A NEW EMPIRICAL APPROACH FOR MEASURING MARKET POWER: THE EUROPEAN BANKING INDUSTRY

José Baños Pino

Fundamentos del Análisis Económico

Universidad de Oviedo

Ana Lozano Vivas

Teoría e Historia Económica

avivas@uma.es

Universidad de Málaga

Ana Rodríguez-Álvarez

Fundamentos del Análisis Económico

Universidad de Oviedo

Preliminary Version (do not quoted)

Abstract: The paper attempts to contribute to the empirical literature of bank competition and empirically evaluate the intensity of banking competition by analyzing to what extend the market power, if it is present, is oriented towards increasing the quality for banking services. To empirically test this issue we propose a new method for defining and assessing competition and we apply it to the European banking industry. The new method of market power measurement proposed takes advantage of the kindness that from duality offers the output oriented distance function allowing not only to measure the market power based on the bank optimal behavior where the bank investment on quality (i.e. stability) is controlled for, but measuring market power considering the multiproduct nature of the banks, an important issue uncover until now in the empirical literature. Moreover, an important advantage of the new method is that does not appeal data on bank prices for competition intensity measurement.

1. INTRODUCTION

Whether competition among banks is good or bad has represented the center of the policymaker and researchers debate on financial liberalization and/or financial stability. As it is well known, the general argument in favor of competition in any industry resides in the fact that competition has efficiency benefits, reducing allocative and productive deadweight losses as well as fostering innovation. However, those competition benefits might be less evident for the case of the banking industry due to its peculiarity and their synergy on the economic and social welfare. For instance, competition in the banking industry may exacerbates the coordination problem of depositors-investors on the liability side and/or fostering runs/panics by increasing incentives to take risk on the asset side (Vives, 2012) hurting the stability of the banking and financial system. Thus, since the overall objective of the financial system is to maximize the social welfare, the policy-makers ambition is to facilitate a banking system that supports both economic efficiency and stability. Regarding this main aspiration it can be observed that the public competition policy has changed profoundly since the mid-1970s. Actually, while policymakers, i.e. Central Banks and regulators, were complacent about collusion agreements among banks before the financial liberalization, however afterward and facing financial deregulation, competition policy was taking seriously in the banking sector under the view that competition enhances efficiency, be it productive, allocative or dynamic (innovation). But, the crisis starting in 2007 with subprime mortgages has overridden competition policy concerns and policymakers decided to protect banking stability with mechanism that should distort competition (public aid programs, programs commitments increasing market power resulting from mergers).

Consistently with the different policymakers view about enabling or not competition in the banking industry, the theoretical research supports both views, i.e. the so called “competition-fragility” view (Berger et al. 2008; Vives, 2010, among others) versus the “competition-stability” view (Beck et al. 2006; Boy and De Nicolo, 2005, among others). Given the profound changes due to both external and internal reasons that the banking industry has been subjected, and the controversy about whether or not the competition in banking is good, in recent years we have witnessed a substantial converge of empirical research interest on the implications of the sequential liberalization of financial regulations and massive innovations in financial products on banking market competition and analyzing the relationship between banking competition and stability.

On those goals regard, we find basically tree broad approaches using on those studies to defining and assessing competition in the banking industry. The so called structure-conduct-performance (SCP) paradigm which evaluates competitive conditions in terms of concentration and posits that there is an increasing relationship between the level of market concentration and market power [Berger and Hannan (1998), Hannan (1991), Molyneux et. al (1994), among others]. On the other hand, the contestability approach focus on behaviour dependent on potential entry, and contrary to the SCP suggests that concentration is not a good proxy of competition in financial services. This approach focus on gauging competitive conditions in terms of the fact that ease of competitive entry can deter the exercise of market power [De Bandt and Davis, (2000)]. Those two approaches are oriented to measure competition at the industry level. Finally, more recently appear the third approach to assessing competition in financial services at the bank level by measuring the responses of prices or outputs to changes in costs. For instance, recent studies on banking use the so-called H-statistic based on the Panzar and Rosse methodology [Bikker and Haaf (2002); Beck, Demirguc-Kunt and Levine (2005), Shaeck, Cihak and Wolfe (2006) and Schaeck and Cihak (2007), among others] which proxies the reaction of output to input prices. Other studies use the Lerner index [Kumbhakar and Lozano (2004), Maudos and Fernández de Guevara (2004)], which expresses the bank market power as difference between the market price and marginal cost divided by the output price. Although this last approach has the advantage to measure the competition intensity of each bank, however account with the limitation of availability of consistent data for defining banking prices. This limitation guides to this stand of empirical literature to disregard the multiproduct nature of the banks since given the unavailability of data most of them employ information about the total assets or total revenue of the banks.

