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Abstract

This paper examines the links between productivity and social welfare, with an application to the banking industry. It models spatial price competition between bank branches jointly with banks' decisions on the opening or closing of branches based on profit expectations. The model predicts that more productive banks set lower (higher) interest rates on loans (deposits) and increase their market share through both higher demand per branch and a larger network of branches. Specifically, the paper i) uses a new measure of bank productivity; ii) provides a productivity differences-based explanation of the distance between bank branches and bank customers; and iii) shows how the intensity of market competition may be unaffected when the number of banks decreases, provided that banks continue expanding their branch network. The empirical implementation of the model uses Spanish banks over the period 1993-2007 and it confirms the theoretical predictions of the paper.

Keywords: banking spatial competition, bank branch productivity, interest rates, branch dynamics, bank economic profits.

JEL Classification: E43, G21, L11, O30, R32.

Resumen

Este trabajo examina los vínculos entre productividad y bienestar, en una aplicación para la industria bancaria. El trabajo modeliza la competencia espacial en precios entre oficinas bancarias, junto con la decisión de los bancos de abrir o cerrar oficinas según las expectativas de beneficio. El modelo predice que los bancos más productivos ofrecerán un menor (mayor) tipo de interés en los préstamos (depósitos) e incrementarán su cuota de mercado gracias a su mayor demanda por oficina y mayor red de oficinas. El trabajo: i) utiliza una nueva medida de productividad de los bancos; ii) proporciona una explicación, basada en las diferencias de productividad, de la distancia entre oficinas y clientes de los servicios bancarios, y iii) muestra que la intensidad de la competencia puede verse inalterada a pesar de que disminuya el número de bancos en el sistema, siempre que estos mantengan la expansión de sus oficinas. La aplicación empírica del modelo utiliza bancos españoles durante el período 1993-2007 y confirma las predicciones teóricas.

Palabras clave: competencia espacial en banca, productividad de la oficina bancaria, tipos de interés, dinámica de oficinas, beneficios económicos en banca.

Códigos JEL: E43, G21, L11, O30, R32.

1 Introduction

Productivity growth is at the core of economic progress. Most of the productivity research focuses on what determines the observed heterogeneity in productivity at the micro and macro levels (Syverson, 2011). However, much less is known about the channels through which productivity improvement translates into social welfare.

This paper is about productivity and social welfare in the banking industry. It provides empirical evidence from Spanish banks during the period 1993-2007. We model a two-stage spatial competition process. In a first step, bank-branches decide on the interest rates of loans and deposits and the number of branches are fixed. In a second step, banks adjust their numbers of branches until the industry economic profits converge to zero. In the short–run, more productive bank-branches set lower (higher) interest rates of loans (deposits) and capture larger market shares in the markets of loans and deposits. In the long–run, more productive banks end up with a larger network of branches than less productive ones. Through competition, productivity growth is translated into lower (higher) interest rates of loans (deposits) and larger branches-network.

In this set up, higher productivity contributes to social welfare through three different channels: i) market prices of differentiated banking products are closer to their marginal costs (lower dead-weight losses from market power); ii) more customers benefit of more favorable interest rates because, in equilibrium, more productive bank-branches capture larger market share; iii) higher customer accessibility to banking services through a larger network of branches that reduces the average distance to the bank-branch.

The theoretical model is a derivation of a standard Salop (1979) model in which we introduce differences in branch productivity. The theoretical predictions derived from the model relate the bank-branch productivity with the short-term equilibrium prices, with the market shares of loans and deposits and with the number of branches in the long-term equilibrium. The theoretical model takes the bank-branch as the competition unit where pricing decisions are taken. As in Salop (1979), the transportation costs differentiate the otherwise homogeneous products, the Nash equilibrium prices are not equal to the marginal costs, and the gross margin is inversely related to the size of the branches network (more branches implies lower average distance and less product differentiation). The bank-branch incurs a fixed cost for opening and operating and, thus, some degree of market power (i.e. price above marginal cost) is needed to avoid negative economic profits in the equilibrium. The size of the branches network and the gross profit margins adjusts through entry and exit decisions until the expected economic profits of one additional branch equals zero.

The main predictions of the model are tested using data from Spanish banks during the period 1993-2007, just before the recent financial and banking crisis. The estimated productivity of each bank-branch and year is computed following the methodology posited in Levinsohn and Petrin (2003), using a production function that deploys labor and IT capital as variable inputs and the capacity of the branch as a fixed input (Martín-Oliver et al, 2013). The econometric estimations confirm the predictions of the model. Industry productivity gains translate into lower (higher) interest of loans (deposits). At the same time, more productive banks charge lower (higher) interest rates of loans (deposits). We also find that more productive banks capture larger market share in both markets, deposits and loans, and earn higher economic profits per bank-branch. As for the dynamics of branches, empirical evidence supports the prediction that banks' opening and closing decisions are taken according to the expectations of future economic profit per branch at the industry level. Additionally, more productive banks expand their network of branches more rapidly, consistent with the prediction that higher productivity will be associated with higher profits also for the new branches. The prediction that branches entry and exit dynamics will continue until profit expectations of further entries are driven to zero is not rejected by the data. The evidence also shows that banks that the least productive ones are candidates to be merged or acquired, as it could be reasonably expected. Therefore, competition drives industry restructuring, even in normal times.

The paper contributes to three main strings of research in banking literature: i) why distance matters; ii) competition and market power; and iii) productivity and profits. Distance matters in the banking industry because it affects transportation and information acquisition costs, particularly in the loans market (Petersen and Rajan, 2002; Degryse and Ongena, 2005; Hauswald and Marquez, 2006; Agarwal and Hauswald, 2010). In environments of information asymmetry between borrowers and banks, the average distance between the locations of banks and the locations of borrower has been explained as a function of incentives of banks to invest in information acquisition (Agarwal and Hauswald, 2010), and incentives to invest in information technologies (Petersen and Rajan, 2002). In this paper, we assume complete and symmetric information between borrowers and lenders. Under these assumptions, average distance between suppliers and customers of bank services is also determined endogenously but this time as a function of differences in productivity among banks. This result suggests that controlling for productivity differences will be particularly relevant in research on distance and interest rates of loans (Degryse and Ongena, 2005).

Although the introduction of uncertainty and asymmetric information in the loans market is beyond the reach of this paper, the model offers some insights on the relationship between productivity and risk exposure of banks. Models of risk taking behavior in banks' loans decisions predict less risk exposure of bank loans in markets with lower mark-ups in the interests of loans (Matutes and Vives, 2000; Allen and Gale, 2004; Repullo, 2004; Boyd and De Nicolo, 2005; Freixas and Ma, 2014). The size of the mark-ups depends generally on the degree of market competition. Our model predicts that, for a given level of industry competition (Nash behavior), more productive banks will charge lower mark ups in their interest rates of loans. Consequently, a negative association would also be expected between productivity and the risk of the loan portfolio. At the same time, since more productive banks capture higher market share, the average distance between borrowers and banks will increase with productivity differences. If higher average distance implies higher information asymmetry between banks and borrowers, then productivity may be positively associated with credit risk[1]. Some preliminary evidence indicates that the ratio of non-performing loans increases with productivity in our sample data.

1. Models on the relationship between competition and risk taking of banks in lending decisions ignore the quantitative effects as they assume that demand of loans is independent of price. Other literature on competition and risk taking by banks argues that higher competition will lower the economic value of banks and, since banks will have less to loose if they go bankrupt, then competition will induce more risk taking behavior (Keeley, 1990; Hellmann et al., 2000; Salas and Saurina, 2003; Albertazzi and Gambacorta, 2009; Jiménez, López and Saurina, 2013). In this paper we assume Nash competitive behaviour of banks all along the exposition so we cannot test for differences in the intensity of competition (for example allowing for collusive behaviour among banks). Finally, productivity may be negatively associated with risk taking if more productive banks are also more efficient in monitoring and screening the credit quality of borrowers (Fiordelisi et al. 2011, Nemanja et al. 2012).

The paper is also related with the literature on price and non-price competition in banking, either statically (Berger and Hannan, 1998, Pinho 2000, Carbó and Rodríguez, 2007; Carbo et al, 2009; Mirzaei et al., 2013) or dynamically, especially through branching opening and closing (Cohen and Mazzeo, 2007; Ho and Ishii, 2011; Aguirregabiria et al., 2012). Our model differs from standard static price and non-price competition in that markets are defined spatially and the bank-branch, not the whole bank, is the basic decision unit. Product differentiation in the demand side is the consequence of differences in distance costs to alternative bank-branches. Differentiation, in turns, determines market power of each bank-branch. The competitive behaviour of banks is that which leads to a Nash equilibrium solution; collusive behaviour is not contemplated. In the supply side, bank differences are limited to heterogeneous productivity. The referenced papers on branches dynamics model the market equilibrium taking the regional market as the unit of analysis.

Our paper models the expansion of the network of branches from the point of view of the profit expectations of individual banks. In this respect, we explain the equilibrium number of branches for a bank as a function of its relative productivity when industry profit opportunities are exhausted. Some relevant predictions from our analysis are: i) market power does not necessarily imply positive economic profits when, as in our case, there are fixed costs of opening a new bank-branch; ii) the industry dynamics of competition with economic profits converging to zero is compatible with the reduction in the number of banks (through mergers and acquisitions) as long as surviving banks open new branches to capture profit opportunities.

Finally, our paper contributes to the literature that explain differences in profits of banks as a function of the differences in their productive efficiency (Berger et al., 2004; Berger and Mester, 2003; Fiordelisi, 2007; Athanasoglou et al., 2008). First, the paper uses a unique measure of productivity (Levinsohn and Petrin, 2003) obtained from a production function of banking services with labour and IT capital as input variables. To the best of our knowledge this is the first paper that uses this productivity measure to explain heterogeneity in banks profits. Second, the paper explains differences in economic profits of banks considering both differences in margins and differences in volumes (market shares). Third, short-term bank-branch economic profits are measured in absolute terms because this is the definition of the dependent variable that comes out directly from the theoretical model. Forth, we integrate in a single model the static and the dynamic relationships between banks' profits and productivity.

