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2010

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Documentos de Trabajo
N.º 1008

BANCO DE **ESPAÑA**
Eurosistema

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(*) This paper is the sole responsibility of its author and the views represented here do not necessarily reflect those of the Banco de España. I am grateful to Vicente Salas for guidance and insights and to Javier Mencía and Jesús Saurina for their helpful comments. This paper has also benefited from the comments of the participants in the 7th International Industrial Organization Conference, 36th EARIE conference and EFMA Meeting in 2009.

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Documentos de Trabajo. N.º 1008
2010

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ISSN: 0213-2710 (print)
ISSN: 1579-8666 (on line)
Depósito legal: M. 14141-2010
Unidad de Publicaciones, Banco de España

Abstract

This paper examines the nature of competition in the Spanish banking industry during the years before and after Spain joined the European Monetary Union (EMU). The paper models competition in a product-differentiated market where banks choose from a list of price (interest rates of loans and deposits) and non-price variables (branches, advertising, IT capital). The empirically estimated demand and cost functions are used to simulate the values of the endogenous variables of the representative bank in response to the historically low official interest rates of the post Euro period. The results show that there has been a convergence in the levels of price competition in the loans and deposits markets during the post Euro period. Additionally, the paper finds that branches have lost weight in the mix of competition variables in benefit of advertising and IT capital. This is interpreted as evidence that traditional *proximity banking* is evolving towards *distant banking*. Finally, the simulation results highlight the high imbalances between loans and deposits for the representative bank in the regime of low official interest rates of the Euro zone.

Keywords: banking competition; product differentiation; intangibles; simulation.

JEL codes: G21, D24.

1 Introduction

One of the most visible consequences for Spain of joining the European Monetary Union (EMU) was the relaxation of the monetary conditions. As a result, the interbank interest rate fell from an average of 11.75% to 3.93% during the eight years prior and after the integration, respectively. Coinciding with the new monetary conditions, Spanish banks expanded the volume of credit at a higher rate than the volume of deposits and relied on the money markets (including the interbank market) to close the gap. Another less visible change in the Spanish banking industry during the post Euro period has been the evolution of the mix of competition variables. In this respect, the Information Technology capital (advertising capital) per branch has risen from a median of 68.84 (13.1) thousands Euros at constant 1983 prices in the 1988-1996 pre Euro period to 85.23 (14.1) thousands Euros in the 1997-2003 period. Additionally, the density of branches decreased from 0.94 in 1997 (when Spain was about to join the Euro) to 0.92 in 2003. The purpose of this paper is to examine the response of the Spanish banks to the new monetary conditions created by the Euro and to the developments in the banking technology and in the consumers' behaviour, taking advantage of a rich database on expenditures in advertising and IT capital at bank level. The analysis will answer to what extent distant banking might be substituting proximity banking around a dense branching network, in Spain and elsewhere.

The theoretical part of the paper models the behaviour of banks that operate in product-differentiated markets of loans and deposits and it assumes that each bank makes competition decisions in price (interest rates) and non-price [advertising, information technology (IT) and branches] variables. On the demand side, the paper assumes that banks' services are differentiated and that customers choose the bank as a utility-maximizing, discrete-choice problem. Consumers' decisions are determined by three differentiating, observable attributes: price (interest rate for loans and deposits), advertising capital and physical capital from the investment in branches. The derivation of the demand functions is based on Berry (1994) and Berry et al. (1995), that provided the methodology to estimate demand functions that result from discrete consumer choices using market share data. On the supply side, loans and deposits are jointly produced with two variable inputs, the combination of labour and services from IT capital, and one quasi-fixed input, the size of the branch [Martín-Oliver and Salas-Fumás (2008)]. Then, a Nash equilibrium solution is obtained for each and all of the decision variables.

The empirical part of the paper presents the estimates of the parameters of the production function and of the market demand functions for loans and deposits obtained for data of Spanish banks during the period 1988-2003. One relevant feature of our data is that the interest rates of loans and deposits used in the estimation are those charged by banks in the current time period (year) and not the average of past and present interest rates, as it has been the case in previous research. Finally, the estimated parameters and functional forms are used to simulate the optimal response of the representative bank in the choice of interest rates and other non-price competition variables in order to respond to changes of the exogenous variables of the model. The different scenarios might simulate a change in the monetary policy (that affects the official interest rate) or the tightening of the credit conditions in the money markets (that increases the price of equity), as it has been the case in the recent crisis.

Competition in retail banking has been widely investigated in both, the traditional structure-performance paradigm and in the new behavioural approaches.[1] Among papers that study banking competition in product-differentiated markets, some consider only price competition in either the deposits [Hannan and Berger (1991)] or in the loans market [Scholnick (1999), Jaumandreu and Lourences (2002), Dell' Ariccia (2001)]; others only non-price competition [Kim and Vale (2001), analyze the number of branches]; and others model both competition on price and non-price variables [Pinho (2000); on price, advertising and branches in deposits markets; Carbó et al. (2005), on price and number of branches in loans and deposits markets]. However, the analysis of banking competition under the lens of product heterogeneity and price and non-price competition has not received as much attention as in other industries. The common factor of the papers in banking is that they based their analysis on *(ad hoc)* demand functions that are not derived from a buyers' behavioural model or require of strong assumptions to reduce the number of substitution parameters across products or firms that are to be estimated[2]. In contrast, this paper postulates demand functions for loans and deposits derived from multiple choice decisions by bank customers and expands the list of decision variables of banks to jointly include IT capital, advertising capital and number of branches, in addition to interest rates.

Only recently there have been papers that model the demand of banking services as a discrete choice of consumers [Adams (2007), Knittel and Stango (2008), Dick (2008), Ishii (2005), Ho (2010)][3]. However, none of these papers uses marginal interest rates to estimate price elasticities and they do not model price and non-price competition with such a wide range of decision variables in both the loans and the deposits markets as it is done in this paper. In addition, the paper jointly estimates the parameters of the cost function of banks together with the parameters of the demand function and the first order equilibrium conditions. Therefore, the parameters of the cost function are estimated under the double condition that the estimated cost function fits the data on total operating costs of the bank and that the marginal revenue has to be equal to the marginal cost. Previous research either estimates the cost function separated from the demand and first order conditions [Carbó (2005)], or estimates the parameters of cost only considering the condition of marginal cost equal to marginal revenue [Ho (2010); Ishii (2005)].

The sample period is divided in two sub-periods, 1988-1996 and 1997-2003 that corresponds to the years before and after Spain prepared and actually became a full member of the EMU. The model is then estimated for each sub-period to test for the stability of the structural parameters of the model that determine the profits of banks and, consequently, the level of effective competition in each sub-period. The empirical model to be estimated consists on a system of simultaneous equations of demand and cost functions, together

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1. Smirlock et al.(1984), Rhoades (1985), Berger and Hannan (1989), Corvoisier and Gropp (2002) are some representative papers that focus on the Structure-Performance and estimate the relation between bank profits and market concentration among other explanatory variables. The New Empirical Industrial Organization approach [Bresnahan (1989)], inspires the work on market power of banks by Molyneux et al. (1994), Claessens and Laeven (2004) who measure market power from the estimate of the *H* statistic of Panzar-Rosse. Shaffer (1993), on the other hand, measure market power of US and Canadian banks from the estimate of the mark-up proposed by Bresnahan and Lau (1982). Martin-Oliver et al. (2006) provide measures of market power from the calculation of the Lerner index of individual banks. These empirical models do not postulate a full competition model with price and non-price competition variables.

2. Bresnahan (1989) and Berry (1994) document that in product-differentiated frameworks the number of cross-effects to be estimated, increases at a larger pace than the number of firms.

3. Research from non banking industries includes Besanko et al.(1998) who estimate a logit demand equations for the markets of catsup and yogurt in the US; Villas-Boas and Winer (1999) consider the introduction of brand choice also in the catsup and yogurt markets; Nevo (2001) measures the level of market power in the ready-to-eat cereal industry; Petrin (2002) quantifies the consumer welfare benefits from the introduction of new products. Barroso (2008) evaluates the dynamic effect of the increasing demand of a new product as the consumers become aware of its existence.

with the profit-maximizing conditions for each competition variable that determine the Nash equilibrium solution of the industry [Besanko et al. (1998); Chintagunta et al. (2006)]. The system is estimated with the non-linear *GMM* estimator using instruments to take care of the potential endogeneity of interest rates in the estimation of the demand of banking products.

The results show that Spanish banks had market power during the whole sample period in both loan and deposit markets (demand functions of loans and deposits are price inelastic). Market power of banks can be explained in part by the product differentiation effects induced by advertising capital and the network of branches. The incorporation of Spain into the EMU changed the competitive conditions of the banking industry: the absolute value of the price elasticity increased in deposits and decreased in loans. As a result, the market power of banks in loans became higher than in deposits. In the second part of the sample period the marginal return from advertising capital (branches) is higher (lower) than in the first part of the period, what suggests a translation from a banking based on *proximity* to a *distant* banking, where assets such as IT or advertising increase their weight in the competition mix at the expense of branches.

The simulation exercise of changes in the monetary conditions reveals that a decrease in the interbank interest rate raises the contribution of loans to total profits and lowers the contribution of deposits. The results of the simulation also show that a fall in the interbank rate generates a gap between the balance of loans and deposits that is consistent with the gap observed in Spanish banks in recent years of unusually low interbank rates, a gap that had to be filled with market-supplied funds.

The rest of the paper is organized as follows. Section 2 presents the basic theoretical model of the profit-maximizing bank. Section 3 contains a description of the database and the methodology applied in the estimations. Section 4 presents the results of the estimation of the model and simulations and robustness tests. Finally, Section 5 presents the conclusions that summarize the main results of the paper.

2 The model

2.1 Consumer behavior

The model assumes that the buyers' relation with banks extends to two different products: loans and deposits. Consumers choose a single bank for each of these two products and their choice is based on a utility-maximizing, discrete-choice problem that takes into account the different observable attributes of banks. The theoretical setup assumes that the choice of the bank for loans and deposits is made separately (no grouping of products) and at every point in time (without taking into account prior relationships), though the empirical estimation will consider potential correlations across choices. In this way, our framework for the demand functions will be at least as good as those papers that consider only one output component, but with some advantages such as the consideration of both output components in the cost equation and the joint estimation of all the demand and cost functions, which will be later analyzed in more detail.

