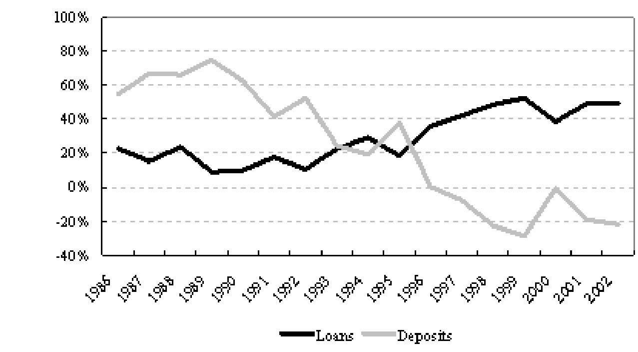


Fig. 4. Absolute margins



Source: Own elaboration from AEB, CECA and Bank of Spain

Fig. 5. Relative margins

The evolution of loan $(r^l - \bar{r} - mcl)$ and deposit $(\bar{r} - r^d - mcd)$ absolute margins and the (Lerner index) relative margins are shown in Figures 4 and 5. In both cases, loan margins rose over the period (as loan marginal cost fell) while deposit margins fell (as deposit marginal cost rose)[1]. This suggests that market power may have increased in loan markets while falling in deposit markets[2]. Over 1997-2002, margins were negative in the deposit market, suggesting a loss leader pricing strategy. Although deposits were not a profitable product by themselves, they allowed banks to capture/maintain customers and, via this "tying arrangement", permit the exercise market power in the loan market since typically having a deposit at a bank is a precondition for obtaining a loan.

3. Estimation results: price and non-price effects

3.1. Price and non-price effects on loans and deposits. Initially, the system of five simultaneous equations (9), (10), (11), (12) and (13) was estimated applying three-stage least squares using the two-step procedure noted in Section 1.2. Since the interest rates on loans and deposits as well as the number of bank branches could be considered to be endogeneous, we initially used one-period lags of these three variables as instruments to deal with the possible contemporaneous correlation of these variables with the error terms in an un-lagged or static model[3]. Unfortunately, several problems were encountered in the resulting dynamic model: lack of convergence in the iteration process, a wrong sign for an own price elasticity, and the inability to estimate some conduct parameters due to data singularities. These results indicate that despite a theoretical preference for estimating a dynamic model with lagged variables, this approach requires too much of the available data to be successful.

Since the reason for specifying the three lagged instrumental variables was to deal with possible contemporaneous correlation, we tested this possibility directly. The average correlation between the variables in the (poorly performing) dynamic model which contained the three lagged variables and the estimated error terms was -0.019 while the average correlation between the variables in the (better performing) static model which contained no lagged variables was -0.016. Looking at the loan demand and deposit supply equations separately, the average correlations in the dynamic

[1] Decomposing the change in the loan absolute margin into a change in the interest spread ($r_l - \bar{r}$) plus a change in marginal costs over 1986 to 2002, the interest spread fell by 2.97 pp., the marginal cost fell by 2.45 pp., and overall the absolute margin fell by 0.52 pp. In the case of deposits, the interest spread ($\bar{r} - r_d$) fell by 4.05 pp., marginal costs increased by 0.59 pp. and the absolute margin fell by 4.64 pp. Consequently, in both cases the evolution of absolute margins is due more to changes in interest spreads than changes in marginal costs.

[2] This market power result is similar to that found by Oroz and Salas (2003). These authors calculate relative margins using aggregate information on interest rates on new operations (marginal interest rates) but do not take into account marginal operating costs as we do here. The results are also in line with Maudos and Fernández de Guevara (2007).

[3] An iterative non-linear program using the Gauss-Newton algorithm in TSP 4.5 was applied. Rival's branches and interest rates are assumed to be exogenous.

model were -0.007 and 0.049, respectively, while in the static model these correlations were -0.019 and -0.016. All these correlations are quite low and very similar. Indeed, correcting for possible contemporaneous correlation (by using a dynamic model) offers no improvement in this regard over the static model. For this reason, we report results using a static or contemporaneous specification for all variables (no lags).