Independently of the approach used for assessing competition, all those papers shared to empirically test the competition intensity of the banking industry regarding the assumption that the increase in competition leads to an improvement in the social welfare, according to the market theory belonging to the traditional view of the Industrial Organization (IO). Moreover, in base of this traditional view the researchers also defended that the increase in competition is pleasing in the banking industry because if the banks have market power will be stimulated to use it to obtain extraordinary revenues, imputing higher interest rates for lending money, and paying lower interests to his depositors. In this sense, the standard IO framework treats banks like any other firm and defend that competition is important for efficiency. However, given the particular characteristics that have the production process of the banks, as well as the important role that the banking industry recovers in the economy, it is not clear that the traditional hypotheses defended in IO, which should be perfectly attributable to any other type of industry, could be moved "per se" to the banking industry. Actually, others theoretical approaches explicitly consider unique characteristics to the banking sector and argue that market power need not necessarily have a negative impact on allocative efficiency. For instance, bank's financial structure and the quality of its loan portfolio can also be important since an indispensable requirement in order the banking industry generates a positive impact on the economy, is the stability of the banking industry. In this line, Allen and Gale (2000) argue that a possible effect that can exercise the increase of the competition in the banking sector is that the financial institutions could assume a higher risk in his investments, given that their profits should be reduced as consequence of the increase of the competition.

Regarding the unique characteristics of the banking sector and with the premise that it should be necessary that the banking industry should support both economic efficiency and stability, the paper attempts to contribute to the empirical literature of bank competition and empirically evaluate the intensity of banking competition by analyzing to what extend the market power, if it is present, is oriented towards increasing the quality for banking services. That is, whether the likely banking market power should be oriented to contribute to stability with benefit for borrowers. To empirically test this issue we propose a new method for defining and assessing competition and we apply it to the banking industry. The new method of market power measurement proposed takes advantage of the kindness that from duality offers the output oriented distance function allowing not only to measure the market power based on the bank optimal behavior where the bank investment on quality (i.e. stability) is controlled for, but measuring market power considering the multiproduct nature of the banks, an important issue uncover until now in the empirical literature. Moreover, an important advantage of the new method is that does not appeal data on bank prices for competition intensity measurement.

We conduct our empirical analysis on the European banking industry. Beside the important deregulation undergone by the European banking industry jointly with the establishment of Economic and Monetary Union (EMU), and the higher financial culture and technical progress in the European banking industry, the recent financial crisis has hit importantly to this industry. Thus, it should be interesting to investigate whether the banks in Europe face those changes by increasing or not their market power, and to what extend they are surviving in this changing environment investing in high-quality services and products. Particularly, our interest is to highlight whether, or not, European banking industry should operate with market power but oriented to protect the stability of the banking system.

Following this introduction, the rest of the paper has the following structure. Section 2 presents the theoretical model which, developed on the kindness that the duality of the output distance function bids, is used as benchmark for the estimation of the market power, and how it can be empirically implemented. Section 3 presents model on bank behavior that allow us to implement the new method for measuring market power to the case of the banking industry. The empirical results are presented in Section 4, and Section 5 concludes.