The rest of the paper is organized as follows. First, in Section 2, we formalize banks behaviour in a simple model where the relevant business unit is the bank-branch, while the number of branches is determined industry wide by opening and closing decisions. Section 3 describes the data sources and provides the descriptive statistics for the main variables, including the productivity measurement. Section 4 shows the results on the effects of productivity on the interest rates, the demands of loans and deposits and the profit level of banks, as well as the tests on the long-term converge of profits to zero as a consequence of the banks' branches dynamics. Finally, the conclusions section summarizes the main results of the paper and their implications.

2 Production, demand and profit functions

In this section, we present the industry competition model and formulate the main hypotheses that will be tested with data from Spanish banks. The model includes the description of the operating technology, the demands and profit functions of banks and the market equilibrium solution for both, the short-run, in which the number of branches is constant (static equilibrium), and for the long-run evolution of the number of branches and of the industry profits (dynamic equilibrium).

2.1 Production and cost function

The modeling of the production function of banks follows Martín-Oliver and Salas-Fumás (2008). The production function for the representative bank branch *i*, is given by:

$$L_i + D_i = \left[\min(q_i, F_i(E_i, IK_i; A_i))\right] \qquad [1]$$

The output of the bank branch is equal to the sum of loans (*L*) and deposits (*D*). Each branch has a fixed capacity *q* determined by the physical space, and a variable capacity that depends on the quantities of variable inputs, the number of employees per branch (*E*) and the IT capital per branch (*IK*)[2]. Parameter *A* represents the level of productivity of the branch. Martín-Oliver and Salas-Fumás (2008) estimate [1] with data from Spanish banks. They find that; i) output does not vary with the physical capital of the bank, confirming that physical capital is a quasi-fixed input tied to the capacity of the branch; ii) the null hypothesis of *F*( ) being linear homogeneous (i.e. it exhibits constant returns to scale in labor and IT capital inputs) is not rejected; iii) the null hypothesis of constant returns to scale at the bank level cannot be rejected. These results justify the output of the bank being written as the product of the output per branch times the number of bank branches, and also the treatment of physical capital as a fixed input.

Taking into account [1] and the linear homogeneity condition, the minimum total variable cost of producing output *(L+D)* per branch is given by:

$$C_i(L_i + D_i; w, cc_{IT}; A_i) = (L_i + D_i)\frac{v_i(w, cc_{IT})}{A_i} \qquad [2]$$

The term $c_i = \frac{v_i(w, cc_{IT})}{A_i}$ is the per-unit variable production cost of bank *i*; the function $v_i(w, cc_{IT})$ is increasing and linear homogeneous in the input prices of labor, *w*, and of IT capital services, cc_{IT}.

The current market price per unit of capacity of the branch is p_K so the investment in capacity per branch is $p_K q_i = K_i$. If cc_K is the user cost of physical branch-capital (equal to interest rate plus the corresponding depreciation rate) the fixed cost in period t of the investment per branch is equal to $cc_K K_i$

2. On the upward bias in bank-level productivity estimates when IT expenditures are ignored see Koetter and Noth (2013).

2.2 The demand functions

We consider a spatial market like in Salop (1979); bank branches are symmetrically located around a circumference of perimeter 1; customers are uniformly located in each point of the circumference so the total size of the market is normalized to 1. The number of branches is initially given and equal to *N,* so the distance between branches is 1/*N*. Deposits and loans markets are taken to be independent, so there are no bundling decisions on loans and deposits. We will denote by sub indexes *L* and *D* to loans and deposits, respectively. Therefore, the interest rates of bank-branch *i* will be r_{iL}, r_{iD}, for loans and deposits, respectively. The notation for the representative competing bank-branch is, r_L. r_D. A customer in the circumference located at distance x_i of branch *i* will compare the cost of a loan from branch *i* with the cost of the loan from the branch of the neighbor competitor. If the cost per unit of distance is τ, the distance x_i for which a borrower will be indifferent between the two branches satisfies the condition:

$$r_{iL} + \tau x_i = r_L + \tau(1/N - x_i) \qquad [3]$$

From [3] and taking into account that there are customers at both sides of the branch, the demand for loans per branch for bank branch *i* and for the representative competitor are:

$$L_{iL}(r_{iL}, r_L) = 2x_i = \frac{r_L - r_{iL} + \tau/N}{\tau} \qquad [4]$$

$$L_L(r_L, r_{iL}) = 2(1/N - x_i) = \frac{r_{iL} - r_L + \tau/N}{\tau} \qquad [5]$$

Repeating the calculation for deposits, the resulting demand functions are:

$$D_{iD}(r_{iD}, r_D) = \frac{r_{iD} - r_D + \tau/N}{\tau} \qquad [6]$$

$$D_D(r_D, r_{iD}) = \frac{r_D - r_{iD} + \tau/N}{\tau} \qquad [7]$$

Banks in our model face the constraint that total investments must be equal to the funds available to finance operations. Loans and fixed assets invested in the branches consume funds while deposits provide funds to finance assets. Additionally, banks have access to financial markets where they can borrow and lend at a given interest rate *r*. If *M* is the amount of market funds per branch lent to or borrowed from the financial markets, then the balance constraint of supply of funds equal to demand is formulated as follows:

$$L + K = D + M \qquad [8]$$

2.3 Short-term profit maximization

The profit per branch is equal to the difference between the revenues from loans granted by the branch and the financial and operating costs. The financial costs include the interests paid on deposits and the costs from market finance. The operating costs gather the variable costs associated to labor and IT capital services and the fixed costs from the investment on capacity. Taking into account [8] and after arranging the terms, the respective profit functions per branch of bank *i* and of the competing representative bank can be written as:

$$\Pi_i = (r_{il} - r - c_{iL})L_{iL}(r_{iL}, r_L) + (r - r_{iD} - c_{iD})D_{iD}(r_{iD}, r_D) - cc_{K_i}K_i \quad [9]$$

$$\Pi = (r_L - r - c_L)L_L(r_L, r_{iL}) + (r - r_D - c_D)D_D(r_D, r_{iD}) - cc_K K \quad [10]$$

,

where *L*( ) and *D*( ) functions are given by equations [4] to [7] above.

Each bank chooses the interest rates of loans and deposits that maximize profits. The Nash equilibrium solutions for bank *i,* are given by:

$$\begin{aligned} r_{iL}^* &= r + \frac{2}{3}\left(c_{iL} - c_L\right) + c_L + \tau / N; \\ L_{iL}^* &= \frac{1}{N} - \frac{1}{3\tau}(c_{iL} - c_L) \end{aligned} \quad [11]$$

and

$$\begin{aligned} r_{iD}^* &= r - \frac{2}{3}\left(c_{iD} - c_D\right) - c_D - \tau / N; \\ D_{iD}^* &= \frac{1}{N} - \frac{1}{3\tau}\left(c_{iD} - c_D\right). \end{aligned} \quad [12]$$

Equations [11] and [12] provide the interest rates and the volumes of loans and deposits at the short-term market equilibrium, for each bank-branch in its local market. Equilibrium interest rates of loans and deposits increase with the market interest rate *r*. Interest rates of loans (deposits) will be lower (higher) in markets with higher density of branches (*N)* and in markets with lower (higher) perceived differentiation (τ) . Within a given geographical market, the interest rate of loans (deposits) charged by a given bank will increase (decrease) with the weighted average of the per-unit operating costs of the bank (c_i) and the per-unit operating cost of its competitors (c_L) (weights of 2/3 and 1/3, respectively). Since per-unit operating costs are inversely related with productivity *A,* interest rates of loans (deposits) are lower (higher) in industries with higher average productivity of banks.

The loans and deposits per bank branch in the equilibrium are smaller in markets with higher density of branches. In equilibrium, bank-branches with higher productivity (lower operating unit costs) have a higher market share in a given spatial. Substituting the equilibrium values of prices and quantities from [11] and [12] in [9], the maximized volume of profit for bank *i* is equal to:

$$\Pi_i^* = \frac{\left(\tau / N - \frac{1}{3}(c_{iL} - c_L)\right)^2}{\tau} + \frac{\left(\tau / N - \frac{1}{3}(c_{iD} - c_D) + \right)^2}{\tau} - cc_{K_i} K_i. \quad [13]$$

Profit of bank-branch *i* increases with the own productivity relative to that of competing banks (as determinant of unit costs *c*). Productivity gains increases profits through two effects, through the increase of the gross profit margin ($r_L^* - r - c_L$ increases with A_i from [11]) and also because it implies more volume of demand per branch. Profit per branch is higher if the bank operates in markets with higher buyers' perceived differentiation and/or in markets with lower density of branches.