Table 1 presents the results of the model using first a regional definition of loan and deposit markets and then a national market definition. For both of these markets all estimated parameters have the expected signs and are statistically significant[1]. Within a regional market framework, the own price elasticity suggests that a 1% reduction in a bank's loan interest rate expands its loan volume by 1.46% while a 1% rise in its deposit rate only expands deposit volume by 0.23%. Almost identical elasticities are found here within a national market framework.

The effect on a bank's loans and deposits from changes in rivals' interest rates mirrors that just noted for changes in a bank's own interest rate (although of course in the opposite direction). That is, a 1% rise in rivals' loan interest rates expands a bank's loan position by 1.12% (versus a 1.46% rise with a 1% reduction in the bank's own loan rate). For deposits, a 1% reduction in rivals' deposit rates expands a bank's deposit position by 0.46% (versus a 0.23% rise with a 1% rise in the bank's own deposit rate). Thus, for the same 1% change there is a stronger loan response from changes in a bank's own loan rate than from that of rivals (and both elasticities are elastic) while on the deposit side changes in rivals' deposit rates generate the greater response (and both elasticities are inelastic).

These results are consistent with borrowers searching more carefully among lenders for their relatively infrequent and often large loan requests as opposed to depositors where access to a convenient location is more highly valued due to their more frequent (sometimes multiple times a week) use of deposit/payment/cash acquisition banking services. Consequently, we would expect that our non-price strategic variable (branches) is more important for the deposit function than for loans.

On a regional basis, however, a bank's own branch elasticity for loans is 0.73 while that for deposits is 0.75 so expanding the number of branches at a bank by 1% expands deposits and loans by essentially the same percentage amount. This means that each new branch adds new loans at basically the same rate as it adds deposits generating a "balanced" balance sheet. These elasticities are identical (after rounding) in a national market environment.

Even so, loans and deposits are differentially affected when rivals expand their branch network. The elasticity of a bank's loans to rivals' branches within regional markets is 0.23 while that for deposits is -.39 so rivals' branches seem to positively affect a bank's own loan position but reduce its deposits. As these elasticities are, again, almost identical within a national market framework, this unexpected result for loans is not due to specifying a regional versus a national market. Most likely, the "income effect" of rising economic growth in Spain during the period, injections of previously "black money" into the economy with the need to declare Peseta holdings to obtain Euros, and falling interest rates, offset the "substitution effect" where rivals' branch expansion would be expected to take away loans from existing banks rather than add to them. Thus we believe that the positive elasticity of bank's loans to rivals' branches to perhaps be the result of a relatively rapidly expanding economy rather than a static or declining one[2].

In addition, running the model separately for commercial and savings banks reveals some important differences[3]. First, the savings bank results are more robust and have greater overall significance. Second, the estimated elasticity of a bank's loans to rivals' branches is negative (as expected) for savings banks but positive for commercial banks. This is consistent with savings banks' response to branch competition being more intense than that for commercial banks since savings bank branching restrictions were lifted during our time period while commercial banks faced no such restrictions at the time. The (unexpected) positive sign for commercial banks suggests that commercial bank loans rose as savings banks expanded their branch networks. This differential response of loans to branch expansion suggests a partially segmented loan market where the expanded availability of savings banks' branches generates greater competition for the types of loans offered by savings

[1] The only exception is for the branch conjectural variation parameter which is significant at the 89% level of confidence.

[2] Kim and Vale (2001) only modeled the loan side and assumed a national loan market for Norway. In this framework, they found that rivals' branches had a significantly negative effect on a bank's loans. During their 8-year period (1988-1995) total loans in Norway grew by 21% while the number of branches fell by 20% and loans per branch expanded by approximately 51%. For the same years in Spain, loans grew by 89% and branches rose by 7% giving an approximate growth in loans per branch of 82%. This difference in loan growth may be the reason why the average bank in Spain found its loans grew even as rivals expanded their branch networks.

[3] Although discussed, these results are not shown here.

banks but not (yet) for the broader range of loans offered by commercial banks.