2. OUTPUT ORIENTED DISTANCE FUNCTION: NEW APPROACH FOR MEASUREMENT MARKET POWER

In this section we first present a theoretical model of firm optimization behavior assembled on the kindness that the duality of output oriented distance function offers to define the new measurement of market power. After that, the empirical model for estimating the market power at the firm level is provided.

2.1. Theoretical model and the output oriented distance function: Market power measurement

Assuming that the goal of the firm is to maximize profits, the optimization problem for each firm belonging to any industry can be formulated as a two stage process (Kumbhakar and Lozano 2004; Kumbhakar 2006, pp. 48). In the first stage the firm, given an output vector, decides the input quantities by solving the optimization problem,

$$\begin{aligned} & \underset{\mathrm{x}}{Min}\ \mathrm{w'x} \\ & \mathrm{s.t.}\ \mathrm{D_o}(x, y, t) \end{aligned} \qquad (1)$$

Where, w is the input price vector, x the input quantity vector, and the technology constrains is represented by the output oriented distance function, i.e., D_O(***x***, ***y***, t), being y the output quantity vector. Actually, according to Shephard (1970), the output oriented distance function can be defined in terms of the production possibility set:

$$D_o(x, y) = min\left\{\delta : \frac{y}{\delta} \epsilon P(x)\right\} \qquad (2)$$

Where $\frac{1}{\delta}$ in equation (2) represents the factor to which can be increased the produced quantity of all the outputs given the technology described by the production possibility set, P(x). That is, for each input vector R_+^K , all the output vector $y\epsilon R_+^M$ that it should be possible to be produced is given by the production possibility set:

$$P(x) = \{y\ \in R_+^M : x\ can\ produce\ y\} \qquad (3)$$

Resolving the optimization problem (1), the minimum cost function C(**w**,***y***,t) is obtained. Once the minimum cost function is attained, in the second stage of the optimization problem, the firm maximize profit,

$$\underset{y}{\mathrm{Max}}\ \pi = \boldsymbol{p'}\ \boldsymbol{y} - \mathrm{C}(\boldsymbol{w}, \boldsymbol{y}, \mathrm{t}) \qquad (4)$$

where the firm chooses outputs and ***p*** represents the vector of the inverse demand function for such outputs.

Applying the first order condition for maximizing profit for one output m, we obtain

$$p_m\left(1 - \frac{1}{\varepsilon_m}\right) = \frac{\partial C}{\partial y_m} = MC_m \qquad (5)$$

were ε_m is the demand elasticity of the output y_m for the firm and, MC_m the marginal cost of the output y_m.

Considering the duality between the cost and the output oriented distance function (Färe y Primont, 1990), the cost function can be defined as:

$$C(\mathbf{w},\mathbf{y},t) = \underset{\mathbf{x}}{\text{Min}} \{\mathbf{w}'\mathbf{x} : \text{ Do}(\mathbf{x},\mathbf{y},\text{t}) \leq 1\} \tag{6}$$

Applying the envelopment theorem to (6) it is obtained:

$$\frac{\partial C(\text{y},\text{w},t)}{\partial y_m} = MC_m = \lambda \frac{\partial Do(\text{y},\text{w},t)}{\partial y_m} \tag{7}$$

Where λ is the Lagrange multiplier associated to the minimizing cost problem in equation (6). By replacing the marginal cost obtained from the first order conditions (5) with the results obtained in expression (7) the outcome is:

$$p_m\left(1-\frac{1}{\varepsilon_m}\right) = -\lambda\frac{\partial D_O(y,w,t)}{\partial y_m} \tag{8}$$

Multiplying both sides of expression (8) by y_m and dividing by $D_o(\mathbf{y}, \mathbf{w}, t)$, gives:

$$\frac{p_m y_m}{D_O(y,w,t)}\left(1-\frac{1}{\varepsilon_m}\right) = -\lambda\frac{\partial D_O(y,w,t)}{\partial y_m}\frac{y_m}{D_O(y,w,t)} == -\lambda\frac{\partial LnD_O(y,w,t)}{\partial Lny_m} \tag{9}$$

The expression (9) can be extended to any other output by applying the same algebraic operation. For instance, for the case of the output n should be obtained:

$$\frac{p_n y_n}{D_O(y,w,t)}\left(1-\frac{1}{\varepsilon_n}\right) = -\lambda\frac{\partial LnD_O(y,w,t)}{\partial Lny_n} \tag{10}$$

Where ε_n is the demand price elasticity of the output y_n of the firm.