2.4 The dynamics of bank branches and of economic profits

The time dynamics of the number of branches of a given bank will depend on the profit expectations for the whole banking industry, and on the own productivity of the bank relative to that of its competitors as determinant of its own profits from the branch expansion. The dynamics of the change in the size of the branch network of bank *i* is then modelled as follows:

$$N_{it} - N_{it-1} = \beta_0 + \beta_1 E\left(\frac{\Pi_t}{N_t}\right) + \beta_2 RA_{it-1} + \omega_{it} \quad [14]$$

where N_{it} is the number of branches of bank *i* in year *t*, $E\left(\frac{\Pi_t}{N_t}\right)$ is the expected profit per branch for the whole banking industry in year *t,* and RA_{it} is a measure of relative productivity of bank *i*. The change in the number of branches of bank *i* will increase with the industry profits expectation and with the relative productivity (comparative advantage) of the bank, i.e., we expect $\beta_1>0$ and $\beta_2>0$.[3]

The expansion of the branch network will continue as long as banks anticipate positive economic profits from opening a new branch. As the number of branches increases, the unit margin, the demand per branch and, consequently, the gross profits decrease. At some point, these gross profits will not be high enough to cover the fixed costs of opening a new branch and the expansion will stop. We model the dynamics of profits per bank-branch resulting from the evolution on the number of branches as an autoregressive equation:

$$\Pi_{it} = \alpha_0 + \alpha_1 \Pi_{it-1} + \nu_{it} \quad [15]$$

The long-run equilibrium with a stationary number of branches requires that economic profits per branch converge to zero. This requires that $E(\alpha_0)=0$ and $E(\alpha_1)<1$. Equation [15] can be modified to allow for idiosyncratic effects of each bank, which will determine whether convergence on bank profits is conditional or unconditional.

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3. In the Salop type model of spatial competition the equilibrium number of branches in the market with free entry is higher than it should be from welfare maximization criteria; this implies inefficient equilibrium interest rates of loans and deposits too. The socially inefficient number of branches and interest rates from free entry is not discussed in the paper. See Berger et al. (1997) for a different approach to efficient banks' branches expansion.

In this formulation the dynamics of branches and profits are both modelled at the bank level and for an industry-wide zero profit condition. The underlying assumption is that if there are any profitable opportunities in any regional market to open new branches, it will have a positive impact on the average industry profit and, thus, banks will have incentives to open new branches. When all the profitable opportunities across markets are exhausted, then the expected profit per branch at the industry level will tend to zero. This approach is different from that in other papers that model equilibrium in the number of branches at the local market level (Cohen and Mazzeo, 2007; Ho and Ishii, 2011; Aguirregabiria et al., 2012).

2.5 Main predictions of the model

Here, we synthesize the predictions derived from the model discussed in this section that we will test empirically.

P1: The productivity determines the performance of banks:

a) Interest rates of loans (deposits) charged by a bank decrease (increase) with the difference in productivity of the bank with respect to competitors and decrease (increase) with the average productivity in the market.

b) Loans and deposits per branch increase with the relative difference of productivity of the bank with respect to its rivals.

c) In the short-term, profits per bank-branch increase with the relative productivity of banks.

P2: The dynamics of branches, [14], is summarized as follows:

a) The number of branches of each bank increases over time with the relative difference in productivity with respect to rivals at the beginning of the period, and with the expectations on future profits of the average branch in the market.

P3.The dynamics of industry profits [15]

a) For the whole banking industry, average economic profit per branch converges towards zero over time.

3 Database and variables

The database refers to Spanish banks over the pre-crisis period of 1993-2007. We use unconsolidated balance sheets and income statement data for each bank and year, with merged banks treated as a new entity. Since data are bank-level and the model is formulated at the branch level, we assume that the bank production is equal to the product of a representative bank-branch times the number of branches of the bank. This representation of the bank is supported by previous research where, for the same database, the hypothesis of constant returns to scale both at the branch- and at the bank-level could not be rejected (Martin-Oliver and Salas-Fumás, 2008).

We now describe the calculation of each of the main variables used in the empirical analysis and provide descriptive statistics on each of them. Appendix A gather together the definitions of the main variables used in the analysis.

3.1 Measurement of productivity

The productivity A_{it} for bank *i* in year *t* is estimated as in Martín-Oliver et al. (2013). The banking firm is modelled following a production approach where the production function is defined at the branch level according to [1]. Banks deploy labour, IT and physical capital services as inputs to produce a multiple-output that includes the collection of deposits, the delivery of loans and the provision of bank services related with them (liquidity provision, payment services, screening applicants, monitoring borrowers, etc). The production function for the representative technology at the branch level is estimated with the methodology developed by Levinsohn and Petrin (2003) that corrects for the simultaneity bias in the *OLS* estimation due to the correlation between the (unobserved) level of productivity and the amount of labour used in production[4].

The "raw" measure of productivity is calculated as the difference between the observed output and the predicted output according to the estimated parameters of the production function and the observed quantities of inputs. This raw measure of productivity may vary across banks for other reasons than differences in the TFP parameter A_i that is the relevant productivity from the model (Martín-Oliver et al 2013). To obtain an estimate of the TFP parameter we decompose the raw productivity measure as follows:

$$Raw\ Productivity_{it} = A_t + X_{it}'\gamma + A_{it} \qquad [16]$$

The productivity of bank *i* is separated into two components: the average productivity for the whole banking industry (A_t), and the differential of the productivity of bank *i*

4. The alternative to the production approach is the intermediation approach, where deposits are included among the inputs, together with labor and capital. We believe that the production approach provides a more accurate estimate of the productivity of banks because banks also consume labor and capital services inputs in the production of deposits and related liquidity services. Moreover, the deposits of banks are determined endogenously from banks' competition. The production approach has also advantages in the empirical side. For example, it only requires information on the quantities of input and output variables, whereas the estimation of the cost function also requires information on input prices, which are often difficult to measure (i.e., pricing risk), or are determined endogenously from the competition process (interest rates of deposits). Martín-Oliver and Salas-Fumás (2008) are the first to estimate the production function (1), and therefore the productivity of banks, with IT capital as a variable input and physical capital as a fixed one, and using the by Levinsohn and Petrin (2003) methodology.

in year t with respect to the industry average (A_{it}). The vector of control variables (X_{it}) accounts for other sources of heterogeneity different from productivity. The industry productivity (A_t) is estimated as the coefficient for the time dummy variable of year t in [16], while the difference with respect to this mean for bank i in period t (A_{it}) is obtained as the residual of the estimation. Since the "raw" productivity measure is expressed in logs, the industry and the bank productivity variables are also in logs.

Figure 1A shows the distribution of the estimated productivity of banks and years for the whole sample period. The distribution is centered on zero because estimated productivities are the residuals from equation [16]. We observe that productivity is heterogeneous across banks (no degenerated distribution) and that the distribution around the mean is quite symmetric. The estimated coefficients for the time dummy variables in equation [16] that give the time trend in average industry productivity are shown in the last column of Table 2. We observe a steady growth of around 3% a year and an accumulated growth of 45.8% for the 15 years of the sample.

Since the short-term equilibrium solutions and the equation of the dynamics of branches are functions of the bank's productivity relative to its competitors, we define two dummy variables that classify banks according to their relative level of productivity. The variable $Id(\text{Prodv}_i < p25^{th})$ takes the value of 1 for all banks-years whose level of productivity is lower than the productivity corresponding to the 25th percentile of the distribution of competing banks of competing banks in the same market.

The variable $Id(Prodv_i > p75^{th})$ takes the value of 1 for banks-years with productivity above the 75th percentile of the distribution in the year. The distribution of productivity for the competitors of bank i is obtained from the estimated productivity of those banks that compete in the relevant market for bank i. We define the relevant market of a bank as all the provinces in which the bank has at least five branches[5]. Figure 1B presents the distribution of productivity for the banks that are located below the 25th percentile and above the 75th percentile of the total distribution of productivity.

3.2 Interest rates

The interest rates of loans and deposits for bank i in year t (r_{Lit} and r_{Dit}, respectively) are interest rates charged by banks in new operations, i.e. *marginal* interest rates. The interest of loans is the weighted average of the interest rates charged in the different types of loans (i.e. business, consumer and mortgage loans), using as weights the volume of the operations. Similarly, the interest rates of deposits are the weighted average of the interest rates paid on current and saving deposits[6]. Since the data of marginal interest rates has a monthly basis, we take averages of the twelve monthly values available for each year to obtain yearly data.

Figure 2 characterizes the evolution of the distributions of the banks' interest rates of loans (panel A) and deposits (panel B). In both cases, we observe a decreasing trend that is

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5. With the minimum of five branches we exclude markets where banks have just an institutional presence (Spanish banks often have a representative office in large cities but without relevant retail banking activity). In the empirical analysis we find that the results are not sensitive to the threshold in the definition of the relevant market, like minimum number of branches equal to three.

6. The use of interest rates of loans and deposits for the transactions in year t has advantages over the more usual estimation of average interest rates equal to the interests charged on loans in year t divided by the stock of loans at the beginning of the period. The reason is that operating efficiency is calculated for year t so it is relevant for the transactions performed along that year. The ratio of flows over stocks combines values of the variables in the numerator and the denominator that result from transactions along several years.

parallel to the evolution of the interbank market interest rate, whose time trend has been very much affected by Spain joining the EMU in 1999. Average and median values of interest rates are similar in both loans and deposits although, in the case of loans, the median is slightly smaller than the mean in the years from 2002 to 2007, suggesting a fatter tail of the distribution of interest rates for higher values of the variable. The coefficient of variation shows an upward trend in both, loans and deposits, which indicates that the relative dispersion in banks' interest rates of loans and of deposits has been increasing over time. Since the standard deviation remains rather stable over time, the time trend observed in the coefficient of variation is due to the decreasing trend in average interest rates. In spite of the level of interest rates having steadily decreased over time, the relative differences with respect the average have become larger.

3.3 Volumes of loans and deposits per branch

The volumes of loans and deposits per branch of bank *i* in year *t* (L_{it} and D_{it}, respectively) are calculated dividing the respective stocks of loans and deposits at the end of year *t* by the number of branches of the bank at the end of *t*. The stocks of loans and deposits are valued at constant prices to control for time variations due to pure monetary effects. The constant prices calculation follows the permanent inventory approach with depreciation equal to zero and price inflation equal to the growth rate of the consumer price index.