3.2. The intensity of price and non-price competition. Conjectural variation (or conduct) parameters reflect the intensity of price and non-price competition. The intensity of price competition in loan and deposit markets is inferred from the loan rate conjectural variation of 0.90 and that for the deposit rate of 0.81. As both of these values are significantly different from zero, Nash behavior is rejected[1]. Simply put, if a given bank changes its loan (deposit) interest rate in a regional market environment, it expects that rivals will respond by changing their loan (deposit) rate by 90% (81%) of the original change. Thus the matching behavior in terms of price competition is fairly strong[2]. In principle, if these conduct parameters were both equal to 1.0, a bank's loan or deposit price variation would be exactly matched leading, most likely, to an expanded reliance on a strategy of non-price competition. In this regard, strong price matching behavior is evident for years when loan rates rose or fell since separately estimated conjectural variations were the same in both cases (α^l_r = 1.22 for years when loan rates rose and 1.21 for years when they fell). This was not the case for deposits since price matching occurred in years when deposit rates rose (α^d_r = 1.49) but did not when rates fell (-0.68).

A common non-price strategy involves the placement of branch offices and the estimated conjectural variation here is 1.39 in a regional market framework (1.65 with a national market). When a given bank establishes a new branch it expects its regional (national) rivals to respond by increasing their branch network by a 1.39 (1.64) branches3. Judging by the larger estimated response, non-price competition in Spain appears to be more intense than price competition. Although it is easy to change interest rates, non-price competition can be less costly since, with floating rates, price competition may have a greater overall effect on deposit costs and loan revenues. Perhaps this helps to explain why branches in Spain are small and very close to one another.

3.3. Results after all deregulation was in place. The deregulation process in Spain was completed by 1992. Specifically, interest rates and controls on fees were liberalized in 1987; branching restrictions were fully removed in 1989; a schedule to phase-out compulsory investment requirements was approved in 1989; liquidity rules were liberalized in 1990; and capital adequacy requirements were modified in 1992. To see how our elasticity and conjectural variation results may be influenced by the use of our relatively long 17-year time period over 1986-2002, the data were divided into pre-1992 and post-1992 sub-periods and the model was re-estimated. Unfortunately, data for 1986-1992 did not permit our non-linear simultaneous equation model to converge and, when the convergence criteria was weakened, the resulting estimates contained the wrong signs. This problem may be due to the fact that deregulation was not yet complete in this earlier period so that bank competition on both a price and non-price basis was basically in its initial stages while, at the same time, a wave of mergers was occurring destabilizing the competitive reactions we are trying to estimate. Fortunately, estimation for the later period after deregulation was completed (1992-2002) was successful and the results are shown in Table 2.

The basic similarity of results between Tables 1 and 2 along with our inability to achieve reasonable estimates for the pre-1992 time period suggest that bank behavior during the post-1992 period drives the estimates for the entire period. Concentrating on the differences in results, the effect on a bank's deposits from changes in either its own or rivals' deposit rates has a somewhat greater impact in the post-1992 period, which suggests less market power[4]. In the loan market, the own-price elasticity falls indicating greater market power. However, the effect on a bank's loan position is now larger for changes in rivals' loan rates.

In the case of branch elasticities, although the positive effect on loans and deposits from a bank's own branch expansion are equal to one another in the post-1992 period (as before), the effect from rivals is to reduce both a bank's deposits (as before) as well as its loans. It was previously suggested that the expansion of a rival's branch network added to a bank's loan position – effectively expanding the entire market for loans. In the post-1992 period, however, the sign is reversed so branching by rivals takes away a

[1] If we estimate the system of equations separately for commercial and savings banks, results show that market power is higher in the savings banks sector. Thus, for savings banks, the loan and deposit rate conjectural variations are 0.49 and 1.07, respectively. For commercial banks, the loan and deposit rate conjectural variations are -0.01 and 0.07, respectively, and are not statistically different from zero. Consequently, Nash behavior is not rejected in the commercial banks sector. The higher market power in the savings banks sector is in line with Fernández de Guevara and Maudos (2007) results who show how the Lerner index is lower in the commercial banks sector.

[2] In a national market environment, rivals' responses are 77% for loans and 86% for deposits.