The expressions (9) and (10) can be re-written as follow:

$$\frac{\text{P}_\text{m}\ \text{y}_\text{m}}{\text{Do}(\mathbf{y},\mathbf{w},\text{t})} = -\lambda\frac{\partial\,\text{Ln Do}(\mathbf{y},\mathbf{w},\text{t})}{\partial\,\text{Ln y}_\text{m}}\theta_\text{m} \tag{11}$$

$$\frac{\text{P}_\text{n}\ \text{y}_\text{n}}{\text{Do}(\mathbf{y},\mathbf{w},\text{t})} = -\lambda\frac{\partial\,\text{Ln Do}(\mathbf{y},\mathbf{w},\text{t})}{\partial\,\text{Ln y}_\text{n}}\theta_\text{n} \tag{12}$$

Were θ_m and θ_n are the “mark-up” on price of the outputs m and n, respectively:

$$\theta_m = \left(1 - \frac{1}{\varepsilon_m}\right)^{-1} \; ; \; \theta_n = \left(1 - \frac{1}{\varepsilon_n}\right)^{-1}$$

Dividing (11) by (12) gives:

$$\frac{P_m\ y_m}{P_n\ y_n} = \frac{\dfrac{\partial \text{Ln Do}(\mathbf{y}, \mathbf{w}, t)}{\partial \text{Ln } y_m}}{\dfrac{\partial \text{Ln Do}(\mathbf{y}, \mathbf{w}, t)}{\partial \text{Ln } y_n}} \frac{\theta_m}{\theta_n} \tag{13}$$

Thus, the ratio between the elasticity of the output oriented distance function, corrected by their respective mark-up is equal to the ratio between the observed revenues of such outputs. Then, if $\theta_m > 1$ and $\theta_n > 1$ mean that the firm accounts with market power in each output market. Contrary, if $\theta_m = \theta_n = 1$, the output markets will be competitive.

2.3. Empirical implementation of the market power measure based on the output oriented distance function

To handle empirically with the output distance function it is necessary to define its parametric specification. A translog functional form is defined given its adjacent flexibility. For the case of M outputs and K inputs, the translog distance function is given by:

$$\begin{aligned} \text{Ln } D_{oi} = {} & \alpha_0 + \sum_{m=1}^{M} \alpha_m \text{ Ln } y_{mi} + 0.5 \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \text{ Ln } y_{mi} \text{Ln } y_{ni} + \sum_{k=1}^{K} \beta_k \text{ Ln } x_{ki} + \\ & + 0.5 \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \text{ Ln } x_{ki} \text{Ln } x_{li} + \sum_{k=1}^{K} \sum_{m=1}^{M} \gamma_{km} \text{ Ln } x_{ki} \text{Ln } y_{mi} + \rho_t\, t + 0.5\, \rho_{tt}\, t^2 + \\ & + \sum_{m=1}^{M} \rho_m\, t \text{ Ln } y_{mi} + \sum_{k=1}^{K} \rho_k\, t \text{ Ln } x_{ki} \end{aligned} \tag{14}$$

Where, the subscripts i denotes the bank. The symmetry restrictions require the follow parameters conditions:

$$\alpha_{mn} = \alpha_{nm} \quad \text{y} \quad \beta_{kl} = \beta_{lk}$$

Additionally, the homogeneity of degree one restrictions in outputs requires:

$$\sum_{m=1}^{M} \alpha_m = 1$$

$$\sum_{m=1}^{M} \alpha_{mn} = 0$$

$$\sum_{m=1}^{M} \gamma_{km} = 0$$

$$\sum_{m=1}^{M} \rho_m = 0$$

One way to impose those restrictions on homogeneity is to normalize the function by one output (Lovell et al., 1994). This transformation enables to estimate equation (14) as a regression model. If one of the outputs is arbitrarily chosen for normalization, for instance M, then:

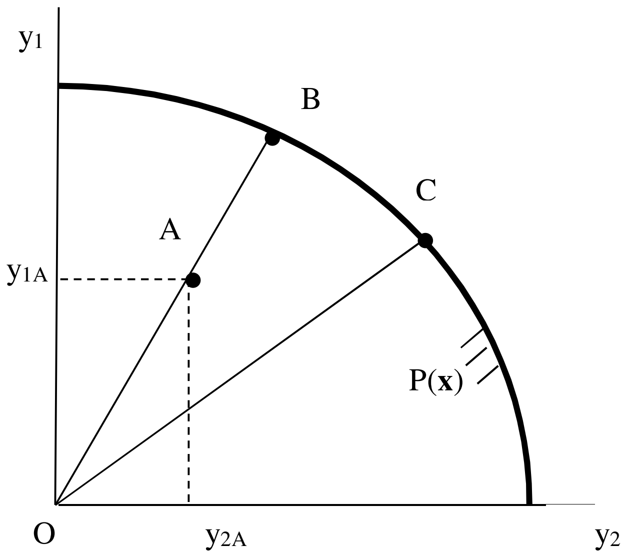
$$\mathrm{Do}\,(\mathbf{x}, \frac{\mathbf{y}}{y_m},\ t) = \frac{1}{y_m}\mathrm{Do}\,(\mathbf{x}, \mathbf{y},\ t)$$

Thus, the translog function given by expression (14), can be re-written as;

$$\begin{aligned} \mathrm{Ln}\,(\frac{D_{oi}}{y_M}) = {} & \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \,\mathrm{Ln}(\frac{y_{mi}}{y_M}) + 0.5\sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \alpha_{mn}\,\mathrm{Ln}\,(\frac{y_{mi}}{y_M})\mathrm{Ln}\,(\frac{y_{ni}}{y_M}) + \sum_{k=1}^{K} \beta_k \,\mathrm{Ln}\, x_{ki} + \\ & + 0.5\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl}\,\mathrm{Ln}\, x_{ki}\mathrm{Ln}\, x_{li} + \sum_{k=1}^{K}\sum_{m=1}^{M-1} \gamma_{km}\,\mathrm{Ln}\, x_{ki}\mathrm{Ln}\,(\frac{y_{mi}}{y_M}) + \rho_t\, t + 0.5\,\rho_{tt}\, t^2 + \\ & + \sum_{m=1}^{M-1} \rho_m\, t\,\mathrm{Ln}\,(\frac{y_{mi}}{y_M}) + \sum_{k=1}^{K} \rho_k\, t\,\mathrm{Ln}\, x_{ki} \end{aligned} \tag{15}$$

Recall that given expression (2) the output distance function has been defined as in terms of the production possibility set. Thus, the function D_{oi} in equation (15) measures the distance of the firm i to the production transformation frontier, that is, the radial increase that could have all the outputs, given the technology and an available input quantity. For illustration, in Figure 1 is represented the production possibility set for the case of two outputs, y_1 and y_2, given an input vector $\boldsymbol{x}$. The value of the distance function for the firm that produce the point quantity A is equal to the ratio δ = OA/OB. It can be observed that the points B and C are on the frontier of the production possibility set and then the value of the distance function is equal to 1. Thus, if $\boldsymbol{y} \in$ P($\boldsymbol{x}$), the $D_O(\boldsymbol{x},\boldsymbol{y}) \leq 1$.