The descriptive statistics of the volume of loans and deposits and per branch are shown in Table 1. Both have dramatically increased during the sample period. The average has been multiplied by a factor of 2.3 in the case of loans and by 2.4 in the case of deposits. The representative branch granted 35,850 thousands Euros of loans and collected 27,350 thousands Euros of deposits in 2007. The magnitude of this raise is replicated in all the percentiles of the distribution of loans and deposits (not shown), consistent with a general increment of the volume of loans and deposits per branch that shifts the distributions towards the right.

3.4 Economic profits per branch

Banks make decisions to maximize economic profits and if the decision unit is the bank branch then the economic profits in our analysis are expressed in profits per branch. Other papers measure profits in terms of rates of return (Bourke, 1989; Athanasoglou et al., 2008; Mirzaei et al. 2013)[7] but banks do not make decisions to maximize rates of returns but to maximize absolute profits.

Our estimate of economic profits is calculated from accounting profits with some adjustments. These adjustments consist on excluding expenditures in IT and advertising from the costs of the year and considering them as investment flows that are capitalized and depreciated yearly at depreciation rates proposed in the literature. In addition, the opportunity cost of equity, which is not considered as a financial cost in the calculation of accounting profits, is counted as a cost in the calculation of the economic profit[8] Economic profits are first calculated at the bank level. Next, the economic profits of the bank in year t are divided by the number of branches to obtain the economic profit per branch of bank *i* in year *t*.

7. One exception is Albertazzi and Gambacorta (2009) that use accounting profits in levels. Notice also that total assets or equity used in the calculations of ROA and ROE are themselves endogenous variables so their determinants will affect the calculated values of rates of return.

8. For a more detailed description of the calculation of economic profits of banks see Martín-Oliver et al. (2007).

Table 1 shows the evolution of the economic profits per bank during the sample period. Economic profits show a cyclical profile with negative average and median values until 1997 and positive afterwards. Figure 3 shows the frequencies distribution of economic profits per branch for all banks and years in the sample data. Figure 3A corresponds to the economic profits divided by the equity of the bank (relative economic profits) and Figure 3B to the volume of profits per branch. For both variables the mean and the median are centred on zero; on average for the whole time period and all banks, we observe that banks' net income just compensates for the opportunity cost of equity. This is consistent with a dynamics of branching that drives the industry economic profits to zero.

The empirical model about the dynamics of the branches of bank *i* in period *t* (Equation 14), includes as explanatory variable the "expected" profits per branch for year *t*+1 in the relevant market, denoted as $E\left(\frac{\Pi_{t+1}}{N_{t+1}}\right)$. Since banks can open new branches in any province of the country and we model the number of branches in the current market and in the potential new ones, the relevant market for the decision of expansion of branches is the whole national market. More particularly, we estimate $\frac{\hat{\Pi}_{t+1}}{\hat{N}_{t+1}}$ for the average bank of the whole banking industry in the following manner. The expected values of the numerator and of the denominator, $\hat{\Pi}_{it+1}$ and $\hat{N}_{it+1}$, are estimated separately for every bank and year using a panel-data model that relates the dependent variable with the lagged dependent variable, the interbank interest rate, the *GDP* growth and the inflation rate. Next, by aggregating at the country level the predictions for all the banks in each year, we obtain the series for the average bank in the whole banking industry, $\hat{\Pi}_{t+1}$ and $\hat{N}_{t+1}$. In order to assess the impact of the prediction error, we estimate $\hat{\Pi}_{t+1}$ and $\hat{N}_{t+1}$ using two approaches. First, we run the estimations every year using only the information available at *t*. And second, the estimations at every year are run using all the information of the whole sample period.[9]

Finally, we calculate the average economic profits per branch for the whole banking industry in year *t* (Π_{Mt}) dividing the sum of economic profits for all banks at *t* by the sum of the number of branches of all banks also at *t*. The average economic profit per branch for the whole industry is the relevant variable in equation [15].

3.5 Number of branches

The dependent variable in Equation [14] is the first-difference of the number of branches of bank *i* at *t*, ΔN_{it}. The variable number of branches for each bank and year is directly taken from the database on banks' statistics available at the Bank of Spain. Table 2 shows the evolution in the number of banks and some descriptive statistics of the number of branches. The number of banks has decreased over time, giving as a result higher market concentration at the bank level. However, the average number of branches per bank has dramatically increased. This raise in the number of branches affects all percentiles of the distribution, though the growth in larger banks is more acute: banks in the 25th and 50th percentiles of the size distribution present a cumulative growth rate in their number of branches of around 94%, whereas banks in the 75th percentile have a growth rate of 133%. The whole pattern of branches expansion reflects the

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9. The predictive power of both approaches is measured with a regression that relates the observed profits per branch with the individual predictions obtained from the two models. When the explanatory variable is the predicted profits per branch with perfect information (using all the observations of the sample), the R2 is 49.59%, whereas it is reduced to 5.8% when we use the profits estimated with sequential information. In both cases, when we aggregate the numerators and denominators, the average profits per branch follow a similar pattern than the observed profits.

growth of the network of branches triggered by the 1988 regulatory change, which removed all restrictions to the geographical extension of saving banks.

The market equilibrium conditions in interest rates of loans and deposits and in volumes of loans and deposits per branch depend on the number of branches in the relevant market. As indicated above, we define the relevant market for a bank as the sum of all the provinces where it has at least 5 branches. However the number of bank branches in each province is endogenous according to the model, since banks decide opening or closing branches in each province. To reduce the possible estimation biases we substitute the total number of branches from all banks in the relevant market, by an estimate of the size of the relevant market, equal to the sum of GDPs of each province that belongs to the relevant market of bank *i*, *GDPMarket*.

3.6 Other explanatory variables

The model presented in this paper assumes certainty and symmetric information in credit markets. In reality, uncertainty and information asymmetries exist and credit risk is a relevant variable in lending decisions by banks. Banks can differ in their willingness to take risk and invest in information to assess the credit worthiness of the borrowers. In order to account for the heterogeneity in the credit risk policy of banks in the sample, we add the variable ratio of loan loss provisions over total assets (i.e. *LLP/Assets*) among the explanatory variables in the models of determinants of interest rates of loans. Banks with higher loan loss provisions can be expected to take higher credit risk ex-ante and charge higher risk premium in the interests of their loans. Thus, we expect a positive effect of this measure of credit risk in the interest rate of loans.

For a given density of demand in the spatial market, higher volume of loans per branch also implies higher average distance between borrowers and bank branches in the particular market. If the information of lenders on the credit quality of the borrowers decreases with distance (Petersen and Rajan, 2002; Degryse and Ongena, 2005; Hauswald and Marquez, 2006; Agarwal and Hauswald, 2010) then one can expect that higher volume of loans per branch will be associated with higher credit risk, since higher volume implies higher average distance between borrowers and lenders. Thus, our empirical model for the volume of loans per branch includes the variable *LLP/Assets* as a explanatory variable to account for this effect. If we find a positive estimated coefficient of this variable, the result could be interpreted as evidence that distance matters for information and risk reasons too.

Other sources of heterogeneity among banks that are unobservable and time invariant are captured in the empirical model by time invariant fixed effects.

In the empirical model, we assume that the banks' differentiation perceived by consumers (parameter τ) is the same across markets and, thus, it is excluded from the list of the explanatory variables for interest rates and volumes of demand.

In some cases, the time dummy variables will be replaced by macro and other time-varying variables common to all banks. These include variables such as interbank interest rates, price inflation and GDP growth of the Spanish economy and the estimates of average productivity for the banking industry, A_t in [16].

4 Empirical models and results

4.1 Empirical models

The first group of empirical models correspond to the econometric formulation of equations [11], [12], [13], [14] and [15] that explain interest rates of loans and deposits, volume of loans and deposits per branch and economic profits per branch.

The empirical model on the determinants of interest rates is formulated as follows:

$$\begin{aligned} y_{it} &= \gamma_0 + \gamma_1 Id\,(Prodv. < 25^{th})_{it-1} + \gamma_2 Id\,(Prodv. > 75^{th})_{it-1} + \gamma_3 A_t + \\ &+ \gamma_4 \ln GDPMarket_{it-1} + \gamma_5 CV_t + \eta_i + v_{it} \end{aligned} \qquad [17]$$

The variable A_t is the average productivity of the industry at year *t* defined above; the size of the market *GDPMarket* replaces the number of branches in the relevant market to avoid endogeneity problems; the CV_t is a vector of time varying control variables. The control variables include the ex-post credit risk of bank *i* in year *t* calculated as the ratio of loan loss provisions over total loans $\frac{LLP_{it-1}}{Assets_{it-1}}$ (only for the interest of loans), and time varying variables such as the Interbank interest rate, the GDP growth rate and the consumer price index (Inflation). We expect that the coefficients of the variables that capture the relative productivity levels of bank *i* will have signs $\gamma_1>0$ and $\gamma_2<0$ for interest on loans and just the opposite signs for interest on deposits. The model also predicts a negative (positive) association between industry productivity and interest rates of loans (deposits): $\gamma_3<0$ (>0). Closer distance between branches in larger markets implies more intense competition, so we expect $\gamma_4<0$ (>0) in the equation of determinants of interest rates of loans (deposits). The effective transmission of monetary policy implies a coefficient of one for the interbank interest variable. For robustness purposes, equation [17] will be estimated replacing time varying variables by time dummy variables.

The empirical econometric model on the determinants of volumes of loans, deposits and economic profits per branch, is formulated as follows:

$$z_{it} = \delta_0 + \delta_1 Id\,(\text{Prodv.} < 25^{\text{th}})_{it-1} + \delta_2 Id\,(\text{Prodv} . > 75^{\text{th}})_{it-1} + \delta_3 \ln GDPMarket_{it-1} + D_t + \eta_i + v_{it} \qquad [18]$$

From the theory we expect $\delta_1<0$, $\delta_2>0$ and $\delta_3<0$ for all dependent variables. When the dependent variable is volume of loans per branch, we also include the variable $\frac{LLP_{it-1}}{Assets_{it-1}}$ in [18]. A positive estimated coefficient for this variable will support the hypothesis that the credit risk of the loan portfolio and the volume of loans per branch are positively correlated because of higher average distance between borrowers and lender.