[3] The 1.39 figure is only significantly different from zero at the 89% level of confidence while the 1.65 value is significant at the 99% level. Either estimate is similar, but lower, than the one reported in Kim and Vale (2001) for Norway (2.08).

[4] As expressions (12) and (13) show, the Lerner index decreases when own-price elasticities (ϕ^l_r and ϕ_r) increase.

bank's loan market share, a result more indicative of both a slower expansion of loan demand and more effective non-price competition by rivals.

Turning to conjectural variations, which reflect the intensity of price and non-price competition, within a regional market framework in the post-deregulation period deposit competition appears to have increased as the conduct parameter falls from 0.81 for the entire period to 0.16 post-deregulation. However, competition seems to have decreased for loans (conduct parameter rises from 0.91 to 1.46). In terms of branches, the conduct parameter is significantly greater than zero (0.32) which means that banks use branches as a strategic variable[1]. Nash behavior is still rejected for loans and branches but not for deposits. Thus while banks still exercise some form of market power or coordination between institutions in the loan market post-1992 and rely on non-price competition using their branch networks, they now seem no longer to (significantly) consider rivals' responses when setting deposit interest rates.

The evolution of the Lerner index (and changes in the interest rate conjectural variation parameter) indicates an increase of market power in the loan market but a decrease in the deposit market. The Lerner index for the loan market can be written as $1-(\bar{r}/r_l)-(mcl/r_l)$ permitting us to determine the relative contribution of changes in interest rates versus marginal cost in the overall change in the index. From 1986 to 2002, the contribution of interest rates $(\bar{r}/r_l)$ decreased 16 percentage points (from .62 to .46) whereas the contribution from marginal cost (mcl/r_l) decreased by 11 percentage points (from .15 to .04). Thus the rise in the Lerner index for the loan market from 0.23 in 1986 to 0.50 in 2002 is due more to changes in loan interest rate behavior than changes in marginal costs. In the deposit market, the Lerner index fell from .55 in 1986 down to -.22 in 2002 and a similar decomposition shows that this reduction is also due more to changes in interest rates than marginal costs[2].

Summary and conclusions

We have estimated an expanded model of bank oligopoly behavior by incorporating price (interest rate) and non-price (branch network) competition as strategic variables in both the market for bank loans as well as deposits. Conjectural variations in this expanded framework suggest that rivals can respond to changes in both loan and deposit market prices as well as through branching behavior. Using data for Spain over 17 years (1986-2002) and for a decade after banking deregulation was competed (1992-2002) to illustrate our model, we find only a few important differences from specifying a regional market framework (common in the U.S.) versus a national one (typical in European studies). The major exception occurs in estimating branch conjectural variation (where there is an important increase at the national level).

A regional market framework is felt to be more relevant and on this level we find relatively large and elastic own price (interest rate) elasticities in an average bank's market for loans but small and inelastic own price elasticities for deposits. As well, increases in rivals' loan rates were seen to add significantly to a bank's own loan position while a reduction in rivals' deposit rates expands a bank's deposit position. The latter deposit "substitution effect" is expected, of course, but the positive effect on a bank's loans when rivals raise – not lower – their loan rate was not. As the expected "substitution effect" for loans was found when the sample was shortened to the period after deregulation was completed (1992-2002), this suggests that either a positive or negative response is possible. If the credit market is expanding rapidly enough, loan demand at the average bank may also expand even in the face of rising interest rates at rival banks. Here the overall economy-driven expansion of loans offsets the price-driven substitution effect among a bank and its rivals. In either case, however, the effects from a given price change in the loan market exceeds that in the deposit market. This is consistent with borrowers searching more carefully among lenders for their relatively infrequent and often large loan requests compared to depositors where access to a convenient location is more highly valued due to their more frequent use of deposit banking services.

In this situation, branching – our non-price strategic variable – should be more important in the competition for deposits than for loans. While changes in a bank's own branch network affect loans and deposits almost equally, the expansion of rivals' branch network should decrease both its loans and deposits. The expected result does occur for deposits but appears to have been offset (by rising economic growth and reduced interest rates) for loans, at least when the model is estimated for the entire 1986-

[1] The same results were obtained using a national market framework except that the branch conjectural variation rose rather than fell. We have more confidence in the regional market results as this is where we believe competition is most relevant and therefore best measured.