The derivation of the demand functions is based on Berry (1994) and Berry et al. (1995) that provided the methodology to estimate demand functions that result from discrete consumer choices using market share data. Consumers choose among all the banks to obtain loans, deposits (and possibly other services) in a utility-maximizing way, where utility is a function of price (decreasing) and also a function of the stock of advertising capital (increasing) and of the number of branches (also increasing). Then, under certain assumptions[4], [Berry (1994)] the aggregated demand functions of each output component faced by banks can be written as the log of its market share (logit functions)[5]:

$$\ln s_i - \ln s_0 = x_i \beta - \alpha\, p_i + \xi_i \qquad (1)$$

where s_i is the market share of bank *i* with respect to the size of the potential market *M*; s_0 is the proportion of the total consumers that does not buy any product (outside good); p_i is the price (interest rate) quoted by the bank, x_i is a vector of observable attributes of bank *i* that increase the consumers' utility observable (basically, number of branches and advertising capital) and ξ_i stands for the unobservable characteristics of bank *i*. The advantage of allowing for an "outside good" is that consumers are not forced to choose from the one of the alternative banks so demand will not depend on the difference of prices across alternatives, but on the levels themselves [Berry (1994)]. In this way, a generalized increase in the prices of all the firms is consistent with a fall of the total demand because a proportion of consumers prefer to purchase the outside good (not to buy). In the case of loans and deposits, the outside good will refer to sources of funds or investment opportunities that consumers

4. The assumptions are: i) no random coefficients (β is constant across costumers); ii) the distribution of consumer preferences identically and independently distributed across products and consumers with the extreme value distribution function; and iii) mean utility of the outside good normalized to zero.

5. There has been advances in the IO literature [Berry et al. (1995)] that aim to relax the cross elasticity patterns derived from the logit model that imply that products are differentiated only through their mean utility levels. The use of nested logits or random coefficient models aim to allow for interactions between product and consumer characteristics so as to avoid that, for instance in the car market, a luxury car and a subcompact car do have the same cross-elasticity with a third car if they have the same market shares. This paper assumes that elasticities do not vary depending on potential groups that could be identified, though it has been considered in previous papers on banking (listed versus non-listed banks (Ho, 2010); multi-state banks versus banks that operate in a single state [Dick (2008)]; thrifts versus banks [Adams (2007)].

can find out of the banking markets. From these demand equations, the price (e) and non-price (Σ) elasticity are:

$$e_{jk} = \frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j} = \begin{cases} -\alpha p_j(1-s_j) & \text{if } j=k \\ \alpha p_k s_k & \text{otherwise} \end{cases} \qquad \Sigma_{jk} = \frac{\partial s_j}{\partial x_k}\frac{x_k}{s_j} = \begin{cases} \beta x_j(1-s_j) & \text{if } j=k \\ -\beta x_k s_k & \text{otherwise} \end{cases} \quad (2)$$

2.2 Banks' production and profit-maximizing conditions

The basic modelling for the production function of banks is taken from Martín-Oliver and Salas-Fumás (2008) with some extensions. The activity of banks consists on granting loans, *L*, and the collection of deposits, *D*. In their activity, banks deploy four different types of resources: labor *(N),* IT capital *(IK),* branches *(B)* and advertising capital *(CK).* Banks finance their loans and operating capital stocks with equity *(E),* deposits *(D)* and the balances borrowed / lent in the interbank market *(BO*, positive or negative). The balancing equilibrium constraints are formulated as follows:

$$p_K K + p_{IK} IK + p_{CK} CK + L = BO + D + E \quad (3)$$

$$E = p_K K + p_{IK} IK + p_{CK} CK + aL \quad (4)$$

where $p_K K = Bk_b$, being k_b the euros invested per branch , *B* is the number of branches and p_K, p_{IK}, p_{CK} are the market purchase prices of one unit of service from the respective capital asset. Equation (3) assures that total assets are equal to total liabilities. Equation (4) assumes that the amount of equity for the representative bank is equal to the amount invested in operating assets plus a fixed positive proportion *a* of the stock of loans determined by the regulatory framework or exogenously set by the bank above the minimum regulatory requirements[6].

Banks operate in a product-differentiated market and offer a bundle of two different outputs, Loans and Deposits. Bank *i* faces a demand function for each output component at year *t*, $L_{it}(r_t^l; B_t, CK_t)$, $D_{it}(r_t^d; B_t, CK_t)$ that depends on the vector of interest rates quoted by the bank *i* ant its competitors and on the vector of the number of branches and advertising capital of bank *i* and its competitors. More concretely, the demand of loans depends negatively (positively) on the interest rate charged by the bank (the competitors) and the demand of deposits increases (decreases) as the own (competitors') interest rate also increases. On the other hand, we consider that banks deploy Advertising Capital *(CK)* and Branches *B)* as value-enhancing components of the demand that aim at increasing the final value of the banks' product, so the demand of loans and deposits both increase (decrease) with the own (competitors') stock of each value-enhancing asset.[7]

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6. Equation (4) could be formulated assuming that regulatory capital is set equal to a proportion of the total assets (loans plus tangible and intangible assets) of the bank, i.e. 8% according to Basel I. This would imply that the financial opportunity cost of tangible and intangible assets will be equal to the weighted average financial cost of interbank finance and equity finance, but the basic model would not change. The equation is written as equality because the cost of equity is higher than the interbank rate; thus, in the optimal solution, banks will choose the minimum equity required.

7. This assumption is in line with the findings of Martín-Oliver and Salas-Fumás (2008). They classify the resources depending on how they contribute to the generation of value differentiating between inputs (increase the production) and value-enhancing resources (increase demand). They find that IT capital, Labor and the physical space provided by branches are inputs of the banks' production function and that the number of branches and advertising capital are value-enhancing resources.

On the production side, we follow Martín-Oliver and Salas-Fumás (2008) and assume that the banks' output is produced under a Leontieff production function that combines the services of two set of inputs: on the one hand, the services from labour and services from IT capital and, on the other hand, the services of a quasi-fixed input, the physical space of the branch. The space of the branch does not limit the volume of operation and the production is done under constant returns to scale in labour and IT capital. Under these assumptions, empirically validated in Martin-Oliver and Salas-Fumás (2008), the total output of the bank can be written as the product of the output per branch times the number of branches. In this paper it is assumed that the aggregate output of the bank can be expressed as a weighted product of Loans and Deposits, so the production function will be written as,

$$\text{Output} = L^{z_1} D^{z_2} = F(N, IK) \quad (5)$$

where z_1, z_2 are the exponential weights to be empirically determined.

Banks pay market prices and opportunity costs for the inputs used in production. The interbank market interest rate is given by r^{ib}, while the cost of equity financing is given by c^o, that we assume to be greater than the interbank rate to account for a positive risk premium asked by the shareholders. The market salary that compensates workers is *w* and the user's costs of capital (financial opportunity cost plus depreciation) for each asset of the bank are given by c_K, c_{IK}, c_{CK}, for physical, IT and advertising capital, respectively.

Taking into account (3), (4) and (5) and the rest of assumptions listed above, we can write the expression of banks profits. The model will assume that the interbank market allows banks to separate loans from deposits in the problem of banks. Then, each bank is assumed to maximize its profits with respect to prices, production inputs and demand-enhancing resources:

$$\max_{r_{it}^l, r_{it}^d, B_{it}, CK_{it}, IK_{it}, N_{it}} \pi_{it} = \left(r_{it}^l - m_{it}\right) \cdot L_{it}^d\left(B_t, CK_t, r_t^l\right) + \left(r_t^{ib} - r_{it}^d\right) \cdot D_{it}^d\left(B_t, CK_t, r_t^d\right)$$
$$- c_{K,it} p_K k_b B_{it} - c_{IK,it} p_{IK} IK_{it} - c_{CK,it} p_{CK} CK_{it} - w_{it} N_{it}$$
$$s.\text{ to } \quad F\left(\text{IT}_{it}, N_{it}\right) = G\left(L_{it}^d, D_{it}^d\right) = \left(L_{it}^d\right)^{z_1}\left(D_{it}^d\right)^{z_2}$$

Banks obtain gross margins from loans and deposits. For loans, the unit gross margin, is the difference between the interest charged by the bank, r_{it}^l, minus the opportunity unit cost of lending $m_{it} = r_t^{ib}(1-a) + a \cdot c_{it}^o + rp_{it}$. The opportunity unit cost of lending includes the cost of regulatory equity (each Euro of loans consumes *a* units of bank's equity that costs c_{it}^0); the cost from the interbank market, $r_t^{ib}(1\text{-}a)$; and finally an ex-ante estimate of the credit risk of the loan[8], rp_{it}. Super-index *d* in *L*, *D* stands for demand function. Net economic profits are equal to the gross profits minus the operating capital and labor costs. These profits are maximized subject to the production technology with multiple outputs $F\left(\text{IT}_{it}, N_{it}\right) = G\left(L_{it}^d, D_{it}^d\right) = \left(L_{it}^d\right)^{z_1}\left(D_{it}^d\right)^{z_2}$ in (5).

8. The calculation of the ex-ante credit risk is explained in Section 3.

The profit maximization problem has an embedded cost minimizing problem linked to the costs of the inputs that enter into the production function[9]. Assuming a Cobb-Douglas aggregation function for inputs in the production function, the cost problem has the form:

$$\min_{IK_{it},N_{it}} C_{it} = c_{IK,it}\, p_{IK}\, IK_{it} + w_{it} N_{it}$$
$$s.\text{to} \quad F(\mathrm{IT}_{it}, N_{it}) = \mathrm{IT}_{it}^{\ \kappa} N_{it}^{\ 1-\kappa} = L_{it}^{\ z_1} D_{it}^{\ z_2}$$

where C_{it} stands for the total operating costs and κ, $1-\kappa$, are the elasticity of the total output to the IT capital and labour inputs, respectively, under the assumption of constant returns to scale in the production function [in line with the findings in Martín-Oliver and Salas-Fumás (2008)]. The resulting dual cost function that represents the total operating costs of the bank depends on the output produced and on the price of the resources deployed as follows[10,11]:

$$\ln C_{it} = \kappa_0 + \kappa \ln c_{IK,it} + (1-\kappa)\ln w_{it} + z_1 \ln L_{it} + z_2 \ln D_{it} \qquad (6)$$

And the profit maximizing model is modified to

$$\max_{r_{it}^{l}, r_{it}^{d}, B_{it}, CK_{it}} \pi_{it} = \left(r_{it}^{l} - m_{it}\right)\cdot L_{it}^{d}\left(B_t, CK_t, r_t^{l}\right) + \left(r_t - r_{it}^{d}\right)\cdot D_{it}^{d}\left(B_t, CK_t, r_t^{d}\right)$$
$$- C_{it}\left(L_{it}^{d}, D_{it}^{d}\right) - c_K p_K k_b B - c_{CK} p_{CK} CK_{it}$$
$$s.\text{to} \quad \ln G_{it}^{s} = z_0 + z_1 \ln L_{it}^{d} + z_2 \ln D_{it}^{d}$$

The First Order Conditions *(FOC)* obtained from the maximization with respect to interest rates, branches and advertising capital define the necessary conditions for the Nash equilibrium solution of the game. The *FOC* with respect to the loan and deposit interest rates or *price equations* are[12,13]:

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9. The number of branches are not included in the cost-minimization problem in spite of being also production inputs because, once the total number of workers and the amount of IT capital are chosen, the number of branches are determined straightforward because of the Leontieff production technology.