All the previous empirical models contain banks fixed effects to control for the unobserved heterogeneity, η_i. Finally, v_{it} is the stochastic error term. All the variables are lagged one period to capture the effect of "at the beginning of the year" and limit the impact of potential endogeneity. The empirical models are estimated with instrumental variables including banks' fixed effects. The measures of relative productivity are instrumented with information of lagged market productivity.

The empirical model on the short-term evolution of branch opening and closing decisions [14] is formulated as follows:

[19]

$$N_{it} - N_{it-1} = \beta_1 + \beta_2 Id\,(Prodv. < 25^{th})_{it-1} + \beta_3 Id\,(Prodv\,. > 75^{th})_{it-1} + \beta_4 F\Pi_{t+1} + D_t + u_{it}$$

This model is estimated with the *GMM* technique. We consider the relative productivity of the bank and future profits as potentially endogenous. Since the dependent variable is an increment and contains information of *t*-1, we define as exogenous variables the lag *t*-2 of total assets, the lags *t*-2 and *t*-3 of the 25^{th}, 50^{th} and 75^{th} percentiles of the productivity distribution and time dummy variables. To assess the validity of the estimates, we provide the *p*-value of the test of over-identifying restrictions to test the consistency of the orthogonality conditions. We estimate the model with the two-step procedure computing robust standard errors using the Windmeijer finite-sample correction mechanism. According to the predictions of the model, we expect that banks with relatively lower productivity level will open a lower number of branches (β_2<0) while banks with relatively high productivity level will tend to open more branches (β_3>0). In parallel, the perspectives of higher future profitability will also lead banks to open new branches (β_4>0).

The third block of empirical estimates models the behaviour of the profit per branch of the banking system according to Equation [15]. We use panel data of profits per branch as dependent variable and the lagged dependent variable and time dummy variables as explanatory ones. The model will be estimated using the *GMM* technique using the *t*-2 and *t*-3 lags of the dependent variable and the time dummies as instruments. If the zero-profit convergence condition is satisfied then the constant and the coefficients of the time dummy variables should be equal to zero and the coefficient of the lagged dependent variable should be lower than one. Next, we estimate with the first-differenced *GMM* estimator using the lags t-3 and t-4 of the profits in levels, to account for the banks' fixed effects and test for conditional convergence.

4.2 Results of the estimation

4.2.1 TESTING PREDICTION *P1*

a. Determinants of interest rates of loans and deposits

The results of the estimation of different specifications of econometric model [17] on determinants of the interest rates of loans and deposits are shown in Table 3. In column (1), we report the estimated coefficients for the econometric model on loan interest rate. Results are in line with the predictions of the theoretical model (summarized at the end of Section 2). First, the interest rates of loans depend on the relative level of productivity of the bank and its competitors: consistent with the theory, banks in the lower tail of the distribution of productivity charge higher interest rates for loans than banks with average productivity. In particular, our estimations indicate that low-efficient bank-branches charge 110 basis points more to the interest rates of loans than the rest of banks. The estimated coefficient of the variable $Id\,(Prodv_i > p75^{th})$ is not statistically significant indicating that banks in the upper tail of the distribution of productivity do not charge lower interest rates than banks with average productivity.

The coefficient of the industry productivity variable (A_t) is negative and statistically significant (*p*-value<1%) as predicted in the theoretical model (equation [11]). The contribution of the industry productivity growth to the dynamics of the interest rates over time is equal to the estimated coefficient of the industry productivity variable multiplied by the observed growth rate in productivity reported in Table 2. Performing these calculations, the industry gains in productivity have resulted in an accumulated decrease of 1.5 percentage points in the interest rate of loans, and an accumulated increase of 0.5 percentage points in the interest rate of deposits during the 15 years of the sample period.

The negative and statistically significant (*p*-value< 1%) coefficient of the size of the relevant market (i.e. *GDPMarket*) is also consistent with the theoretical predictions. This result suggests that there is a higher density of branches in larger markets than in small markets. This implies that the distance between branches in large markets is smaller what, in turn, increases competition and lowers the average interest rates of the relevant loan market. Finally, the interest rates of loans also vary with the risk profile of the bank portfolios captured through the explanatory variable of the (*ex post*) credit risk ratio (i.e. loan provisions on assets). The estimated coefficient is positive and statistically significant at 10% level. This is the expected result if the *ex post* credit risk indicator is positively correlated with the *ex ante* credit risk perceived by banks at the time the loan is granted.

As for the monetary transmission mechanism, the coefficient of the interbank rate is positive and significant (*p*-value<1%). However, the estimated value of the coefficient is lower than 1, suggesting frictions in the transmission process. Finally, interest rates of loans are counter-cyclical as the estimated coefficient of the GDP growth is negative.

Column (2) of Table 3 shows the estimated coefficients for the model on the interest rates of deposits. As in the case of loans, part of the heterogeneity observed in the interest rates reflects differences in productivity across banks. Interests on deposits are 130 basis points lower for low-productivity banks than for the average bank (statistically significant at 1%). Interest rates are positively associated with the average industry productivity, with an estimated positive coefficient of 0.024. Next, the monetary transmission mechanism operates for deposits too (positive estimated coefficient for the interbank interest rate), though the estimated coefficient is lower than in the interest rate of loans, probably due to the heterogeneous composition of deposits (liquidity provision and savings vehicle). The estimated coefficient for the variable size of the relevant market is not significant and interest rates of deposits increase with inflation and decrease with the growth of GDP.

Columns (3) and (4) in Table 3 show the results when the common time varying effects are captured by time-dummy variables. The results are broadly consistent with those of columns (1) and (2), although banks interest rates are less sensitive to differences in productivity among banks. For deposits, the dummy of high-productivity banks, which pay an interest rate 30 basis points higher than the average bank, now captures the relative differences in productivity among banks.

The last two columns of Table 3 allow for differences in the monetary transmission mechanism as a function of the productivity of banks (low-productivity banks, high-productivity banks and rest of the banks). For this purpose, we add the interaction of the bank relative productivity dummy variables and the interbank interest rate as explanatory variables. For the loans, the estimated coefficient of the interbank rate is now higher (closer to one) than in column (1) while the coefficient of the interacted variable is negative for the low productivity banks. This means that banks with low productivity reduce the speed for translating changes in the monetary policy to the pricing of loans, creating market inefficiencies. The opposite occurs with the transmission to the interest of deposits, that is, less productive banks translate changes in the monetary policy to interest rates faster than more productive ones, probably because the former face stronger competition in the deposits markets from more efficient banks.

b. Determinants of loans, deposits and economic profits per branch

The estimations of econometric model [18] on the determinants of loans, deposits and economic profits per branch are presented in Table 4. From column (1), banks in the lower (upper) tail of the distribution of productivity get a lower (higher) volume of loans per branch: the coefficient of $Id(Prodv < P25^{th})$ is negative and the coefficient of $Id(Prodv > P75^{th})$ is positive, both significant at 1%. The negative estimated coefficient for the proxy of the size of the relevant market is consistent with the prediction that the demand per branch decreases with the intensity of competition (more bank branches in the market).

Ex post credit risk is positively correlated with the volume of loans per branch; since more loans per branch implies longer average distance between borrowers and the bank branch, then the evidence is consistent with the hypothesis that information asymmetries also affect the market equilibrium in the banks credit market. The argument that productivity increases both loans per branch and the average distance to borrowers implies that credit risk from information asymmetries should be higher in more productive than in less productive banks. As a robustness exercise, we test this assessment and estimate an econometric model using *LLP/Assets* as dependent variable and banks' productivity (both absolute and relative productivity measures) as explanatory variable. Estimation results confirm the positive and significant association between productivity and loan loss provisions, even when controlling for loans growth, time effects and bank effects.

When the dependent variable is the volume of deposits, column (2), the results show that banks in the lower tail of the distribution of productivity have a lower volume of deposits per branch (*p*-value<1%). The coefficient for the measure of the size of the market is negative and statistically significant (*p*-value<10%).

Finally, the column (3) of Table 4 shows the results for the model of economic profits per branch. The positive and statistically significant coefficient of $Id(Prodv > P75^{th})$ confirms that higher productivity is rewarded with higher economic profits. The economic profits per branch for high-productivity banks are, on average, 307,200 Euros higher than for the rest of the banks. Profits per branch decrease with the size of the relevant market, again, as expected from the theory.

Figure 4A represents graphically the estimated coefficients for the time dummy variables of the three estimations. The values of the estimated coefficients show the time evolution of the volume of loans, deposits and economic profits per branch after controlling for the effects of the other explanatory variables and capture industry and macroeconomic conditions common to all banks. Loans and deposits per branch are in logs and so are the time trend values (left scale). Economic profits per branch are in thousands of Euros. The time trend in loans grows at a relatively constant rate since 1996, when Spain started the nominal convergence to become member of the Euro zone and monetary conditions started to relax, with lower official interest rates. Deposits per branch grew at moderate rates until year 2000 and at higher rates after this year. The time trend of loans is above the trend in deposits from 2003 on, generating a liquidity gap that was financed with funds raised in wholesale markets. The time trend in profits per branch started at negative values and stayed in values around zero from 1996 to 2003, turning positive for the rest of the sample years.