[2] The deposit decomposition is $(\bar{r}/r_d)-(mcd/r_d)-1$. The contribution of interest rates $(\bar{r}/r_d)$ was 48 percentage points (which fell from 1.62 to 1.14) while that from marginal costs (mcd/r_d) was 29 percentage points (which rose from .07 to .36).

2002 period. The expected result for loans, however, occurs during the sub-period 1992-2002 after deregulation was complete.

Our model assumes that changes in interest rates or branching arrangements can affect returns and market shares and that these changes will engender a response by rivals which can be estimated through a conjectural variation or conduct parameter. Our results suggest that when a given bank changes its loan rate, it expects that rivals will respond by changing their loan rate by about 90% of the original change (the conduct parameter is 0.9, which is near the situation of joint profit maximization or perfect collusion). Similarly, changes in a bank's deposit rate generate changes in rivals' deposit rates by about 80% (the conduct parameter is 0.81) of the original change. Thus interest rate matching behavior seems fairly strong. While strong matching behavior exists for years when loan rates rise or fall, the response for deposit rates has been asymmetrical. There is strong matching for years when deposit rates rise (mostly after branching restrictions were lifted and savings banks were competing for market share) but weak matching for years when they fell.

The closer the deposit and loan price conjectural variation parameters are to 1.0 (a unit value reflects perfect collusion), the more a bank would tend to rely on a strategy of non-price competition. With the current level of price competition, the establishment of a new branch by a bank leads rivals to respond by increasing their branch network by a 1.39 branches. For the shorter period after deregulation was completed, strong "price matching" behavior is evident for loans (with a conduct parameter of 1.46) but less so for deposits (.16) or branches (.32). Even so, with price matching for loans, non-price competition through branching becomes more important in this market.

Our results support the view that non-price competition can play an important role in banking and that in Spain price competition has decreased in the loan market but increased in the deposit market over 1986-2002. We also find that the relative intensity of price versus non-price competition has varied over time, in our case after 1992 when the country's banking sector was finally fully deregulated. In terms of interest rates, competition has decreased in the loan market after deregulation but has increased in the deposit market. In fact, the Lerner index of market power has decreased from 1992 to 2002 in the loan market, but has decreased in the deposits markets during the whole period of 1986-2002. Unfortunately, such changes in price and non-price competition make more tenuous attempts to generalize to the future conjectural variation results obtained with historical information. This is not unlike trying to infer market competition from changes in market structure without knowing how entry conditions may affect this result. What this suggests is that industry measures of conjectural variation have to be kept current in order to be most useful.

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Appendix

The derivatives of the loan demand (9) and deposit supply (10) functions with respect to branches and interest rates for use in (6), (7) and (8) are:

$$\frac{\partial l_{it}}{\partial b_{it}} = \frac{l_{it}\phi^{l}{}_{b}}{b_{it}}, \tag{14}$$

$$\frac{\partial d_{it}}{\partial b_{it}} = \frac{d_{it}\phi^{d}{}_{b}}{b_{it}}, \tag{15}$$

$$\frac{\partial l_{it}}{\partial b_{iRt}} = \frac{l_{it}\phi^{l}_{bR}}{b_{iRt}}, \tag{16}$$

$$\frac{\partial d_{it}}{\partial b_{iRt}} = \frac{d_{it}\phi^{d}_{bR}}{b_{iRt}}, \tag{17}$$

$$\frac{\partial l_{it}}{\partial r^{l}{}_{it}} = l_{it}\left(\frac{\phi^{l}{}_{r}}{r^{l}{}_{it}} + \frac{\phi^{l}{}_{rR}}{r^{l}{}_{iRt}}\alpha^{l}\right) = \frac{l_{it}}{r^{l}{}_{it}}\left(\phi^{l}{}_{r} + \phi^{l}{}_{rR}\frac{r^{l}{}_{it}}{r^{l}{}_{iRt}}\alpha^{l}\right), \tag{18}$$