Figure 1. Production Possibility Set



Observe that the distance function of the firm is as well equivalent to the inverse of the Farrell technical efficiency measure oriented to output. Moreover, the distance function $D_O(\boldsymbol{x}, \boldsymbol{y})$ must set the properties of non-decreasing, convexity and lineally homogenous in outputs; and non-increasing and quasi-convex in inputs (Färe and Primont, 1995). The technical change effect it will be capture by introducing a time exogenous variable, t. Thus, the distance function with output orientation will be represented by $D_O(\boldsymbol{x}, \boldsymbol{y}, t)$ as it was used in all the above expressions. This equivalence of the distance function to the inverse of the Farrell technical efficiency measure enrich our method for measuring market power based on the output distance function since allow to use an unique framework for measuring market power taking into account the multiproduct nature of any firm and without using bank prices, but also to measure the productive efficiency of the firms. Thus, recalling to the literature of stochastic frontier approach, this distance is due to technical inefficiency and it is able to empirically measure it just turning equation (15) in a stochastic frontier. To do that, it is only necessary to add a symmetric error, v_i, that captures the random error, and D_{oi} is replaced by e^{-u_i}, being u_i a random variable non negative that captures the technical inefficiency. The stochastic distance function with output orientation will be defined by:

$$-\mathrm{Ln}(y_M) = \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \mathrm{Ln}(\frac{y_{mi}}{y_M}) + 0.5 \sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \alpha_{mn} \mathrm{Ln}(\frac{y_{mi}}{y_M}) \mathrm{Ln}(\frac{y_{ni}}{y_M}) + \sum_{k=1}^{K} \beta_k \mathrm{Ln}\, x_{ki} +$$
$$+0.5 \sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} \mathrm{Ln}\, x_{ki} \mathrm{Ln}\, x_{li} + \sum_{k=1}^{K}\sum_{m=1}^{M-1} \gamma_{km} \mathrm{Ln}\, x_{ki} \mathrm{Ln}(\frac{y_{mi}}{y_M}) + \rho_t\, t + 0.5 \rho_{tt}\, t^2 + \qquad (16)$$
$$+ \sum_{m=1}^{M-1} \rho_m\, t\, \mathrm{Ln}(\frac{y_{mi}}{y_M}) + \sum_{k=1}^{K} \rho_k\, t\, \mathrm{Ln}\, x_{ki} + u_i + v_i$$

If $u_i = 0$ means that the distance function takes the value 1, with the firm producing on the frontier, while values of $u_i > 0$ means that the firm is producing below the frontier, that is it has technical inefficiency. The parameters of this function can be estimated by maximum likelihood once the distribution for $v_{i,}$ y u_i have been defined.

3. BANK MARKET POWER MEASUREMENT

Once we have presented the new method to measuring the market power based on the output distance function, the next step is to fit it to the special case of the banking industry. Thus, this section presents first a model on banking behavior where the unique characteristics of the bank are accounted for. Then, the market power measurement, obtained in the previous section, is accommodated to the banking firm.

To establish how bank behaves we resort to the standard Monti-Klein model as a simple version of bank imperfect competition model which it has been extensively used in the banking literature [Klein (1971), Monti (1973) and Slovin & Shuska (1983) and Sastre, (1991), among others]. The bank is assumed to develop their activities into two not competitive markets: the loan and the deposit markets, and two competitive markets: the bonds and the interbank markets. Taking into account that the bank's balance sheet constrain requires that the total liabilities has to be equal to the total assets, that is

$$L + A + R = M + D \qquad (17)$$

were L is the amount of loans, A the amount of others earnings assets (composed basically by bonds), R the amount of reserves, M the net interbank activity of the bank and D the amount of deposits. Thus, R = qD, where q is the bank reserve rate, and given that the net position of the bank in the interbank market is given by M = L + A – (1-α)D, the profit of each bank at each time can be settled as:

$$\pi(D,L,A) = (r_L - r)L + (r_A - r)A + [r(1-\alpha) - r_D]D - C(D,L,A) \qquad (18)$$