Wrapping up, Tables 3 and 4 support the predictions of Prediction 1 of the theoretical model. These results confirm that the productivity of banks affects their interest rates of loans and deposits, as well as their volume of demand per branch. Higher productivity is associated with lower (higher) interest rates of loans (deposits) and higher demand for banking services. Higher productivity is rewarded with higher economic profits per branch. Interest rates of loans (deposits) are lower (higher) in larger markets, i.e. in markets with higher volume of demand for bank services. Demand per branch and economic profits per branch however, are negatively correlated with the size of the relevant market. The positive time trend in loans and deposits per branch over the period of study is consistent with a period of decreasing interest rates and unit margins: as the gross profit margin decreases, the volume of demand per branch must increase to break-even. During 2004-2007, average profits per branch turn positive and with positive growth rate. This could be explained because banks finance the liquidity gap with securitization and wholesale–market financing, which entail low or zero fixed-cost per branch.

4.2.2 TESTING PREDICTION *P2*

The second set of hypotheses refers to the determinants of the changes in the number of branches of individual banks, as formulated in econometric model [19]. Estimation results are reported in Table 5. They correspond to two specifications of the basic model, which has been estimated with two-step robust GMM. The specifications differ in the procedure used to estimate the expected industry economic profits per branch in period *t*+1. In column (1) they are estimated using the full sample information while the estimation in column (2) only uses information available at *t*-1. The statistical tests reject the null hypothesis of over-identifying restrictions

Results are very similar in both cases. The estimated coefficient for $Id(\text{Prodv}_i < p25^{th})$ is negative and significant (*p*-value <1%) and the coefficient for the forecasted economic profits per branch is positive and statistically significant (*p* value<1%). The empirical results confirm that expectations on industry economic profits per branch drive the expansion of the branch network for all banks and that the less productive banks, on average, expand their network in 15 branches per year less than the rest of banks.

Figure 4B shows that the estimated coefficients of the time dummy variables in the estimations of columns (1) and (2) of Table 5, which capture the year-industry average change in the number of branches. First, it is decreasing until 1998; then, it stabilizes around zero, until 2003 and, finally, it increases again until 2007. The comparison of Figure 4B and Figure 4A reveals that the average industry change in the number of branches in Figure 4B is negative during the years of negative economic profits per branch; they are around zero when average profits are also zero; and the average change in the number of branches is positive when average industry economic profits are also positive.

The contraction in the number of branches during the first period when the average industry economic profits are negative just indicates that the number of bank branches was too high and price competition intense. Under this situation, banks reacted reducing the stock of branches until the average profits reached a value close to zero. Then, the situation stabilized for several years, when profits remained around zero and the average change in the number of branches was also around zero. Starting in 2003, the profits per branch and the number of branches increased in parallel. In this period, the volume of deposits was lower than the volume of loans and Spanish banks relied on securitization and wholesale markets finance to close the liquidity gap (Figure 4A). The business model of Spanish banks changed and deposits collected by the branch network no longer were the only source of lending funds. The logic of more branches, more competition and lower profits broke down and economic profits per branch grew at the same time that the network of branches was expanding in an explosive way.

4.2.3 TESTING PREDICTION *P3*

We now test for the zero-profit condition for the banking industry using bank-level data. The results of the GMM estimation of equation [15] with time dummies and not controlling for banks' fixed effects are presented in column (1) of Table 6. The null hypothesis that the constant and the coefficients of the time dummy variables are all equal to zero cannot be rejected. In addition, we cannot reject the null hypothesis that the coefficient of the lagged dependent variable is smaller than 1 (p-value<5%). These results can be interpreted as evidence in favor of convergence of economic profits per branch towards zero for the Spanish banking industry. However, the large magnitude of the coefficient of the lagged dependent variable (0.86) implies a slow process of convergence, since it will take up to 7 years (1/(1-0.86)) converging to zero profits.

In the specification reported in column (2) that controls for unobserved heterogeneity including banks' fixed effects, the estimated coefficient for the lagged dependent variable is equal to 0.6, which is lower (p value <5%) than the estimated value in column (1). The magnitude of the difference between these two coefficients supports the hypothesis of conditional convergence. That is, we cannot reject that each bank converges towards an idiosyncratic level of economic profits per branch. The estimated speed of convergence is now faster, 2.5 year (1/(1-0.6)). Finally, in column (3), we show the estimation of the model of unconditional convergence allowing for different speed of adjustment in branch profits for the periods before and after the Euro. The estimated coefficient associated to the interaction term is not statistically significant and, thus, there is no evidence of a different speed of convergence between the pre- and the post-Euro years.

The estimated fixed effects in the model of dynamics in economic profits per bank-branch can be interpreted as an estimate of the long-term profits for a particular bank resulting from its unique competitive advantage (or disadvantage). The examination of these fixed effects gives additional insights on the characteristics of the industry dynamics. First, we compare the average value of the fixed effects of banks that survive until 2007 with that of banks that disappear because of M&A during the sample period. Results give an average profit of -100,700 Euros per branch for the banks that disappear and of 33,810 Euros per branch for those that continue in 2007. This difference is statistically significant (p value <1%). Therefore, as expected from the effects of competitive selection (Wheelock and Wilson, 2000), banks that leave the industry (61 out of 150) are those with negative expectations on long–term profits[10].

Second, we find that the average fixed effects of the 89 surviving banks is not statistically different from zero, so industry average profits remain around zero in the long-term. However, differences among continuing banks are not totally random, as we find that the estimated fixed-effects are positively correlated (correlation value of 32.2%, p-value $< 5\%$) with long-term estimated differences in productivity per branch-bank. Additionally, we find no significant differences between banks and saving banks. According to size categories, we find that, once differences in long-term productivity are controlled for, large banks are only slightly (10,000 Euros per branch) more profitable in the long run than medium and small banks (p value <10%). Therefore, the evidence suggests that permanent differences in economic profits per branch-bank are tied to idiosyncratic characteristics of banks, not particularly related to size or ownership, the same that cause permanent differences in productivity. Finally, the fact that some banks that survive in 2007 have estimated fixed effects negative and significant indicates that the survival of these banks is at risk.

10. Mergers and acquisitions will imply transfers of banking operations from less efficient to more efficient banks, lowering costs and interest rates, according to the model. Since our operating and competition unit is the bank-branch, mergers and acquisitions are not expected to affect the market power or collusive behavior of banks. Erel (2011) finds evidence that mergers of banks reduce interest rates of loans but only while the cost savings effects dominate the market power effects, so market structure also matter as a determinant of the interest rates of loans.

5 Conclusion

This paper models the static and dynamic Nash equilibrium in interest rates, market shares, and economic profits of banks competing in spatially differentiated markets, with free entry and exit of branches. The equilibrium values of these variables are explained as a function of bank-branch productivity. Productivity is obtained from the estimation of the production function of bank services, in which labor and IT capital are considered variable inputs and the capacity of the bank-branch is considered a fixed input. The predictions of the theoretical model posited in the paper are tested with data from Spanish banks. Both, the theoretical model and the empirical results confirm that productivity is an important driver of the observed heterogeneity in prices, market shares and profits of banks. The results also confirm that the (Nash) competition among banks (including entry of new branches) translates productivity differences (across banks) and productivity growth (over time) into benefits for the banks' clients.

A remarkable empirical finding of this paper is that the productivity gains of the banking industry are translated into changes in the interest rates of loans and deposits. During the 1993-2007 period, an increase of one point in the productivity of the Spanish banking industry implied a reduction (increment) in the interest rates of loans (deposits) of around 3.1 basis points (1.1bp). Since the estimated average annual rate of productivity growth was around 3.0% (Table 2), loan interest rates decreased an average of 9.4 bp per year (1.41pp accumulated during the whole period). For deposits, productivity growth translates into a yearly increase of 3.48 basis points in the interest rates (0.52pp accumulated during the sample period). Social benefits from lower intermediation costs in the Spanish banking industry occur at the same time that the industry undertakes a process of concentration with a substantial reduction of the number of banks. This confirms the relevance of the bank-branch competition to explain the industry performance.

One lesson from the paper is that positive gross profit margins (as, for example, the Lerner index higher than zero) can be compatible with competitive market conditions (i.e., zero long-run economic profits in the bank industry) if banks have fixed operating costs from their branch network. In fact, the market power resulting from differentiation among banks (i.e., spatial differentiation) is necessary to earn gross profits and to cover the fixed costs.

The structural change of the dynamics of bank-branches in Spain after the Euro can be explained (at least in part) by changes in the operating conditions of banks. Once in the Euro, the available deposits collected through the branch network no longer act as a constraint to grant bank loans. The reason is that the Euro granted the access of Spanish banks to international wholesale and interbank markets. In this new scenario, differences in productivity at the bank-branch level are less important to determine the competitive advantage of banks. The reason is that banks are less and less dependent of their network of branches and, as a consequence, spatial competition becomes less important to explain the growth rate of banks' activity.

Results of the paper open several lines of future research. The preliminary evidence found in the paper supporting a positive association between credit risk and the volume of loans per branch as well as between credit risk and the productivity of banks, suggests that credit risk increases with average distance what is expected under imperfect information. Then one extension of the spatial competition model should be explicitly extended to account for information asymmetries in the credit market and how they interact with distance between borrowers and lenders in determining the interest of loans and the credit risk of the portfolio of loans. Another extension of the paper is in modeling the equilibrium in the number of branches in each spatial market (province in our case) from entry and exit decisions by banks, which will require modeling the profit opportunities in each regional market. Finally, it will be interesting to examine how differences in the productivity of banks before the crisis conditioned the performance of banks in the years of the crisis, in terms of survival, need of public aid, etc.