10. Note that the sum of the *z*'s does not necessary adds up to 1, since we only impose constant returns to scale at the input level, without imposing further restrictions to the combination of loans, deposits and commissions that make up the output.

11. It could be argued that a translog cost function or the Fourier functional form constitute a better fit to the actual operating costs. However, we prefer this expression since we intend to obtain sharp effects of every variable on costs to relate them with the rest of equations in the system, and the high number of parameters to be estimated in the translog form (exponentially increasing with the number of inputs and outputs) results in sometimes less precise estimates of the input and output effects.

12. Appendix A presents the analytical derivation of the *FOC*.

13. The price equations in (7) can be easily rearranged to obtain the well-known result $\frac{r_{it}^{l} - m_{it} - \frac{\partial C_{it}}{\partial L_{it}}}{r_{it}^{l}} = \frac{1}{e_l}$; $\frac{r_t^{ib} - r_{it}^{d} - \frac{\partial C_{it}}{\partial D_{it}}}{r_{it}^{d}} = \frac{1}{e_d}$, that is, the net relative profit margin (the so-called Lerner index) is equal to the inverse of the absolute value of the price elasticity.

$$r_{it}^{l} = \left(1 - \frac{1}{e_l}\right)^{-1} \cdot \left(m_{it} + \frac{\partial C_{it}}{\partial L_{it}}\right) \quad ; \qquad r_{it}^{d} = \left(1 + \frac{1}{e_d}\right)^{-1} \cdot \left(r_t^{ib} - \frac{\partial C_{it}}{\partial D_{it}}\right) \qquad (7)$$

where e_l and e_d are the price elasticity of the demand of loans and the demand of deposits; $\frac{\partial C_{it}}{\partial L_{it}}, \frac{\partial C_{it}}{\partial D_{it}}$ are the marginal operating costs of loans and deposits, which under the assumptions of the model are equal to $z_1 \cdot \frac{C_{it}}{L_{it}}$ and $z_2 \cdot \frac{C_{it}}{D_{it}}$. The second set of optimality conditions refer to profit maximizing conditions for advertising capital *(CK)* and number of branches (*B*) (i.e. the value-enhancing inputs that enter into the demand function)

$$v_l \frac{\Sigma_{L,B}}{e_l} + \cdot(1 - v_l)\frac{\Sigma_{D,B}}{e_d} = \frac{c_{K,it}\, p_K k_b B_{it}}{r_{it}^{l} L_{it}^{d} + r_{it}^{d} D_{it}^{d}} \qquad (8)$$

$$v_l \frac{\Sigma_{L,CK}}{e_l} + \cdot(1 - v_l)\frac{\Sigma_{D,CK}}{e_d} = \frac{c_{CK,it}\, p_{CK} CK_{it}}{r_{it}^{l} L_{it}^{d} + r_{it}^{d} D_{it}^{d}} \qquad (9)$$

where $v_l = \frac{r_{it}^{l} L_{it}}{r_{it}^{l} L_{it} + r_{it}^{d} D_{it}}$; $v_l = 1 - v_d$; $\Sigma_{J,R}$ is the elasticity of output demand *J* with respect to *K* and e_l, e_d are the price-elasticity of loan and deposit demands.

These *FOC* conditions on the optimal advertising and branch capital coincide with those from the well-known Dorfman-Steiner (1954) conditions (originally formulated for advertising expenditures). Equations (8) and (9) imply that it is optimal for a bank to increase their assets deployed up to the point where the user's cost of the advertising capital / number of branches (marginal cost) is equal to the respective marginal revenue generated from such expenditures for a given price. The marginal revenue, in turn, is equal to the weighted average of the absolute margin obtained for every unit of additional output in loans and deposits times the elasticity of the demand of the respective output component to the stock of advertising / number of branches. For both loans and deposits, the profit margin per unit of output is equal to the inverse of the price elasticity [equation (7)], when all variables evaluated at the optimal values. The weights are the contribution of each output component to the total income.

Notice that the model assumes that banks set the optimal level of branches and advertising capital at the same time as prices. Therefore, the model does not contemplate dynamics in the decision of which is the optimal number branches and stock of advertising capital. In this framework, (8) and (9) have to be interpreted as the conditions that maximize the profits of the bank in the long run, that is, once all the adjustment costs necessary to move from one equilibrium to the next have been satisfied.

3 Data sample and estimation methodology

3.1 Database

The database used for the empirical analysis comes from the population of Spanish commercial and savings banks in the period 1988 to 2003. We have a sample of 200 different banks that represent 95% of the assets of Spanish banking system; the rest belong to the credit cooperatives, for which most of the data needed are not available, and to small banks with a proportion of assets smaller than 0.1% of the system. The raw data from accounting statements of banks have been transformed to obtain an estimate of the replacement cost of the book valued assets. A systematic methodology is applied to obtain the user cost of capital for each asset and bank over time. Martín-Oliver, Salas and Saurina (2007) provide a detailed description of how the variables used in this analysis have been constructed; we present a summary of the methodology in Appendix B.

This paper also uses data on total operating economic costs of banks that will be used for the estimation of the parameters of the production function (from duality). The information on prices is obtained from the data of *marginal* interest rates of loans and deposits made during every year. Most often, the only data available for researchers are the ratios between the flows of revenues or interest payments from the income statement and the stock of accounts reported in the balance sheet. As opposed to this, the interest rate data used in this paper are actual interest rates charged by the bank in the new operations made during every year. Finally, the paper also uses data on the credit risk of loans from the Spanish Credit Register to construct the risk premium that is a part of the marginal cost of loans. The risk premium is estimated as a function of the probability of default of the banks' loans times the estimated average loss given default [see Martín-Oliver et al. (2006)]. In the model, banks are assumed to estimate the risk premium for loans granted at every year *t* using standard time series econometric techniques and all the information available from 1986 (first year of information of the Credit Register) until *t*. We assume that regulatory requirements imply that banks need 8% of equity for each euro of total assets, so we set a =0.08.

Table 1 presents the descriptive statistics of the two components of banks' output, i.e. loans and deposits at constant Euros of 1983. We observe that the number of banks has decreased during the sample period from 151 in 1988 to 80 in 2003, mainly due to mergers and acquisitions. In the empirical estimations, banks that result from a merge are considered as new entities. The outstanding amount of loans has been multiplied by 3 during the period, increasing at an average annual rate of 8.58% and 15.80% in the 1988-1996 and 1997-2003 time periods, respectively. The balance of deposits has also increased but at a smaller pace (average growth rate of 8.32% in 1988-1996 and 12.56% in 1997-2003); therefore the increase of the loan activity has been funded through other sources than deposits (bonds, securitizations, ..,). Differences in growth rates for each output have modified the output mix of the banks over time from 40.1% of loans and 59.9% of deposits in 1988, to 47.9% and 52.1%, in 2003, respectively. Table 1 also presents the descriptive statistics of the market share of loans and deposits computed with respect to the *potential market*, whose definition is explained in Section 3.2.1.

Table 2 shows the descriptive statistics of the explanatory variables that will be used in the analysis for the two time periods that will be separately estimated, 1988-1996 and 1997-2003. The average bank has managed to increase its size in all the resources deployed in their activity: number of workers (31.9% more in 1997-2003 than in 1988-1996), number of branches (234 in the first period and 359 in the second), IT capital (the stock of this input more than doubled) and Advertising capital (43.82% of growth between the two periods). On the other hand, the total operating costs have also increased (78.9% of growth between 1988-1996 and 1997-2003) mainly due to the larger bank size and the wider amount of resources deployed, as the input prices have been kept either constant (wages) or have decreased (user cost of capital). Finally, the interest rates of loans and deposits have also dropped due to the fall in the interbank rate that is the reference for these markets. Nonetheless, part of the drop of loan interest rates is due to the fall of the risk premium embedded in the price of loans (average yearly growth of -0.59% in the first period and of -7.67% in the second period) that can be attributed to better screening and monitoring of borrowers, as well as improvements in risk measurement and management.

3.2 Empirical model and estimation

The model that we estimate consist on a non-linear system of seven equations that includes two demand equations (1), the cost function (6), the pricing equations for loan and deposit interest rates (7), the branch equation (8) and the advertising equation (9).

3.2.1 DEMAND EQUATIONS

The two demand equations are formulated according to (1) for the case of demand of banking services. The demand for each bank depends on the interest rates, the number of branches and the advertising stock[14]:

$$\ln s_{it}^{l} - \ln s_{ot}^{l} = \beta_0^{l} + \alpha_l \ln r_{it}^{l} + \phi_l \ln B_{it} + \gamma_l \ln CK_{it} + Time\ dummies + \xi_{it}^{l} \qquad (1.1)$$

$$\ln s_{it}^{d} - \ln s_{ot}^{d} = \beta_0^{d} + \alpha_d \ln r_{it}^{d} + \phi_d \ln B_{it} + \gamma_d \ln CK_{it} + Time\ dummies + \xi_{it}^{d} \qquad (1.2)$$

where super-indexes *l* and *d* in s_{it} refer to loans and deposits, respectively. The expected relationship between interest rate and output is negative in the case of loans ($\alpha_l < 0$) and positive for deposits ($\alpha_d > 0$). Next, we expect a positive contribution of the number of branches and the stock of advertising capital on every output demand ($\phi_j, \gamma_j > 0; j \in \{l, d\}$). Finally, we have included time dummies to control for a potential cyclicality of the ratio of bank products demand to the outside good demand.

Equations (1.1) and (1.2) define the market shares of loans and deposits for bank *i* at time *t*. However, there are some issues that need to be addressed to perfectly define the extent and scope of the demand faced by each bank:

Relevant Geographic Market. The range of banks in the consumer' choice gathers the whole population of Spanish banks. Although it may seem more reasonable to assume that consumers choose among banks operating in their local geographical markets, empirical analysis of the Spanish banking system suggests that the hypothesis of a single national market is a reasonable one for the purpose of the paper. First, the concept of "local bank" can be blurred in Spain because most of the banks have expanded across

14. We consider that the indirect utility function depends on the log of the interest rate of loans in order to obtain a constant price elasticity that does not depend on the level of the quoted interest rate [see Nevo (2001)].

the 50 Spanish provinces: in 2003, 92.2% of banks operate in more than one province, 63.8% in more than 5 provinces, 21.6% in more than 25 and 12.8% in 45 provinces or more. Second, the average number of banks per province in 2003 was close to 40 (out of 90) in 2003 (around 30 in 1988), so even if consumers chose only among local suppliers, the latter would represent a large proportion of the national population of banks. In addition, Martín-Oliver, Salas and Saurina (2007) provide evidence supporting that Spanish banks apply the same pricing policy in all the provinces where they operate and suggest that there is no segmentation across geographical regions, what points towards a relatively integrated national market. Also, Carbó et al. (2005) estimate price and non-price elasticities (interest rates and branches) for Spanish banks distinguishing between separate regional markets and a single national market for loans and deposits and they do not find significant differences between estimations.