where r_L is the loan interest rate, r_A is the other assets interest rate, r is the interbank interest rate, r_D is the deposit interest rate. Being C(D, L, A) the operating cost of the bank, i.e. the cost of managing an amount of deposit, D, loans L and other earning assets, A. Thus, the bank profit is the sum of the intermediation margins on loan, other earning assets and deposit, once the operative cost are accounted for. It is assumed that the loan demand is non-increasing with the loan interest rate, $\frac{\partial L(r_L)}{\partial r_L} < 0$, while the deposits supply is increasing with the deposit interest rate, $\frac{\partial D(r_D)}{\partial r_D} > 0$. Considering the banking competition in the loan and deposit market, the loan demand (deposit supply) function for the bank i depends of the bias between of their own interest rate and the bank rivals interest rate. Following Corvosier y Gropp (2002) the average loan (deposit) interest rate of the industry is considered as proxy of the rival interest rate.

Following Freixas and Rochet (1997) we assume that the banks supply services on loan, other earning assets and deposits by using physical capital and labor. That is, the banking technology has a multiproduct nature.[1] Moreover, given that one of the aim of the paper is to attempt to evaluate whether banks are able to exercise market power when this is oriented towards increasing the quality of banking services and products, and thus to contribute to stability with benefit to borrowers, we resort to the modern approach in the banking literature for measuring the activity of banks (Huges and Mester, 1993a, b, 1994). As the modern approach of bank's activity states, proxies of quality of bank services which contribute to the information processing to the borrowers are accounted for in the context of the framework suggested by Hughes and Mester (1993), and Berger and DeYoung (1997). That is, by introducing in the cost function Q_1 and Q_2 as proxies of bank quality services. Consequently, our cost function of equation (18) turns out to be $C(D, L, A, Q_1, Q_2)$. Since banks behave maximizing profits, the first order condition are applying to resolve the maximization profits problem,

[1] See Benston (1965) and Bell and Bell y Murphuy (1968) for more detail about the definition of the production process of the banking industry.

$$\frac{\partial \Pi}{\partial L} = r_L^{'}(L)L + r_L(L)r - MCm_L(D, L, A, Q_1, Q_2) = 0;$$

$$r_L(1 - \frac{1}{\varepsilon_L}) - r \quad = MCm_L(D, L, A, Q_1, Q_2)$$

$$\frac{\partial \Pi}{\partial D} = \quad r(1 - \alpha) - r_D^{'}(D)D - r_D(D) - MCm_D(D, L, A, Q_1, Q_2) = 0;$$

$$r_D(1 + \frac{1}{\varepsilon_D}) = r(1 - \alpha) - MCm_D(D, L, A, Q_1, Q_2)$$

$$\frac{\partial \Pi}{\partial A} = r_A - r - MCm_A(D, L, A, Q_1, Q_2) = 0 \qquad (19)$$

The results obtained by applying the first order conditions imply that the bank set r_L when the marginal revenue is equal to the marginal cost; the deposit interest rate, r_D, when the bank is indifferent in financing with deposit or in the interbank market and r_A as aggregation of the interbank interest rate and the operative marginal cost. Once the optimal value of the interest rate for loans, deposits and other earning assets are established, the demand of loan and other earning assets and the supply of deposit are obtained. As consequence, and given the balance sheet constraint, the amount of bank reserve is reached, being the interbank activity the amount that permits to adjust the investment needed with the funds captured in the deposit market.