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APPENDIX

Table A1. Definition of the variables used in the analysis

Raw Productivity	It is calculated as the difference between the observed and the predicted output. We estimate the parameters of the production function for the representative technology at the branch level production function as in Martín-Oliver et al. (2013) following a production approach. Inputs of the production function are labour, IT and physical capital services and output is multiple including the collection of deposits. Raw productivity is decomposed in the sum of three components as follows: Raw Productivity$_{it}$=A_t+X_{it}'γ+A_{it}. Where A_t denotes the average productivity for the whole banking industry, the vector of control variables (X_{it}) accounts for other sources of heterogeneity different from productivity and, as a residual, productivity of bank i in year t denoted as A_{it}. It is expressed in logs.
Banking industry productivity	The average productivity for the whole banking industry in year *t* (A_t) is the coefficient associated to the time dummy that takes value 1 if the observation belongs to year *t* in the regression of raw productivity on a set of time dummies and a vector of control variables. It is expressed in logs.
Total Factor Productivity	It is also refered in the paper as "productivity" of firm i in year t is obtained as a residual (A_{it}) in the regression of raw porductivity on a set of industry dummy variables and a vector of control variables. It is expressed in logs. We define two dummy variables that classify banks according to their relative level of productivity: *Id(Prodv $_i$ <p25 th)* and *Id(Prodv $_i$ >p75 th)*
Id(Prodv $_i$<p25 th)	Identifier of high relative productivity that takes value 1 if the bank's productivity in yeart is under the 25th percentile of the distribution of productivity of bank *i*'s competitors in its relevant markets and zero otherwise.
Id(Prodv $_i$>p75 th)	Identifier of low relative productivity that takes value 1 if the bank's productivity in yeart is higher than the 75th percentile of the distribution of productivity for competitors of bank i in its relevant markets and zero otherwise.
Relevant market of bank i	The relevant market for bank *i* is composed by all the provinces in which the bank has at least 5 branches.
Size of the relevant market (GDPMarket)	It equals to the sum of GDPs of each province that belongs to the relevant market of bank i.
Balance sheet and income statement control variables	Information on variables such as ,total Assets, Equity , Loans, deposits, accountant profits and interest rates is collected from the financial statements that Banco de España records for regulatory and supervisory purposes. Stock variables have been transformed to be expressed at replacement costs.
Number of branches	It is drawn from the Branches Registry of Banco de España, which contains the location of all bank branches in Spain at the municipal level. For every bank and year, we consider the total number of branches.
Profits per branch	We consider economic profits, which are first calculated at the bank level. Next, the economic profits of the bank in year *t* are divided by the number of branches of the bank at the end of year t to obtain the economic profit per branch of bank i in year t. The measure of economics profits is calculated from accounting profits after i) adding expenditures in IT and advertising, which are considered as investment flows and, consequently, must be substracted from the accountant costs of the year ii) substracting the opportunity cost of equity (not considered as a financial cost in the calculation of accounting profits).
Expected profits per branch	Expected values of the numerator (economic profits) and the denominator (number of branches) are calculated separately for every bank and year. Then, predictions for every bank and year are aggregated at the country level in each year to obtain the series for the average bank for the whole banking industry. Finally, we divide the aggregates of the expected economic profits at time t and of the number of branches at time t, to obtain the prediction of the average economic profits per branch for the whole banking industry in year t. Forecasts of future (economic) profits per branch in period t+1 and of the number of branches in period t+1 are computed in two alternative manners: 1) using all the information of the sample available at time t; 2) using the information available until time t-1.
Loans (deposits) per branch	The stock of loans (deposits) are valued at constant prices following the permanent inventory method, with depreciation equal to zero and price inflation equal to the the growth rate of the consumer price index. The stock of loans (deposits) is divided by the number of branches of the bank ante the end of the year.
Interest rates of loans (deposits) for bank i in year t	We consider the interest rates charged by banks in new loans and deposits (marginal interest rates) . Average of 12-monthly data for a given year.
LLP/Assets	It is a measure of expost credit risk defined as the flow of loan loss provisions over the volume of loans, both for bank i at the end of year t.
Real GDP growth	Annual growth rate of teal GDP
Interbank rate	Real Interbank rate defined as 12-month nominal interbank interest rate minus inflation rate.
Inflation	Annual growth rate of the consumer price index.

Table 1. Descriptive statistics of economic profits, volume of loans and volume of deposits per branch

	Average	Median	Std. Dev.	Average	Median	Std. Dev.	Average	Median	Std. Dev.
	Economic Profit per Branch			Volume of Loans per Branch			Volume of Deposits per Branch		
1992	-276.8	-38.12	649.3	15,848	5,673	31,644	11,386	7,674	13,840
1993	-243.8	-40.95	590.2	16,873	5,425	32,959	12,308	7,740	16,651
1994	-279.2	-26.19	664.2	17,042	5,866	33,823	13,134	7,869	18,158
1995	-292.4	-27.62	655.7	18,923	6,056	38,072	14,391	7,976	21,260
1996	-177.6	-17.65	540.8	18,233	6,634	35,790	15,304	8,539	22,413
1997	-178.5	4.575	571.3	20,260	7,255	36,854	15,780	9,213	21,319
1998	-128.6	32.28	601.6	21,944	8,129	38,302	16,565	9,525	22,945
1999	-146.7	44.02	617.3	21,855	8,476	37,353	15,435	9,502	20,319
2000	-162.2	28.13	658.8	21,392	9,344	34,273	18,436	10,378	23,476
2001	-160.3	22.72	661.2	22,823	9,915	36,865	21,114	11,468	26,673
2002	-134.0	22.63	594.5	23,496	11,005	36,087	22,474	12,412	27,255
2003	-163.3	15.45	622.7	25,488	12,538	38,299	21,346	12,792	26,543
2004	-98.96	19.73	547.3	27,442	14,058	38,609	22,189	13,617	26,902
2005	-51.08	21.53	472.5	30,019	17,005	38,298	24,338	15,224	27,931
2006	-14.93	34.08	490.5	33,063	18,733	38,519	26,532	16,666	28,014
2007	40.90	40.94	365.7	35,854	20,620	39,944	27,347	17,685	28,102

Note: All variables expressed in thousands of constant Euros of 1992.

Table 2. Number of banks, number of branches and time varying explanatory variables

	No. of banks	Number of Branches		LLP/Assets (x100)		GDP Market (m€)		Real Interbank	GDPG	Inflation	Industry Productivity
		Average	Std. Dev.	Average	Std. Dev.	Average	Std. Dev.				
1992	143	223.0	454.9	0.744	0.804	108,666	76,048	7.38%	0.9%	3.54%	7.457
1993	141	221.9	421.4	0.899	1.087	117,501	81,636	6.34%	-1.0%	5.92%	7.526
1994	137	231.8	431.2	0.794	1.194	132,704	90,454	3.73%	2.4%	4.57%	7.485
1995	138	236.5	445.1	0.450	0.673	152,969	103,965	5.32%	2.8%	4.72%	7.510
1996	133	250.6	475.2	0.327	0.353	170,017	112,879	3.80%	2.4%	4.67%	7.533
1997	131	260.3	496.1	0.214	0.196	185,808	123,377	3.23%	3.9%	3.56%	7.606
1998	125	280.0	535.4	0.183	0.246	222,033	139,640	2.17%	4.5%	1.97%	7.607
1999	121	290.6	595.1	0.307	0.874	250,224	153,124	0.84%	4.7%	1.83%	7.598
2000	113	309.7	663.0	0.320	0.366	284,424	177,583	1.33%	5.0%	2.31%	7.682
2001	108	319.1	653.7	0.366	0.351	323,247	199,831	0.48%	3.6%	3.43%	7.669
2002	103	332.4	650.3	0.391	0.422	369,641	217,734	0.42%	2.7%	3.59%	7.729
2003	97	353.4	674.4	0.474	0.819	411,952	240,666	-0.69%	3.1%	3.07%	7.704
2004	94	377.6	695.4	0.330	0.276	451,631	262,814	-0.73%	3.3%	3.04%	7.728
2005	93	395.4	727.3	0.303	0.264	529,902	298,693	-1.03%	3.6%	3.01%	7.784
2006	92	416.2	757.0	0.305	0.218	614,128	339,968	-0.08%	3.9%	3.37%	7.886
2007	90	443.1	792.1	0.376	0.289	706,662	376,953	1.66%	3.8%	3.52%	7.914

Table 3. Estimation of equations [11] and [12]: Determinants of interest rates

Dependent Variable:	(1) Loan Interest Rate	(2) Deposit Interest Rate	(3) Loan Interest Rate	(4) Deposit Interest Rate	(5) Loan Interest Rate	(6) Deposit Interest Rate
$Id(Prodv.<P25^{th})_{t-1}$	0.011 **	-0.013 ***	0.009 **	-0.004	0.015 **	-0.018 ***
	(0.005)	(0.004)	(0.004)	(0.002)	(0.007)	(0.006)
$Id(Prodv.>P75^{th})_{t-1}$	0.003	-0.006	0.002	0.003 *	0.006	-0.009
	(0.004)	(0.004)	(0.004)	(1.760)	(0.007)	(0.006)
Industry Productivity	-0.031 ***	0.011 *			-0.033 ***	0.014 **
	(0.008)	(0.006)			(0.008)	(0.006)
Interbank x $Id(Prodv.<P25^{th})_{t-1}$					-0.283 **	0.346 ***
					(0.141)	(0.118)
Interbank x $Id(Prodv.>P75^{th})_{t-1}$					-0.190	0.193 *
					(0.132)	(0.111)
LLP / $Assets_{t-1}$	0.081 *		0.074 *		0.084 *	
	(0.046)		(0.045)		(0.044)	
ln(GDP Market)	-0.004 ***	-0.001	-0.004 ***	0.000	-0.003 ***	-0.001
	(0.001)	(0.001)	(0.001)	(0.640)	(0.001)	(0.001)
Interbank rate	0.732 ***	0.667 ***			0.857 ***	0.528 ***
	(0.030)	(0.024)			(0.075)	(0.061)
GDP Growth	-0.004 ***	-0.003 ***			-0.005 ***	-0.003 ***
	(0.000)	(0.000)			(0.000)	(0.000)
Inflation	0.745	0.433 ***			0.740 ***	0.437 ***
	(0.045)	(0.027)			(0.044)	(0.026)
No. of obs	1456	1479	1461	1487	1456	1479
R^2	88.74%	88.84%	89.29%	92.95%	88.87%	92.95%
Fixed Effects	YES	YES	YES	YES	YES	YES
Time dummies	NO	NO	YES	YES	NO	NO

Note: Standard Errors in parentheses. Standard Errors robust to heteroskedasticity and clustered at bank level. (***)=significant at 1%, (**)=significant at 5%, (*)=significant at 10%

Table 4. Estimation of equation [18] for the determinants of the demands of loans and deposits per branch and of the economic profits per branch.