Relevant consumer and relevant activity. It is assumed in the paper that banks heterogeneity lies only on the quoted interest rates and on their non-price attributes; but this would be wrong if banks geared their activity to the retail/wholesale business or if they were focused on households or firms. In Spain, the latter scenario is not realistic because banks are almost exclusively focused on retail banking, and their activity provide services to households and firms without any significant specialization[15].

Size of the potential market. Previous work in the IO literature assumes that the potential market for a product or service is equal to the total population of the geographical region [Berry et al. (1995) for car markets; Nevo (2001) for ready-to-eat cereal industry]. In banking, Adams et al. (2007) consider the potential size of the deposit market to be equal to the number of household multiplied by the average number of deposit accounts per household. Nonetheless, this measure could be biased if the number of active bank accounts that are no longer operative by costumers differs across banks[16]. In this paper we will assume that the potential size of the market is equal to the sum of the financial operations that take place through the banking market and also the non-banking market, where no banks are part of the transactions (outside good). To determine the potential size of the loan market we have information of the Spanish firms' balance of banking and non-banking loans[17] and we make the assumption that the relation between non-banking loans and banking loans available for firms can be extrapolated to the rest of sectors. Thus, the potential size can be proxied as $M_l = L_B \cdot \frac{F_B + F_{NB}}{F_B}$, where L_B is the total balance of banking loans and F_B, F_{NB} are the balances of banking and non-banking loans for firms.

15. The average of the distribution of the weight of loans to households accounts for the 45.85% of the loans granted to the private sector in 2003 (the rest are loans to firms), with an standard deviation of 22.8%, being the 10th percentile equal to 29.3% and the 90th percentile equal to 82.9%. Among the loans to households, the average of the distribution of the weight of mortgages was 58.59%, with a standard distribution of 25.6%, a 10th percentile of 8.9% and a 90th percentile of 82.5%.

16. There might be different incentive policies within banks that penalize employees that close deposit accounts of customers and, to avoid it, they maintain the account open, but with no balance and operations.

17. Information obtained from *SABI*, a database of balance sheets items of Spanish non-financial firms.

For deposits, we take as potential size of the market, M_d, the total balance of financial assets held by households according to the Spanish Financial Accounts published by Banco de España. This approach to estimate the potential market would be in line with Dick (2008) and Ishii (2005) that consider non-banking deposits as part of the total potential market.[18]

3.2.2 COST FUNCTION

The second component of the system of equations to be estimated comes from the cost function presented in (6):

$$\ln C_{it} = \kappa_0 + \kappa \ln c_{K,it} + (1-\kappa)\ln w_{it} + z_1 \ln L_{it} + z_2 \ln D_{it} + Time\ Dummies + \xi_{it}^{c} \quad (6.1)$$

where ξ_{it}^{c} is the error component with zero mean. We impose the restriction that the sum of the coefficients of the log input prices has to be equal to 1, as derived from the duality between the production and the cost function. The values of z_1 and z_2 give the contribution of each component to the aggregate output of the bank and they do not have to be restricted to sum up to 1. Appendix B provides an explanation of how the user costs of capital are calculated.

3.2.3 FIRST ORDER CONDITIONS

The last block of equations to be included in the joint estimation comes from the profit maximizing conditions (7), (8) and (9) on interest rates, the stock of branches and the stock of advertising capital. The reason to include them in the estimation is twofold: first, they guarantee that the coefficients estimated are consistent with the profit-maximizing behavior assumed in the model[19] and, second, the conditions will be formulated so that we can test whether or not the observed values of the decision variables are consistent with the profit maximizing behavior. Substituting the expressions for the marginal operating costs for loans and deposits from equation (6), $z_1 \frac{C_{it}}{L_{it}}$ and $z_2 \frac{C_{it}}{D_{it}}$, and substituting the respective price elasticity (2) calculated from the demand equations, the *FOC* (7) can written as follows:

$$r_{it}^{l} - \left(1 - \frac{1}{\alpha_l \left(1 - s_{it}^{l}\right)}\right)^{-1} \cdot \left(m_{it} + z_1 \frac{C_{it}}{L_{it}}\right) + \delta^{l} + \varepsilon_{it}^{l} = 0 \quad (7.1)$$

$$r_{it}^{d} - \left(1 + \frac{1}{\alpha_d \left(1 - s_{it}^{d}\right)}\right)^{-1} \cdot \left(r_t^{ib} - z_2 \frac{C_{it}}{D_{it}}\right) + \delta^{d} + \varepsilon_{it}^{d} = 0 \quad (7.2)$$

Proceeding in a similar manner the *FOC* (8) and (9) can be written as:

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18. In order to check the sensitiveness of the results under a change in the measure of *M*, alternative measures of *M* have been considered and the results presented in this paper did not change significantly. Among them, I considered that the banking market was equal to a fixed proportion over time of the whole potential market equal to the average number of loans and the number of current accounts over time per household (around 80%). This approach is in line with Adams (2007), that obtains the potential size of the deposit market multiplying the number of deposits accounts per household and the number of households. The model was estimated considering that the potential size was 1/0.8 of the banking market and also 1/0.7 and 1/0.5. As said, the estimated coefficients remain fairly constant.
19. This procedure is similar to Besanko et al. (1998), that also estimate demand functions imposing the pricing equations implied by the Nash equilibrium behavior of firms in the yogurt and catsup market.

$$\frac{c_{K,it}\, p_K k_b B_{it}}{r_{it}^l L_{it}^d + r_{it}^d D_{it}^d} - \left(v_l \frac{\phi_l}{\alpha_l} + v_d \frac{\phi_d}{\alpha_d} \right) + \delta^b + \varepsilon_{it}^b = 0 \tag{8.1}$$

$$\frac{c_{CK,it}\, p_{CK} CK_{it}}{r_{it}^l L_{it}^d + r_{it}^d D_{it}^d} - \left(v_l \frac{\gamma_l}{\alpha_l} + v_d \frac{\gamma_d}{\alpha_d} \right) + \delta^a + \varepsilon_{it}^a = 0 \tag{9.1}$$

The intercepts $\delta^l, \delta^d, \delta^b, \delta^a$ and the residuals $\varepsilon_{it}^l, \varepsilon_{it}^d, \varepsilon_{it}^b, \varepsilon_{it}^a$ of the respective equations are added to the first order conditions to allow for possible deviation of profit maximizing behavior of banks. The equations 7.1, 7.2, 8.1 and 9.1 will be included in the estimation and it will return an estimation of the value of the intercepts. The distribution of the intercepts will depend on the distribution of the coefficients of the demand and cost equations and it will provide a test for the profit maximizing behaviour of banks: if we perform a Wald test of statistical significance of the intercepts $\delta^l, \delta^d, \delta^b, \delta^a$ and it cannot reject the null hypothesis that the value is non-different from zero, then the hypothesis of profit maximization in the choice of the respective decision variable will not be rejected. On the other hand, if the test rejects the null hypothesis, it will imply that the observed values of the respective decision variable are not consistent with profit maximizing behaviour.

3.3 Estimation methodology

The error term of the demand equations includes, among other components, the unobserved bank characteristics of loans and deposits. Interest rates $\left(r_{it}^l, r_{it}^d\right)$ are correlated to these characteristics $\left(\xi_{it}^l, \xi_{it}^d\right)$ because, in spite of being unobservable for the researcher, they are observable for both banks and consumers (quality of consumer service, reputation, solvency and soundness of the bank, etc). This endogeneity biases the *OLS* coefficient of the interest rate in both loans and deposits towards zero, underestimating the own price elasticity. The equation of the operating costs can present also potential biases due to endogeneity because it includes as regressors the *quantity* of loans and deposits produced by each bank, that are determined jointly with the operating costs. To cope with this problem, the estimation will be based on the definition of a set of orthogonality conditions derived from the assumption that ξ is mean independent of some set of exogenous instruments. For the estimation of the demand equations, Berry, Levinsohn and Pakes (1995) provide instruments (*BLP* instruments) that have been generally adopted in the literature. Let $z = (z^l, z^d, z^c)$ be the set of instruments to be used, where z^l, z^d, z^c are the instruments for demand of loans, demand of deposits and operating costs, respectively. For the demand of loans and deposits, we use the same set of instruments $(z^l = z^d)$, that include the price of the inputs used in production (wage of workers, opportunity cost of capital), the average number of branches across competitors and the average stock of advertising capital across competitors.[20] Moreover, we also add the average stock of IT capital and the net revenues of commissions in z^l, z^d as cost shifters that will affect the interest rate quoted by the bank. The set of instruments for the operating costs equation, z^c, contains again the wage of workers, the opportunity cost of capital, the average of the wage paid by competitors[21] and the net commissions. Additionally, the stock of advertising capital and the number of branches are also added in z^c because their cost is not included in the operating cost equation (it only includes IT capital and labour expenses), but they are related to the output of the bank through the demand side. Finally, z^c also contains the number of workers per branch

20. Papers that use the BLP instruments also include the observed characteristics of the product in the set of instruments. However, in our case these variables are endogenous in the model because they are included in the set of decision variables of the banks' problem (branches and advertising capital) and are left out of the instrument set.

21. We also included the average opportunity capital of competitors, but it proved to be highly collinear with the rest of instruments.

(proxy for the average size of branches) to account for additional banks' differentiation at the branch level in terms of quality of service, variety of services, etc. Summing up, we have a set of orthogonality conditions defined from the equations of demand and costs and we add the four *FOC* from the maximization problem of banks (7.1), (7.2), (8.1), (9.1):

$$\Lambda = \begin{bmatrix} z'_l \, \xi^l \\ z'_d \, \xi^d \\ z'_c \, \xi^c \\ 4 \;\; FOC \end{bmatrix}$$

With the definition of the orthogonality conditions, the two-step *GMM* estimator is the vector $\theta = \{\theta^l, \theta^d, \theta^c\}$ that solves the problem

$$\min_{\theta} \Lambda' A_N^{-1} \Lambda$$

where A_N is a consistent estimate of $E(\Lambda\Lambda')$ obtained from a preliminary suboptimal *GMM* estimator where $A_N = z'z$. The overall goodness of the estimations will be evaluated through the validity of the moment conditions (Sargan test of over-identifying restrictions).