$$\frac{\partial d_{it}}{\partial r^{d}{}_{it}} = d_{it}\left(\frac{\phi^{d}{}_{r}}{r^{d}{}_{it}} + \frac{\phi^{d}{}_{rR}}{r^{d}{}_{iRt}}\alpha^{d}\right) = \frac{d_{it}}{r^{d}{}_{it}}\left(\phi^{d}{}_{r} + \phi^{d}{}_{rR}\frac{r^{d}{}_{it}}{r^{d}{}_{iRt}}\alpha^{d}\right), \tag{19}$$

where $\alpha^{l} = \partial r^{l}{}_{iRt}/\partial r^{l}{}_{it},\ \alpha^{d} = \partial r^{d}{}_{iRt}/\partial r^{d}{}_{it}$ are the conjectural variations in interest rates.

The marginal operating costs of loans and deposits from a standard translog cost function are:

$$\ln c_{it} = \gamma_0 + \sum_h \gamma_h \ln w_{hit} + \gamma_l \ln l_{it} + \gamma_d \ln d_{it} + \frac{1}{2}\sum_h \sum_m \gamma_{hm} \ln w_{hit} \ln w_{mit}$$
$$+\frac{1}{2}\gamma_{ll}(\ln l_{it})^2 + \frac{1}{2}\gamma_{dd}(\ln d_{it})^2 + \gamma_{ld}\ln l_{it}\ln d_{it} + \sum_h \gamma_{hl}\ln w_{hit}\ln l_{it} + \sum_h \gamma_{hd}\ln w_{hit}\ln d_{it} \tag{20}$$
$$+\mu_1 Trend + \frac{1}{2}\mu_2 Trend^2 + \mu_l Trend \ln l_{it} + \mu_d Trend \ln d_{it} + \sum_h \mu_h Trend \ln w_{hit}$$

The marginal operating costs of loans and deposits are given by:

$$mcl_{it} = \frac{\partial c_{it}}{\partial l_{it}} = \frac{c_{it}}{l_{it}}\left(\gamma_l + \gamma_{ll}\ln l_{it} + \gamma_{ld}\ln d_{it} + \sum_h \gamma_{hl}\ln w_{hit} + \mu_l Trend\right), \tag{21}$$

$$mcd_{it} = \frac{\partial c_{it}}{\partial d_{it}} = \frac{c_{it}}{d_{it}}\left(\gamma_d + \gamma_{dd}\ln d_{it} + \gamma_{ld}\ln l_{it} + \sum_h \gamma_{hd}\ln w_{hit} + \mu_d Trend\right). \tag{22}$$

Substituting (14) to (19) and (21) and (22) in (6) to (8) yields:

$$\frac{\partial V_{it}}{\partial b_{it}} = \left(r^l{}_{it} - \bar{r}_t - mcl_{it}\right)\frac{l_{it}\phi^l{}_b}{b_{it}} + \left(\bar{r}_t - r^d{}_{it} - mcd_{it}\right)\frac{d_{it}\phi^d{}_b}{b_{it}} +$$
$$\beta_t\left[\left(r^l{}_{it+1} - \bar{r}_{t+1} - mcl_{it+1}\right)\frac{l_{it+1}\phi^l_{bR}}{b_{iRt+1}}\frac{\partial b_{iRt+1}}{\partial b_{it}} + \left(\bar{r}_{t+1} - r^d{}_{it+1} - mcd_{it+1}\right)\frac{d_{it+1}\phi^d_{bR}}{b_{iRt+1}}\frac{\partial b_{iRt+1}}{\partial b_{it}}\right] = 0, \tag{23}$$

$$\frac{\partial V_{it}}{\partial r^l{}_{it}} = l_{it} + \left(r^l{}_{it} - \bar{r}_t - mcl_{it}\right)\frac{l_{it}}{r^l{}_{it}}\left(\phi^l{}_r + \phi^l{}_{rR}\frac{r^l{}_{it}}{r^l{}_{iRt}}\alpha^l{}_r\right) = 0 \tag{24}$$

$$\frac{\partial V_{it}}{\partial r^d{}_{it}} = -d_{it} + \left(\bar{r}_t - mcd_{it} - r^d{}_{it}\right)\frac{d_{it}}{r^d{}_{it}}\left(\phi^d{}_r + \phi^d{}_{rR}\frac{r^d{}_{it}}{r^d{}_{iRt}}\alpha^d{}_r\right) = 0 \tag{25}$$

Then the Lerner index of loans and deposits from equations (11) to (13) can be directly obtained from equations (23) to (25).