Dependent Variable:	(1) Loans per Branch	(2) Deposits per Branch	(3) Profits per Branch
Id(Prodv.<P25th)$_{t-1}$	-0.584 ***	-0.576 ***	-8.320
	(0.166)	(0.181)	(138.7)
Id(Prodv.>P75th)$_{t-1}$	0.405 ***	0.114	307.2 ***
	(0.126)	(0.127)	(119.1)
LLP / Assets$_{t-1}$	7.953 **		
	(3.260)		
ln(GDP Market)	-0.086 **	-0.062 *	-55.612 **
	(0.034)	(0.033)	(26.23)
No. of obs	1525	1525	1525
R^2	85.75%	78.96%	61.61%
Fixed Effects	YES	YES	YES
Time dummies	YES	YES	YES

Note: Standard errors in parentheses. Standard errors robust to heteroskedasticity and clustered at bank level. Estimation with instrumental variables. Instrumented variables: Identifier of low relative productivity, Id(Prodv.<25th), and identifier of high relative productivity, Id(Prodv.<25th). Instruments: Percentile 25th, 50th and 75th of the distribution of competitors' productivity. Time dummy variables represented in Figure 4A (***)=significant at 1%, (**)=significant at 5%, (*)=significant at 10%

Table 5. Estimation of equation [19] on the growth in the number of branches

Dependent Var:	(1) ΔBranches	(2) ΔBranches
$Id(Prodv.<P25^{th})_{t-1}$	-15.210 ***	-15.223 ***
	(4.447)	(4.464)
$Id(Prodv.>P75^{th})_{t-1}$	-5.693	-5.510
	(3.514)	(3.360)
Profit per $Branch_{t+1}$	0.082 ***	0.0690 ***
	(0.017)	(0.018)
Overidentifying restrictions (*p*-value)	0.482	0.751
Time Dummies	YES	YES
No. of obs	1462	1462

Note: Standard Errors in parentheses. Estimation (1): Forecast of profits per branch computed using all the information of the sample. Estimation (2): Forecast for *t*+1 computed with the information available until *t*-1. Estimation with two-step *GMM,* standard errors robust computing Windmeijer finite-sample correction. List of instruments: log of total assets in *t*-2, productivity from *t*-2 to *t*-4 and time dummy variables (represented in Figure 4B). Instruments: Percentile 25th, 50th and 75th of the distribution of competitors' productivity. (***)=significant at 1%, (**)=significant at 5%, (*)=significant at 10%

Table 6. Estimation of [15]: Time dynamics of economic profits per branch

	(1)	(2)	(3)
Ec Profit $_{t-1}$	0.861 ***	0.602 ***	0.600 ***
	(0.060)	(0.093)	(0.097)
Id (year>1999)xEc Profit $_{t-1}$			-0.130
			(0.096)
CONTROL FIXED EFFECTS?	NO	YES	YES
TIME DUMMIES	YES	YES	YES
No. of obs	1690	1527	1527

Note: Standard Errors in parentheses. Estimation (1) and (3) estimated with *GMM*-panel data techniques without controlling for bank fixed effects. Instruments: dependent variable lagged at *t*-3 and *t*-4 and time-dummy variables. Estimation (2) controls for fixed-effects using *GMM*, differentiating the dependent variable and using as instruments the lags *t*-3 and *t*-4 of the level of profits. (***)=significant at 1%, (**)=significant at 5%, (*)=significant at 10%

Figure 1. Distributions of productivity

A. All Banks

B. Own and Competitors' productivity

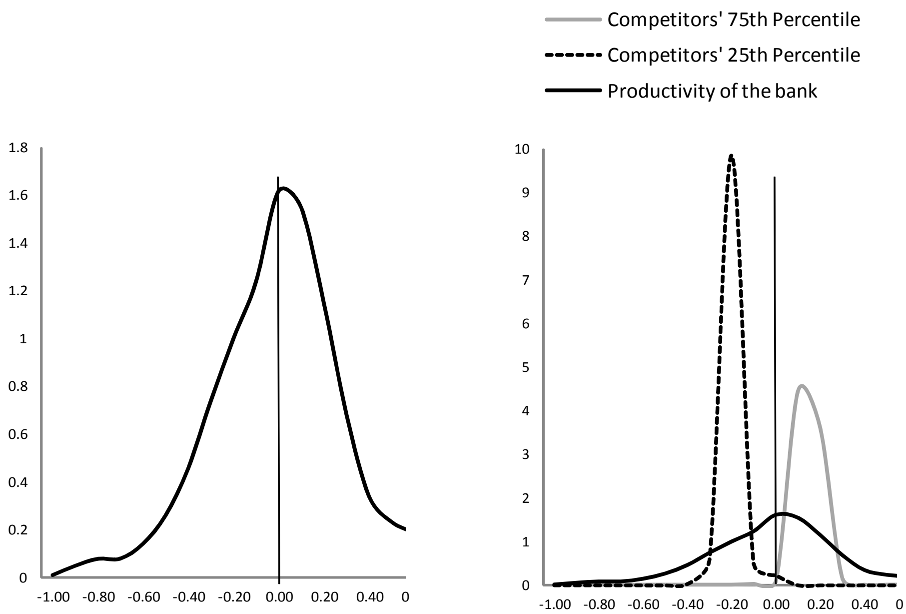
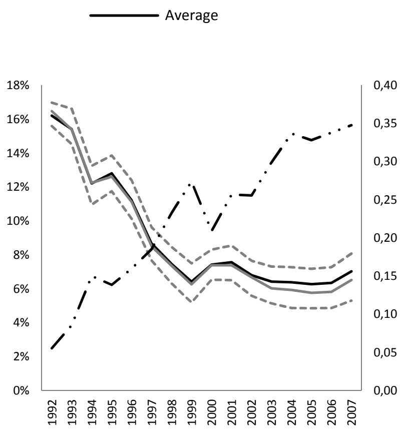


Figure 1A presents the distribution of our measure of productivity, Ait. Values are centered around zero because they come from the residuals of regression (16). Figure 1B presents presents the distribution of productivity for the banks that are located below the 25th percentile and above the 75th percentile of the total distribution of productivity

Figure 2. Evolution of the bank-level distribution of interest rates over time in the banking industry

A. Loan Interest Rates



B.Deposit Interest Rates

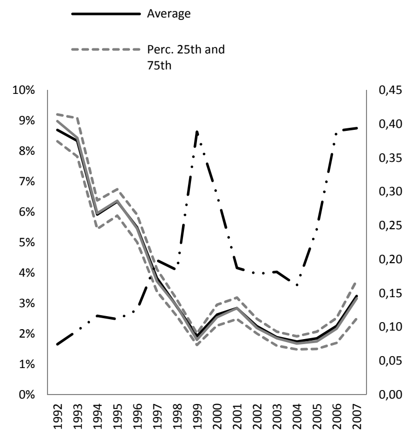
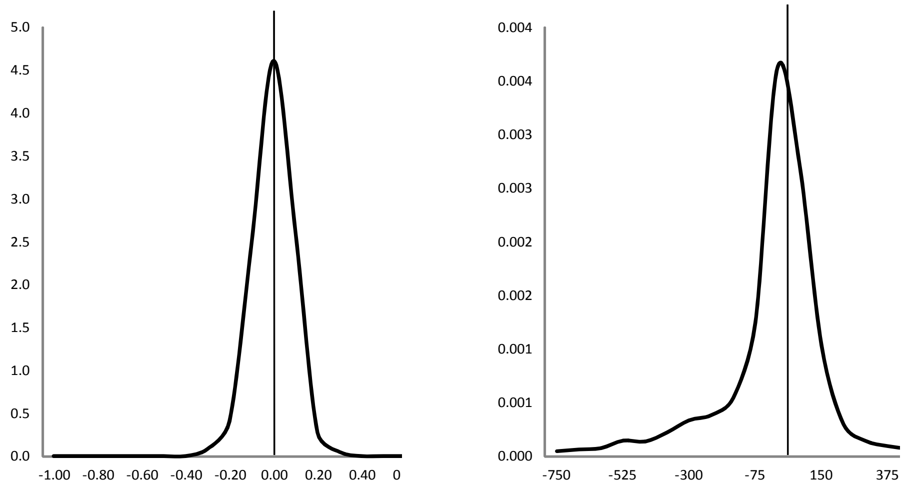


Figure 2A (2B) present the evolution of the average, median, 25th percentile and 75th percentile of the marginal loan (deposits) interest rates quoted by banks during a given year. It also present the coefficient of variation (ratio of standard deviation to average)

Figure 3. Industry distribution of the rate of return and the economic profits per bank-branch

A. Economic profits on equity **B. Economic profits per branch**



Note: Units in terms of 1 in the x-axis

Note: th€ in the x-axis

Figure 4. Estimated values of coefficients for time dummies

A. Time dummies from Table 4:

Demand and profits per branch

B. Time dummies from Table 5:

Growth of branches

Figure 4A (4B) present the value of the time dummy variables obtained from the estimation presented in Table 4 (Table 5)

Table A1. Definition of the variables used in the analysis

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