4 Results

4.1 System of equations: Demand, cost and FOC

4.1.1 OLS VERSUS IV-GMM

The results of estimating the system of equations are presented in Table 3. The model has been estimated for two different time periods, 1988-1996 and 1997-2003 in order to analyze the effects and implications on competition of the integration of Spanish banks inside a broader (European) banking market (1997-2003). For each time period, the equations of demand, costs and *FOC* are jointly estimated using the *OLS* instruments (that is, the regressors themselves) and the results (first column) are compared with the instrumented two-steps *GMM* estimations (second column) to evaluate the potential estimation biases when the endogeneity of interest rates is not taken into account. In both time periods, the effect of the endogeneity is evident in the demand of both loans and deposits, as the (absolute) magnitude of the coefficient of interest rate is greater by a factor of four in the instrumented *GMM* estimation compared to the *OLS* estimation. In the case of deposits, the estimated coefficient for the interest rate variable is not even statistically different from zero. Finally, the estimates of all the intercepts included in the *FOC* are significantly different from zero at 1% in all the time periods (10% for δ^b, δ^a in the first period), what can be interpreted as an inconsistency between the results obtained from the estimation and the fulfilment of the *FOC* derived from the model. Therefore, all these findings can be interpreted as evidence that the *OLS* estimation provides biased estimates of the coefficients of interest rates and also of the rest of variables. Therefore, the econometrically sound estimates are considered to be those obtained from the two-step *GMM* estimation with instruments and, thus, they will be the focus for the rest of the paper. The estimates of both time periods satisfy the Sargan test of over identifying restrictions, what guarantees the complementarities of the set of moment conditions used in the estimations.[22]

4.1.2 ESTIMATES OF THE 1988-1996 PERIOD

The estimates of the 1988-1996 period show that the demands of loans and deposits are significantly associated to the interest rate paid by the bank in the expected direction, that is, the demand of loans is negatively related to the price whereas the demand of deposits increases with the interest rate.

The contribution of the value-enhancing demand resources, i.e. branches and advertising capital, is positive and significant in loans and deposits, what confirms that banking products are differentiated across entities because the demand of loans and deposits increases with the stock of advertising capital and with the size of the branch network, for a given interest rate.

The estimates of the cost function show that the output of banks is made out by the product of the balance of loans and deposits with exponential weights of 0.42 and 0.56, respectively. This output is produced in the physical space provided by homogeneous branches with a production technology that combines labour, with a weight of 0.67, and IT

22. The results of the estimations are similar if the demand equations include fixed effects of banks (not shown), though advertising become non-significative in the demand of loans and branches are non-significative in the demand of deposits.

capital, with a weight of 0.33 (this value is not statistically significant probably due to the low variation of the user cost of IT capital across banks).

The bottom part of Table 3 shows the *p-values* from the test of statistical significance of the intercepts $\delta^l, \delta^d, \delta^b, \delta^a$ from (7.1), (7.2), (8.1) and (9.1). The null hypothesis that each of these average residuals is equal to zero cannot be rejected except in the case of loans. This result would imply that banks did not set interest rates according to the profit-maximizing conditions derived from the model. One possible explanation is related to the high levels and high volatility of the estimates of the risk premium of loans. Notice that, in the estimation of the marginal cost of loans, it is assumed that the risk premium for the new loans in year *t* is calculated from the expected loss of the current bank's loan portfolio. However, the credit risk perceived by the banks for new loans in *t* might have differed from the risk perceived when the loans in the portfolio were granted. This decoupling between the perceived credit risk for the new loans and the average risk of the existing credit portfolio is more likely to occur in periods of abrupt changes in the macro economic conditions, as it happened when Spain suffered a serious recession in the early nineties[23]. Moreover, the interbank market was not fully developed in this period, what led banks in many cases to cross subsidize from deposits to loans markets.

4.1.3 CHANGES IN ESTIMATES BETWEEN PERIODS

Table 3 also presents the results of the estimation for the 1997-2003 period. The null hypothesis of structural stability of the model in the two time periods is tested using the distribution of coefficients obtained from 1,000 bootstrap replications of the two-step *GMM* coefficients performed for each time period. The results of the test (not shown) individually and jointly reject for all the coefficients the null hypothesis of no-significant difference between the two time periods, at a significance level of 5%. Therefore, all the differences and comparisons between the two time periods that will be commented below refer to statistically significant differences explained by the structural changes underwent by the Spanish banking sector.

The estimated coefficient of the loan interest rate in 1997-2003 has halved with respect to the first period (absolute value fell to 5.29 compared to 10.88), whereas the coefficient of the deposit interest rate has risen from 4.50 to 6.85. The contribution of the number of branches to product differentiation has decreased in both the demand of loans and deposits, as the estimated coefficients have declined from 0.74 to 0.62 in loans and from 0.48 to 0.32 in deposits. On the other hand, the coefficients of advertising capital have increased from 0.15 to 0.28 in loans and from 0.51 to 0.65 in deposits. The decline of the contribution of the number of and the increase of the contribution of advertising capital may indicate that "proximity banking" may lose weight in the choice of bank costumers in favour of distant or internet mediated banking, which is heavily intensive in advertising.

The estimated elasticities of the output of banks to labour and IT capital derived from the production/ cost function remain relatively stable over time, although the increase in the

23. Robustness tests have been performed on this result by using alternative calculations of the risk premium, from the zero-risk premium scenario to premiums based on forward looking estimates of the default losses. In all cases, the changes in the estimated coefficients of the model concentrate in the estimated value of the intercept of the *FOC* of loans and of the coefficient of the interest rate of loans. Therefore, it can be concluded that, except for the estimated elasticity of demand for loans, the rest of the estimates appear robust to different hypothesis about how banks actually determine the risk premium for their loans in the first time period.

elasticity of output to IT capital in the second period, from 0.33 to 0.37, suggests that the production technology of banking services has become slightly more intensive in IT capital at the expense of labour services.[24] The sum of the estimated weights of loans and deposits in the total output of banks is equal in the two time periods and close to one (0.98). However the weight of deposits increased from 0.56 to 0.62 and the weight of loans decreased from 0.42 to 0.36. This implies that the relative increase in the operating costs derived from the increment of 1pp in the volume of deposits is higher than the relative increase derived from the same increment in the volume of loans, and that the magnitude of these differences has increased over time.

The test of statistical significance of the intercepts $\delta^l, \delta^d, \delta^b, \delta^a$ from the profit-maximizing condition is not rejected for any of the decision variables of banks for the 1997-2003 period. Therefore, the empirical evidence suggests that banks have made lending decisions with more accurate estimates of the credit risks of the borrowers, probably helped by the technical advances in measuring and tracking credit risks. As well, the development of the interbank market has contributed to separate loans and deposits pricing decisions, as it assumed by the theoretical model,

4.2 Own and cross elasticities of the demand of loans and deposits

Table 4 presents the own and cross elasticities of the Loans and Deposits demand functions to the interest rates and value-enhancing resources (branches and advertising capital). The elasticities are calculated for the representative bank[25] from the estimates shown in Table 3 using the expressions of elasticities in (2) derived from the discrete-choice model.

The own price elasticities of demand for loans and deposits in the 1988-1996 period are -10.82 (10.88·0.995) and 4.47 (4.50·0.995) respectively. Taking into account equations (7.1) and (7.2) the price elasticity imply a relative gross margin (Lerner index) of 9.2% in the market of loans and a relative gross margin of 22.3% in the market of deposits. The finite price elasticity of demand implies that banks can set interest rates above the marginal costs in both loans and deposits markets, i.e., banks have market power. In the time period 1997-2003, the estimated price elasticity for the demand of loans is lower in absolute value than in the previous period (-5.26) while the price elasticity of the demand of deposits is higher (6.61). These values imply a relative gross margin in loans of 19.0% and a relative gross margin in deposits of 22.3%, The gross relative margins of loans and deposits are now more similar than they were in the previous period and their evolution implies that, in EMU, Spanish banks increased their market power in loans and decreased their market power in deposits.

The estimated own and cross price elasticity in the period 1997-2003 imply that if the representative bank *i* increased its loan interest rate in one percentage point in the 1997-2003 period, its relative demand fell by 5.26% in favour of its competitors, whose individual demand rose by an average of 0.026%. Taking into account that there was an average of 95 banks in the period, the total increase in the demand of loans for the rest of banks is 2.47%. The rest of the demand decrease of bank *i* (2.79%) went to the outside good, that is, consumers that switch to non-banking markets. In the deposit side,

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24. Martín-Oliver and Salas-Fumás also report an increase of the intensity of IT capital in the production function of Spanish banks and find that an additional investment in IT of one million euros may be substituted for twenty-five workers.

25. The market share of the representative bank is assumed to be 0.5% (average market share of loans and deposits in 2003 is 0.43%). Notice that the market share is computed taking into account the potential market, that is, the denominator includes the purchases of all banking and non-banking (outside good) products.

an increase of the interest rate in 1 percentage point raised the demand by 6.62% from the transfer of the demand of competitors, which lose an average of 0.033% of their demand (3.13% for the aggregate demand of the 95 competitors), and from consumers of the outside good (3.48%).

The price elasticities for deposits and loans estimated in this paper are in line with the elasticity estimates reported in other papers, though slightly higher: for bank deposits, Ishii (2005) obtains a price elasticity of 4.20; the deposit rate elasticities across MSA in the US have a median value of 3.47 in Adams (2007); Dick (2008) reports a price elasticity for bank deposits of 2.99. For the case of loans, Ho (2010) estimates a price elasticity equal to -1.6 for the banks in Hong Kong. The reason why our elasticities are higher could be twofold: First, the interest rates used in this paper are those paid/charged to the new deposits/loans granted during the year *t (marginal* interest rates), while the elasticity estimates of the above-mentioned papers are obtained using interest rates calculated as the ratio between the interest expenses/revenues and the stock of deposits/loans at the end of the period *(average* interest rates). Second, the price elasticities estimated in this paper are drawn from the joint estimation of the equations of demand and cost and profit-maximizing conditions and they are computed introducing for the first time the risk premium in the price equation. This implies that price elasticities have to be equal to the inverse of the relative margin net of operating costs and risk premium (see footnote 13) what might increase their absolute value compared to other papers that did not include the price equations [Adams (2007); Dick (2008)] or that did not explicitly considered the loans risk premium [Ho (2010)]. Moreover, the inclusion of the cost function in the empirical model guarantees that the estimated coefficients of the cost function will fit the data on total operating costs. As these coefficients also appear in the first order conditions, the estimated elasticities of this paper are subject to further restrictions than if the cost parameters are estimated only with the condition of price equal to marginal cost [Ishii (2010); Ho (2010)].