The empirical estimation of non-price rivalry involves various additional specifications. Rivals' branch network for bank *i* in region (province) *p* (b_{iRp}) is calculated as:

$$b_{iRp} = \sum_{i \neq j}^{n-1} b_{jp}\ . \tag{26}$$

When a given bank *i* has branches in different regions, the rivals' branch network for bank *i* in all regions where bank *i* is located is computed as a weighted average of rivals' branch network in each region, using as weights the regional branch distribution of bank *i*[1]:

$$b_{iR} = \sum_p b_{iRp}\left(\frac{b_{ip}}{\sum_p b_{ip}}\right). \tag{27}$$

In the case of loan and deposit interest rates, rivals' interest rates in each region *p* are calculated as[2]:

$$r_{iRp} = \sum_{i \neq j}^{n-1} r_{jp}\left(\frac{b_{jp}}{\sum_{i \neq j}^{n-1} b_{jp}}\right) \tag{28}$$

[1] We compute rivals' bank network and interest rates separately for each year. To calculate rivals' interest rates, for each bank in each year, a weighting matrix with *(n-1)*x*p* elements is computed. Over the period of 1986-2002, a matrix with *n*(n-1)*T*p* elements (almost 20 million) is computed.

[2] Having no information to do otherwise, we assume that banks set the same interest rates across their branches.

and the rivals' interest rate for bank i in all regions is computed as a weighted average of rivals' interest rates in each province:

$$r_{iR} = \sum_p r_{iRp} \left(\frac{b_{ip}}{\sum_p b_{ip}} \right). \quad (29)$$

Descriptive statistics (means) of the variables used are in Table A.1.

Table 1. Empirical results (1986-2002)

	Rival´s variables at regional level		Rival´s variables at national level	
	Estimate	S.E.	Estimate	S.E.
Constant (loan demand equation)	5.164**	0.226	5.120**	0.232
Elasticity of loans w.r.t. own branches (Φ^l_b)	0.728**	0.017	0.734**	0.016
Elasticity of loans w.r.t. rival branches (Φ^l_{bR})	0.227**	0.035	0.252**	0.036
Elasticity of own loan interest rate (Φ^l_r)	-1.457**	0.100	-1.487**	0.097
Elasticity of rival loan interest rate (Φ^l_{rR})	1.117**	0.119	1.271**	0.125
Loan market size	0.104**	0.023	0.113**	0.024
Constant (deposit suppy equation)	1.730**	0.358	1.713**	0.342
Elasticity of deposits w.r.t. own branches (Φ^d_b)	0.749**	0.017	0.751**	0.016
Elasticity of deposits w.r.t. rival branches (Φ^d_{bR})	-0.389**	0.043	-0.382**	0.043
Elasticity of own deposit interest rate (Φ^d_r)	0.230*	0.098	0.233**	0.079
Elasticity of rival deposit interest rate (Φ^l_{rR})	-0.463**	0.123	-0.467**	0.111
Deposit market size	0.650**	0.041	0.649**	0.039
Conjectural variations in loan interest rate (α^l)	0.901**	0.056	0.770**	0.046
Conjectural variations in deposit interest rate (α^d)	0.810**	0.118	0.860**	0.128
Conjectural variations in branches (α^b)	1.390	0.856	1.648**	0.624
N. obs.	1688		1688	

Notes: ** Parameter significant at the 99% level of confidence; * parameter significant at the 95% level of confidence. Standard errors are computed from heteroskedastic-consistent matrix (Robust-White).