Table 4 also shows the estimates of the elasticities of loans and deposits to changes in the number of branches and to changes in the stock of advertising. For the representative bank, an increase of 1% in the number of branches raises the relative share of the bank in the loans market by 0.62%. This increase is the result of a loss of 0.003% in the market share of each competitor (aggregated loss of 0.29% for all the competitors) and the loss in market share of the outside good (non-banking alternatives). For deposits, a 1% increase in the number of branches raises the market share of the representative bank in 0.32%, that is a half of the increase in the loans market. On the other hand, if the bank increases the stock of advertising capital in 1%, then the gains of market share in the loans and in the deposits markets would be 0.28% and 0.65%, respectively. Therefore, the results suggest that a branch' expansion is more effective than an increase in advertising expenditures to gain market share in the loans market while advertising capital is more effective than branches in the deposit market.

Table 4 also shows the marginal gross return from investment in advertising and in the number of branches, calculated according to the right hand side of equations (8.1) and (9.1). In the period 1988-1996, the marginal gross profit margin of one euro spent in branches was 0.089 euros (0.032 originated in the loans market plus 0.057 originated in the deposits market). During the period 1997-2003, the marginal gross profit from one additional euro invested in branches decreased slightly to 0.081 euros and the largest contribution came from the loans market (0.056 versus 0.025 in the deposits market). The marginal gross profit for advertising increased over time from 0.067 in 1988-1996 to 0.076 in 1997-2003. In both time periods, the contribution to this profit is higher in the deposits market than in the loans market, though in the later it has increased over time.

The increasing returns from advertising capital, combined with the higher weight of IT capital, and the smaller returns derived from the number of branches suggest that banks have evolved towards a new type of banking where intangibles gain importance over physical assets as competition tools. In other words, the traditional *proximity banking* based on a wide branch network to be close to the customer is evolving towards a *distant banking*, where internet and advertising are becoming the core variables of banking competition.

4.3 Simulation

In this section, we use the estimations of the demand and cost functions to simulate the optimal decisions of the representative bank that maximizes profits in response to changes of the exogenous variables. The target is to shed light on how banks will react (modifying quoted interest rates, optimal size, etc) in response to changes of exogenous factors, as monetary policy, input prices, etc. As this exercise predicts the reaction of banks due to changes of the conditions that define the playing field of competition, it can represent an interesting tool for policy makers in order to assess the potential implications for the banking system of a decision they make (i.e. changes in the monetary policy).

The simulation exercise is performed using the four *FOC* in (7.1), (7.2), (8.1), (9.1) and the value of the coefficients of Table 3 corresponding to the 1997-2003 period. Given the values of the exogenous variables, we can solve for the four unknowns in the *FOC* and obtain the optimal value of the decision variables of banks under those conditions. The exogenous variables are the interbank interest rate r_t^{ib} , the opportunity cost of equity, c_{it}^{o} , salaries, w, the amount of investment in physical capital needed to open a branch, k_b, the credit risk premium, rp_{it} and the potential market of loans and deposits, M_l, M_d. On the other hand, the endogenous or decision variables are the loan interest rate r_{it}^{l} , the deposit interest rate, r_{it}^{d} , the number of branches, B_{it}, and the advertising capital, CK_{it}. Once we have solved for them, we can determine the demand of loans and deposits, the operating costs and total costs, the net income and the *ROE*.

This section presents two simulation exercises that respond to two different questions. The first exercise aims to assess the impact of an external shock coming from a change in the monetary conditions. The second exercise measures the reaction of a bank under a price change of one of its inputs. As the exogenous variables are set at their median values in both exercises, the optimal responses that are predicted can be attributed to the representative bank[26]. Notice that the predictions of the endogenous variables refer to long-term equilibrium decisions as a response to a permanent variation of the monetary policy and a permanent variation of the input prices, when all the adjustments in the transition are completed.

The first exercise simulates the decline of 1 percentage point of the 1-year interbank interest rate, from 5.3% (approx. value in 1997) to 4.4% (value in 2001). As the interbank interest rate decreases, so does the profit maximizing interest rates of loans

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26. In order to assess the validity of the simulations, we have replicated the evolution of the exogenous variables during 1997-2003 and we have compared the expected behavior of the median bank with the real variables of a representative bank in the sample. The predicted trends are in line with the real behavior of the representative bank, though the variations are larger because the model does not contemplate the existence of adjustment costs.

and deposits (Figure 1a). The absolute gross margin with respect to the interbank rate remains rather stable and is higher in loans than in deposits due to the embedded 0.8 percentage points that correspond to the risk premium.

As loan and deposit interest rates decrease, the demand of loans increase and the demand of deposits decrease. At the same time, the profit-maximizing conditions vary in such a way that loans become more profitable and it is optimal to increase the optimal stock of advertising tied to loans and to increase the number of branches. However, the drop of the interest rate acts in the opposite direction on the deposit side. The production inputs (labour and IT) are adapted at every point to meet the demand of banking services. Adding up the effects, Figure 1b shows that, for representative bank, the deposit effect dominates and banks decrease their size until the interbank rate reaches 4.9%. For further reductions, the loan effect outweighs the deposit effect and it is optimal to increase the stock of advertising capital and number of branches. This inflection point will obviously vary depending on the conditions assumed in the exercise and determined by the value of the rest of exogenous variables.

As the interbank decreases, Figure 1c documents a gap between the stock of loans and deposits that becomes larger for lower levels of the reference rate. This is consistent with the actual evolution of loans and deposits in Spain during the years prior to the 2007 crisis, when the reference rates were unusually low. Finally, Figure 1d presents the revenues and costs that result from the optimization and Figure 1e shows the economic profit normalized per Euro of equity[27]. It presents a slight negative trend, but the values remain above zero.

Figure 2 presents the results of the second exercise that simulates a rise of the opportunity cost of capital from 9.3% to 10.5%. This scenario could be understood as the isolation of the price effect embedded in the tightening of the standards to access to funds as a result of a potential collapse of the money market.

The changes in the opportunity cost of equity leave practically unchanged the profit maximizing interest rates of loans and deposits since such cost only marginally affects the operating cost through the user cost of IT capital (Figure 2a). The main induced changes affect the costs of the value-enhancing resources that become higher as the opportunity cost of equity increases. For this reason, the optimal levels of the stock of advertising and branches decrease (Figure 2b), which in turn decrease the demand of all banking services at a very similar pace (Figure 2c). On the production side, the decrease in the demand reduces the use of labour and IT capital. However, higher levels of the cost of equity increase the user's cost of IT capital and, therefore, IT capital will be partly substituted by the labour as a production input (not shown). Finally, the fall in banking activity due to the higher cost of equity implies lower revenues and lower total costs (Figure 2d) that result in positive values of the *ROE* around values of 2%, what implies that the representative bank adapts its size and production to maintain constant levels of economic profits.

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27. The level of equity has been computed for every scenario as the 8% of the total assets, assuming that the level of capital is the minimum required by *Basel I*, an assumption we also make in the formulation of the theoretical model of profit maximization, see footnote 6.

5 Conclusions

The creation of the EMU has increased banking integration in Europe and, for countries like Spain, it has meant a substantial reduction in the official interest rates compared with the pre Euro period. This paper documents the change in the competitive conditions of the Spanish banking industry during the period in which Spain prepared and finally joined the EMU. The analysis is focused on both price and non-price competition variables. The paper provides estimates of the elasticity of the demand of loans and deposits for price, advertising capital and number of branches, where the demand function is derived from a multiple-choice model of consumers' behavior with differentiated products. It also provides estimates of the elasticity of operating cost to the quantity of inputs (labor and IT capital) and to the quantity of loans and deposits. All these elasticities are obtained as part of a joint estimation process that includes, in addition to the cost and demand functions, the profit-maximizing conditions from banks. The inferences of changes in the competitive conditions of the Spanish banking industry are made by comparing the elasticity in the more recent time period and the elasticity in the period before.

The paper finds that when Spain becomes a member of the EMU, the representative bank faces a more price-elastic demand for deposits and a less price-elastic demand for loans. Then, the conclusion is that market power of Spanish banks has lowered in the deposits market and it may have increased in the loans market as a result of becoming part of the Euro zone. Nonetheless, the empirical analysis casts doubts that interest rates of loans satisfied the profit-maximizing conditions in the pre-Euro period. The paper reports a change in the value of the Lerner index (consistent with the estimated elasticity) of the representative bank from 22.3% (9.2%) in deposits (loans) during the period previous to the EMU to 15.1% (19%) in the EMU period. In the production side, banks have become more efficient in production in the EMU period, as the marginal operating costs of deposits (loans) has fallen from a value of 1.2 (2.2) cents in the first part of the time period to 0.8 (1.1) cents of euro in the second part. The reduction in operating costs coincides with a trend of increasing substitution of IT capital in the place of workers to produce banking services: the stock of IT per worker increased from an average of 10.54 thousands of constant Euros of 1983 during the first time period to an average of 16.81 during the second.

As regards non-price competition variables, the paper finds an increase in the gross marginal return for Advertising capital and a decrease in the gross marginal return for Branches during the EMU period, compared with the values of marginal returns in the years before. The changes in marginal returns are in part the result of an increase in the elasticity of the demand to Advertising capital (especially in loans) and a decrease in the elasticity of the demand to Branches. The relative shift from branches to advertising as a differentiation variable for the representative Spanish bank is interpreted in the paper as evidence that retail banking in Spain is evolving from a business model of proximity banking (with a dense network of physical branches) to a model of distant banking (with telephone and internet supported transactions).

The simulated values of the endogenous variables of the model to changes in the interbank rate provide results that are consistent with the actual evolution of these variables. In particular, it documents the gap between loans and deposits for the representative bank when interest rates become particularly low in the second part of the period. The gap has been filled mainly with funds supplied by foreign banks belonging to the Euro system, something that has been possible because Spain was part of the system.

One possible limitation of the paper is the consideration of the national market as the relevant market instead of regional or local markets, the assumption that the choice of the number of branches and stock of advertising capital is made without taking into account adjustment costs and the assumption of homogeneity between the two types of banks in Spain, commercial and savings banks. These caveats should be considered in future research.

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Table 1: Descriptive statistics of the output components and market shares of banks, m€ y %

	Loans				Market Share Loans				Deposits				Market Share Deposits			
N	Average	P25	P50	P75	Average	P25	P50	P75	Average	P25	P50	P75	Average	P25	P50	P75
151	595.7	97.0	224.0	435.8	0.259	0.041	0.098	0.194	857.3	153.8	342.6	757.3	0.356	0.054	0.143	0.321
143	678.9	122.7	251.9	544.7	0.258	0.040	0.089	0.192	982.1	182.4	387.8	868.5	0.360	0.048	0.137	0.305
130	726.6	132.1	265.1	535.2	0.267	0.033	0.091	0.203	985.6	132.5	383.6	839.6	0.391	0.041	0.145	0.316
128	903.5	155.8	320.6	684.2	0.269	0.031	0.094	0.200	1,181	167.4	443.7	1,004	0.402	0.031	0.142	0.318
125	855.9	145.2	311.9	712.0	0.264	0.029	0.086	0.210	1,139	134.5	440.2	1,007	0.403	0.025	0.144	0.316
126	972.8	123.2	312.4	853.3	0.254	0.028	0.081	0.196	1,333	125.2	461.9	1,130	0.400	0.033	0.131	0.339
122	1,021	140.5	377.3	862.1	0.289	0.030	0.093	0.243	1,432	176.4	499.4	1,258	0.412	0.039	0.143	0.375
119	1,074	144.2	417.3	1,007.8	0.298	0.032	0.095	0.257	1,566	200.2	523.6	1,327	0.400	0.031	0.124	0.354
114	1,184	153.7	458.2	1,094.0	0.312	0.035	0.105	0.274	1,668	218.4	647.6	1,357	0.408	0.036	0.139	0.350
113	1,342	182.5	541.7	1,161.5	0.316	0.033	0.108	0.282	1,766	273.7	655.4	1,511	0.395	0.032	0.135	0.353
108	1,506	210.5	605.5	1,331.6	0.329	0.034	0.106	0.271	1,819	255.7	723.7	1,546	0.417	0.044	0.139	0.348
103	1,875	244.0	686.1	1,566.6	0.344	0.035	0.111	0.288	2,196	271.4	899.7	1,776	0.418	0.041	0.133	0.343
91	2,406	354.3	862.0	1,868.3	0.366	0.030	0.116	0.298	2,719	393.8	1,033	2,260	0.435	0.037	0.136	0.359
88	2,661	378.8	999.1	2,090.7	0.376	0.034	0.131	0.305	3,008	377.1	1,147	2,418	0.465	0.045	0.163	0.405
85	2,955	542.6	1,130.1	2,497	0.397	0.038	0.142	0.340	3,276	437.2	1,310	2,670	0.476	0.054	0.179	0.413
80	3,463	616.3	1,346.0	2,854	0.426	0.041	0.151	0.381	3,752	605.3	1,548	3,093	0.503	0.059	0.188	0.453
Acumulative growth																
-3.51%	8.58%	5.75%	8.95%	11.50%	2.29%	-1.95%	0.92%	4.32%	8.32%	4.38%	7.96%	7.29%	1.71%	-4.92%	-0.41%	1.07%
-5.76%	15.80%	20.29%	15.17%	14.99%	4.96%	3.86%	5.54%	5.01%	12.56%	13.23%	14.33%	11.94%	4.05%	10.24%	5.53%	4.15%

Note: Stocks of loans and deposits at constant Euros of 1983. N refers to the number of banks in the sample. Market shares are computed in terms of the potential market, as explained in Section 3.2.1 and they are expressed in percentages, Average is the average value of the distribution and P25, P50, P75, correspond to the value of the 25th, 50th and 75th percentile, respectively, of the variable and Total stands for the sum of the output of all the banks in the sample.

Table 2: Descriptive statistics of the explanatory variables

		Average	P10	P25	P50	P75	P90	Std. Dev.	Average Growth
N. Workers	1988-1996	1,711	89	268	658	1,473	3,514	3,401	3.89%
	1997-2003	2,258	138	379	934	2,124	4,718	4,418	5.06%
IT capital	1988-1996	18,322	740	2,267	6,800	16,665	39,284	36,759	11.06%
	1997-2003	41,042	1,343	4,665	15,530	30,892	85,397	96,423	11.62%
N. Branches	1988-1996	234	7	40	110	211	500	415	5.54%
	1997-2003	359	13	69	166	342	798	645	6.06%
Advertising Capital	1988-1996	3,756	73	295	1,386	3,728	8,667	7,308	8.25%
	1997-2003	5,402	180	464	2,186	5,287	11,787	10,608	2.51%
Loan Interest Rate	1988-1996	15.22	11.47	13.50	15.63	17.09	18.18	2.53	-3.60%
	1997-2003	7.30	5.22	6.16	7.29	8.37	9.30	1.62	-4.94%
Deposit Interest Rate	1988-1996	7.80	5.52	6.39	7.92	9.09	9.90	1.68	-4.68%
	1997-2003	2.56	1.67	1.99	2.49	3.04	3.63	0.76	-11.99%
Interbank Interest Rate	1988-1996	11.72	7.36	10.00	11.81	13.31	15.44	2.81	-6.04%
	1997-2003	3.86	2.35	3.16	4.01	4.77	5.20	0.97	-11.50%
Risk Premium	1988-1996	2.47	0.57	1.31	2.12	3.36	4.61	1.73	-0.59%
	1997-2003	0.94	0.28	0.51	0.84	1.15	1.72	0.73	-7.67%
Operating Costs	1988-1996	41,604	2,146	5,924	13,344	31,933	82,051	91,473	5.22%
	1997-2003	74,436	3,141	8,372	22,991	59,330	109,978	217,466	10.14%
User Cost of Capital	1988-1996	13.85	11.66	12.64	13.71	15.32	16.08	1.58	-0.63%
	1997-2003	10.05	7.64	8.59	10.24	11.08	12.26	1.73	-1.16%
Wage	1988-1996	16.72	14.31	14.87	15.91	18.87	19.79	2.19	-0.62%
	1997-2003	16.91	13.97	14.20	15.52	20.26	22.20	3.19	0.02%

Note: Number of workers and number of branches are expressed in units. IT capital, Advertising capital, Operating costs and wages areexpressed in thousands of Euros of 1983. User cost of capitalis the nominal cost of equity plus the depreciation rate and less the growth rate of the asset's price. Average is the average value of the distribution and P10, P25, P50, P75, P90 correspond to the value 90th percentile, respectively, of the variable. Average growth refers to the average growth of the yearly average of the variable.

Table 3: Estimation of the Demand and Cost Functions

	1997-2003								1988-1996							
	OLS				GMM-IV				OLS				GMM-IV			
	Coefficient		t-ratio		Coefficient		t-ratio		Coefficient		p-value		Coefficient		t-ratio	
DEMAND OF LOANS																
r_l	-1.24	***	-7.18		-5.29	***	-4.79		-2.44	***	-8.65		-10.88	***	-6.53	
Branches	0.50	***	10.94		0.62	***	5.41		0.50	***	11.75		0.74	***	10.50	
Advertising	0.34	***	9.42		0.28	***	3.04		0.27	***	9.53		0.15	**	2.43	
DEMAND OF DEPOSITS																
r_d	0.37		1.25		6.65	***	3.12		0.30		1.42		4.50	***	5.14	
Branches	0.40	***	8.20		0.32	***	3.15		0.55	***	17.10		0.48	***	10.30	
Advertising	0.49	***	13.38		0.65	***	6.52		0.37	***	15.58		0.51	***	13.06	
COST FUNCTION																
c_K	0.34		0.86		0.37		0.54		0.29		1.15		0.33		0.69	
w	0.66	***	7.07		0.63	***	5.08		0.71	***	8.83		0.67	***	6.37	
ln Loans	0.44	***	7.91		0.36	*	1.93		0.38	***	10.58		0.42	***	8.11	
ln Deposits	0.60	***	11.69		0.62	***	3.76		0.55	***	15.10		0.56	***	11.77	
PROFIT-MAX RESTRICTIONS																
δ^l	-0.17	***	2.72		0.03		0.32		0.45	***	8.66		0.14	***	6.34	
δ^d	-0.23	***	3.29		0.30		1.53		3.10	***	3.72		-0.02		-0.40	
δ^b	-0.31	***	4.56		-0.02		-0.63		1.06	*	1.70		0.01		0.61	
δ^a	-0.41	***	4.05		0.06		1.47		0.74	*	1.68		0.06		1.47	
Time Dummy variables	Yes				Yes				Yes				Yes			
N.Obs.	668				668				1158				1158			
Sargan test (*p*-value)	-				0.186				-				0.143			

(*)=significant at 10% (**)= significant at 5% (***)= significant at 1%.

Note: The dependent variable of the equations Demand of Loans and Demand of Deposits are the share of loans and deposits, respectively and the dependent variable of Cost Function is the log of the operating costs of the bank. Branches and Advertising refer to the number of branches and advertising capital (thousands of constant Euros) deployed by the bank; r_l, r_d stand for interest rate of loans and deposits. c_K and w stand for the user cost of capital and wage in constant Euros, respectively. *ln Loans*, *ln Deposits*, refer to the log of the balance in thousands of constant Euros of loans and deposits. Finally, we provide the estimation of the intercepts of the profit-maximizing equations in (7.1), (7.2), (8.1), (9.1), δ^l, δ^d, δ^b, δ^a, that are meant to be statistically non-different from zero if banks are maximizing profits. The Sargan statistic tests the consistency of the orthogonallity conditions used in the estimation, as the number of orthogo-nallity conditions is greater than the number of parameters to be estimated ($r > k$).

Table 4: Elasticities of Demand, Gross Marginal Returns and Marginal Costs

		LOANS		DEPOSITS	
		1988-1996	1997-2003	1988-1996	1997-2003
ELASTICITIES					
Interest Rates	Own	-10.826	-5.264	4.478	6.617
	Cross	0.054	0.026	-0.023	-0.033
Branches	Own	0.736	0.617	0.478	0.318
	Cross	-0.004	-0.003	-0.002	-0.002
Advertising	Own	0.149	0.279	0.507	0.647
	Cross	-0.001	-0.001	-0.003	-0.003
Gross Marginal Return BRANCHES		0.032	0.056	0.057	0.025
Gross Marginal Return ADVERTISING		0.006	0.026	0.061	0.050
MARGINAL COST		0.022	0.011	0.012	0.008
LERNER INDEX		0.092	0.190	0.223	0.151

The first six rows of the table refer to the own and cross elasticities of interest rates, number of branches and advertising capital for Loans, Deposits and Commissions. Elasticities have been computed for a bank with a market share s_j of 0.5%. The rows *Marginal revenue BRANCHES / ADVERTISING* are calculated from equations (8.1) and (9.1) using the estimated coefficients from Table 3 and the median weights in data of loan and deposit. They show the marginal gross revenues from capital services provided by branches and advertising capital, which in the optimal solution are also equal to the respective share of service costs of the respective capital input over total revenues of the bank. The last two rows present the attributed marginal cost and the lerner index implied by the average prices and costs. More concretely, *MARGINAL COST* reflects the marginal operating derived from the cost function in (6.1) calculated from the estimations of Table 3 and the data. *Lerner Index* is the relative margin per Euro net of marginal costs of the respective output component that is equivalent to the inverse of the price elasticity (Equation 7.1 and 7.2).

Figure 1: Simulation of a fall in the interbank interest rate.