Table 2. Empirical results (1993-2002)

	Rival´s variables at regional level		Rival´s variables at national level	
	Estimate	S.E.	Estimate	S.E.
Constant (loan demand equation)	0.711**	0.428	0.868	0.444
Elasticity of loans w.r.t. own branches (Φ^l_b)	0.757**	0.021	0.750**	0.021
Elasticity of loans w.r.t. rival branches (Φ^l_{bR})	--0.818**	0.074	-0.854**	0.071
Elasticity of own loan interest rate (Φ^l_r)	-1.112**	0.114	-0.884**	0.093
Elasticity of rival loan interest rate (Φ^l_{rR})	1.420**	0.164	1.239**	0.159
Loan market size	1.017**	0.064	1.035**	0.062
Constant (deposit suppy equation)	-1.602**	0.621	-0.912	0.567
Elasticity of deposits w.r.t. own branches (Φ^d_b)	0.782**	0.023	-0.781**	0.023
Elasticity of deposits w.r.t. rival branches (Φ^d_{bR})	-1.014**	0.080	-0.863**	0.073
Elasticity of own deposit interest rate (Φ^d_r)	0.457**	0.109	0.349**	0.088
Elasticity of rival deposit interest rate (Φ^l_{rR})	-0.645**	03140	-0.618**	0.141
Deposit market size	1.182**	0.076	1.048**	0.069

Conjectural variations in loan interest rate (α^l)	1.466**	0.116	1.366**	0.135
Conjectural variations in deposit interest rate (α^d)	0.164	0.139	0.131	0.160
Conjectural variations in branches (α^b)	0.317**	0.041	2.874**	0.288
N. obs.	958		958	

Notes: ** Parameter significant at the 99% level of confidence; * parameter significant at the 95% level of confidence. Standard errors are computed from heteroskedastic-consistent matrix (Robust-White).

Table A.1. Descriptive statistics (means)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
l_R (loans) thousands of euros	1.348	1.318	1.537	1.716	1.840	2.083	2.520	2.960	2.760	2.901	3.115	3.336	4.092	4.964	5.521	4.795	6.265
d_R (deposits) thousands of euros	1.847	1.862	2.144	2.263	2.379	2.578	3.158	3.505	3.482	3.588	3.729	3.932	4.758	5.785	6.315	5.510	6.895
r^l_{it} (loan interest rate)	0.182	0.186	0.172	0.172	0.177	0.174	0.164	0.154	0.125	0.129	0.122	0.100	0.088	0.074	0.078	0.081	0.070
r^d_{it} (deposit interest rate)	0.077	0.076	0.071	0.082	0.090	0.092	0.084	0.086	0.062	0.069	0.063	0.046	0.036	0.025	0.032	0.036	0.029
Regional r^l_{iRt} (rivals' loan interest rate)	0.190	0.196	0.181	0.182	0.191	0.181	0.167	0.158	0.136	0.138	0.130	0.105	0.090	0.078	0.084	0.086	0.074
Regional r^d_{iRt} (rivals' deposit interest rate)	0.069	0.068	0.063	0.073	0.084	0.086	0.081	0.080	0.061	0.066	0.061	0.045	0.037	0.029	0.035	0.035	0.029
National r^l_{iRt} (rivals' loan interest rate)	0.177	0.184	0.174	0.176	0.186	0.176	0.163	0.153	0.131	0.131	0.125	0.100	0.089	0.077	0.084	0.086	0.075
National r^d_{iRt} (rivals' deposit interest rate)	0.072	0.071	0.066	0.077	0.088	0.088	0.082	0.083	0.065	0.067	0.064	0.047	0.039	0.030	0.037	0.037	0.030
b_{it} (number of branches per bank)	154	150	166	166	167	181	218	197	195	202	214	218	259	302	314	282	332
Regional b_{rRt} (rivals' branch network)	1.386	1.454	1.424	1.613	1.762	1.927	1.740	1.855	1.899	2.044	2.063	2.167	1.972	1.876	1.948	1.943	1.960
National b_{rRt} (rivals' branch network)	27.623	28.009	28.793	29.566	30.353	30.999	31.230	31.689	31.773	32.551	33.217	34.053	34.829	34.889	34.902	34.372	34.112
Number of banks	177	175	169	179	178	171	141	148	146	149	144	145	125	116	112	107	103

Source: AEB, CECA and own elaboration.