INTERBANK	OPPORT. COST	k_b	WAGE	RISK PREMIUM
-	11.2%	198	16	0.8%

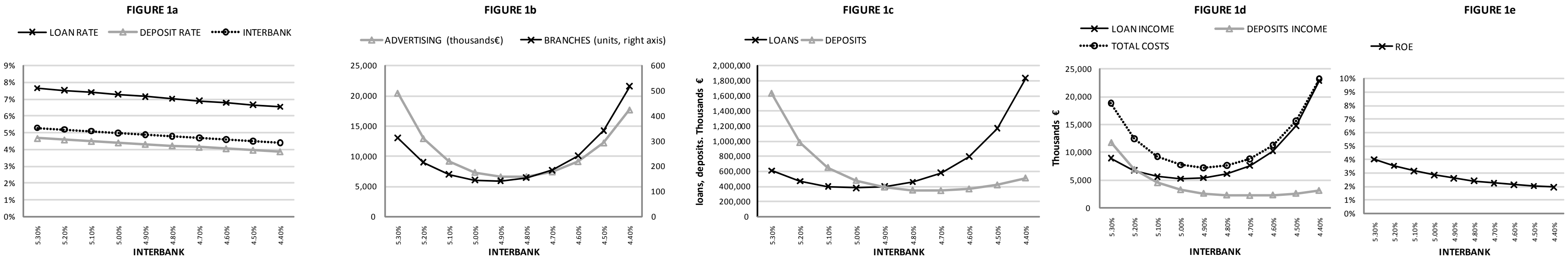
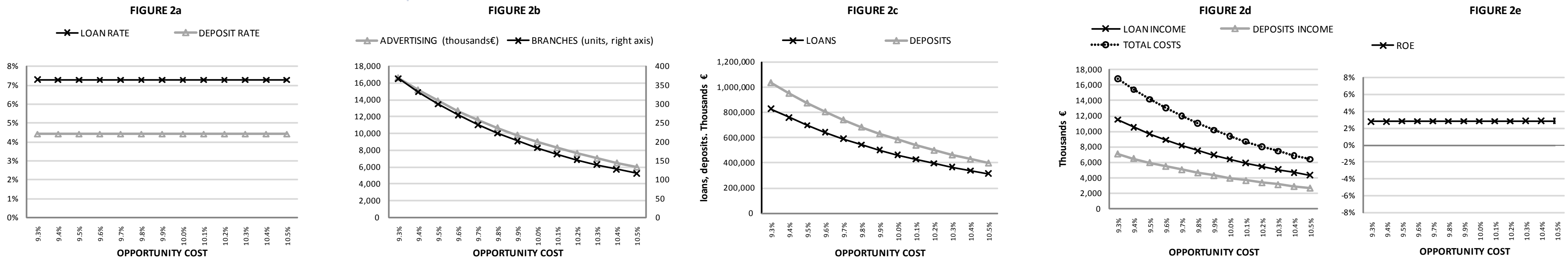


Figure 2: Simulation of a rise in the opportunity cost of capital.

INTERBANK	OPPORT. COST	k_b	WAGE	RISK PREMIUM
5.0%	-	198	16	0.8%



Note: Both figures represent the optimal behavior of the representative bank under the model of 1997-2003. Loan and deposit incomes are net of the interbank and risk; for loans, $(r_l\text{-}m)\cdot L$ and for deposits, $(r_t\text{-}r_d)\cdot D$.

APPENDIX

A. Derivation of the First Order Conditions of the profit-maximizing problem

In the model, each of the *N* banks of the market maximizes its profits playing a game in which each bank expects their competitors not to respond to changes in its decision variables. The necessary conditions for the Nash equilibrium of this game will be determined by the set of *FOC*s obtained from the profit maximization with respect to the banks' decision variables. Solving the problem with respect to the interest rates of loans (assuming $\frac{\partial r_{jt}}{\partial r_{kt}} = 0$):

$$L_{it}^{d} + \left(r_{it}^{l} - m\right)\frac{\partial L_{it}^{d}}{\partial r_{it}^{l}} - \frac{\partial C_{it}}{\partial L_{it}}\frac{\partial L_{it}^{d}}{r_{it}^{l}} = 0 \quad \Rightarrow \left(r_{it}^{l} - m\right) - \frac{\partial C_{it}}{\partial L_{it}} = -L_{it}^{d} \cdot \frac{1}{\frac{\partial L_{it}^{d}}{\partial r_{it}^{l}}} \quad \Rightarrow$$

$$r_{it}^{l} = \left(1 - \frac{1}{e_l}\right)^{-1} \cdot \left(m_{it} + \frac{\partial C_{it}}{\partial L_{it}}\right)$$

That is the *FOC* (7) for loans. The other *FOC* in (7) for the deposit interest rate is straightforward. The second set of optimality conditions that jointly with (7) determine the Nash equilibrium of the game refer to the optimal expenditures on advertising capital (CK_{it}) and the number of branches (B_{it}) If we maximize the profits with respect to branches:

$$\left(r_{it}^{l} - m\right) \cdot \frac{\partial L_{it}^{d}}{\partial B_{it}} + \left(r_t - r_{it}^{d}\right) \cdot \frac{\partial D_{it}^{d}}{\partial B_{it}} - c_{K,i}\, p_K k_b - \frac{\partial C_{it}}{\partial B_{it}} = 0 \Rightarrow \left(r_{it}^{l} - m\right) \cdot \frac{\partial L_{it}^{d}}{\partial B_{it}} + \left(r_t - r_{it}^{d}\right) \cdot \frac{\partial D_{it}^{d}}{\partial B_{it}} - c_{K,i}\, p_K k_b$$

$$-\left(\frac{\partial C_{it}}{\partial L_{it}}\frac{\partial L_{it}}{\partial B_{it}} + \frac{\partial C_{it}}{\partial D_{it}}\frac{\partial D_{it}}{\partial B_{it}}\right) = 0$$

$$\Rightarrow \left(r_{it}^{l} - m - \frac{\partial C_{it}}{\partial L_{it}}\right) \cdot \frac{\partial L_{it}^{d}}{\partial B_{it}} + \left(r_t - r_{it}^{d} - \frac{\partial C_{it}}{\partial D_{it}}\right) \cdot \frac{\partial D_{it}^{d}}{\partial B_{it}} - c_{K,i}\, p_K k_b = 0$$

From (4), we know that $\frac{\partial C_{it}}{\partial L_{it}} = r_{it}^{l} - m_{it} - \frac{r_{it}^{l}}{e_l}$; $\frac{\partial C_{it}}{\partial D_{it}} = r_t - r_{it}^{d} - \frac{r_{it}^{d}}{e_d}$, substituting above,

$$\Rightarrow \left(\frac{r_{it}^{l}}{e_l}\right) \cdot \frac{\partial L_{it}^{d}}{\partial B_{it}} + \left(\frac{r_{it}^{d}}{e_d}\right) \cdot \frac{\partial D_{it}^{d}}{\partial B_{it}} = c_{K,i}\, p_K k_b \Rightarrow$$

$$\Rightarrow \left(\frac{r_{it}^{l} L_{it}^{d}}{e_l}\right) \cdot \frac{\partial L_{it}^{d}}{\partial B_{it}}\frac{B_{it}}{L_{it}^{d}} + \left(\frac{r_{it}^{d} D_{it}^{d}}{e_d}\right) \cdot \frac{\partial D_{it}^{d}}{\partial B_{it}}\frac{B_{it}}{D_{it}^{d}} = c_{K,i}\, p_K k_b B_{it} \Rightarrow$$

$$\Rightarrow v_l \frac{\Sigma_{L,B}}{e_l} + v_d \frac{\Sigma_{D,B}}{e_d} = \frac{c_{K,i}\, p_K k_b B_{it}}{r_{it}^{l} L_{it}^{d} + r_{it}^{d} D_{it}^{d}}$$

where $v_l = \frac{r_{it}^l L_{it}^d}{r_{it}^l L_{it}^d + r_{it}^d D_{it}^d}$; $v_d = 1 - v_l$. Following this latter derivation, obtaining the *FOC* for advertising capital is straightforward.

B. Methodology used to estimate the stock of material and immaterial assets and the user cost of capital

For each bank, data are available on the year-by-year investment flow in Physical assets, Advertising and IT. Data are obtained from confidential accounting statements reported by banks to the Banco de España. The stock of a particular asset in year *t*, at current replacement cost, is obtained applying the permanent inventory method.

Let I_t be the gross investment flow of new capital services in year *t*; K_t the stock of homogeneous capital services at the end of year *t*; ϕ the depreciation rate of the asset used in production activities during a one-year period; μ the rate of technological progress incorporated into capital services invested during one year, with respect to those invested one year before, and let q_t be the price of one unit of services in period *t*. The permanent inventory method determines the replacement cost of the stock in year t as follows,

$$p_t K_t = p_t I_t + \frac{1-\phi}{1+\mu} \cdot \frac{p_t}{p_{t-1}} \cdot \left(p_{t-1} \cdot K_{t-1}\right)$$

To replace in *t* one unit of capital service in place at the end of the previous year, *t-1*, with the technical progress in capital goods of the period, only $1/(1+\mu)$ units are needed. Depreciation implies that for each unit of capital in place in *t-1*, there is only $(1-\phi)$ units remaining at the end of the year. This computation of the net capital services is exact when the depreciation of the asset is exponential at rate ϕ.

The term $(1-\phi)/(1+\mu)$ is substituted by $(1-\delta)$ where δ is the overall economic depreciation rate. The value of δ is set to 0.03 for buildings, 0.15 for fixed assets different from IT, 0.35 for IT capital, and 0.35 for advertising capital. These are values in line with others used in the literature. The price index of buildings is taken from the Housing Ministry (Ministerio de la Vivenda) and the price index of other non-IT fixed capital is set equal to the price deflator of gross capital formation. We assume that the price index of quality-adjusted IT capital is zero, and the price index of advertising capital is the price of market services published by the Spanish Institute of Statistics. The zero inflation rate of the price of IT capital services departs from the 15% to 20% decline assumed in other studies with US data, Litchenberg (1995), because, in Spain, general inflation is much higher than in the US, and technological innovations are introduced at a later time.

The user cost of capital represents the rental price per unit of service the firm would pay in the case that the unit of service was rented in the market. Even though capital services are supplied internally, we assume that there is an opportunity cost for one unit of service equal to the rental price. For capital service *K*, the user cost is given by $c_k = \left(c^o + \delta - \dot{p}_k\right)$, where c^o is the financial opportunity cost of capital, δ is the depreciation rate defined earlier, and $\dot{p}_k$ is the rate of change in price of the asset during the period (asset-specific inflation). The calculation of the user cost of capital requires us to know c^o. Since the paper assumes that material and immaterial operating assets are financed by equity, the estimated cost of c^o is set equal to the estimated cost of equity for each bank. This, in turn, is set equal to the interest rate charged for loans by the bank, plus a financial risk premium that is inversely related to the proportion of capital to total assets of the bank.

For a more detailed explanation of the methodology for both, replacement costs of invested assets, and user cost of capital, see Martin-Oliver, Salas-Fumás and Saurina (2007).

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