Once, the profit maximization problem of the bank is resolved, the next step is to attempt to implement the new method of measuring the market power for the case of the banking industry. First, given the multiproduct nature of the bank production process, it is able to represent the banking technology by the output oriented distance function defined in Section 2, where the banks incur in cost for managing loans, L, other earning assets, A, and deposit, D. Thus, considering the distance function $D_O(\boldsymbol{x}, \boldsymbol{y}, t)$, the above bank's first order conditions can be connected with the results obtained in equation (7), where in general term are $MC_m = \lambda \frac{\partial Do(\mathrm{y}, \mathrm{w}, t)}{\partial y_m}$. Therefore, the above first order conditions can be written as:

a) Loan interest rate:

$$r_L\left(1 - \frac{1}{\varepsilon_L}\right) - r = -\lambda \frac{\partial D_O(L, A, D, Q_1, Q_2, x, t)}{\partial L} \qquad (20)$$

b) Deposit interest rate:

$$r(1\text{-}\alpha) - r_D(1 + \frac{1}{\varepsilon_D}) = -\lambda \frac{\partial D_o(L, A, D, Q_1, Q_2, x, t)}{\partial D} \qquad (21)$$

c) Other earning asset interest rate:

$$r_A - r = -\lambda \frac{\partial D_o(L, A, D, Q_1, Q_2, x, t)}{\partial A} \qquad (22)$$

Considering that $\left(1 - \frac{1}{\varepsilon_L}\right) = \theta_L^{-1}$and $\left(1 + \frac{1}{\varepsilon_L}\right) = \theta_D^{-1}$, given equation (9) and operating algebraically, we can re-written equations (20)-(21) as:

$$\frac{r_L L - rL\theta_L^{-1}}{D_O(L, A, D, Q_1, Q_2, x, t)} = -\lambda \frac{\partial LnD_O(L, A, D, Q_1, Q_2, x, t)}{\partial LnL} \theta_L \qquad (23)$$

$$\frac{r\ D\ (1-\alpha) - r_D D\theta_D^{-1}}{D_O(L, A, D, Q_1, Q_2, x, t)} = -\lambda \frac{\partial LnD_O(L, A, D, Q_1, Q_2, x, t)}{\partial LnD} \theta_D \qquad (24)$$

$$\frac{r_A A - rA}{D_o(L, A, D, Q_1, Q_2, x, t)} = -\lambda \frac{\partial LnD_o(L, A, D, Q_1, Q_2, x, t)}{\partial LnA} \qquad (25)$$

Since in the banking model we have assumed that the market of bonds is competitive, then the bank behaves as price-taker in the other earning assets mark. Finally, dividing equations (23) and (24) by equation (25), then:

$$\frac{r_L\ L \quad r\,L\theta_L}{r_A\ A \quad r\,A} = \frac{\dfrac{\partial\ Ln\ Do(L, A, D, Q_1, Q_2, x, t)}{\partial\ Ln\ L}}{\dfrac{\partial\ Ln\ Do(L, A, D, Q_1, Q_2, x, t)}{\partial\ Ln\ A}} \theta_L \qquad (26)$$

$$\frac{r\,D(1 \quad \alpha)\theta_D \quad r_D\ D}{r_A\ A \quad r\,A} = \frac{\dfrac{\partial\ Ln\ Do(L, A, D, Q_1, Q_2, x, t)}{\partial\ Ln\ D}}{\dfrac{\partial\ Ln\ Do(L, A, D, Q_1, Q_2, x, t)}{\partial\ Ln\ A}} \theta_D \qquad (27)$$

Using expressions (26) and (27), with the information about the loan revenues and other earning assets revenues, deposit cost, and once we estimate the output oriented distance function, it is sable to identify the conduct parameters (mark-up) θ_L and θ_D for each bank. That is, to quantify the market power of the banks without needing banking prices, just revenue and cost information. Additionally, given that we have controlled for banking quality services and products on the cost function, it is able to determine which part of the market power is due to the cost that the banks support for investing in this higher-quality on services and products. That is, to additionally estimate the changes of the mark-up when the quality proxies change, i.e. $\frac{\partial \theta_L}{\partial Q_1} \quad and \quad \frac{\partial \theta_L}{\partial Q_2}$.

4. EMPIRICAL EXERCISE AND RESULTS

The interest of the empirical analysis is to test whether the European banks behaves with market power and whether this market power could be due to the fact that the banks invest in quality of their services and products.

To perform such analysis based in the new methodology for measuring market power defined from the output oriented distance function, we use a sample composed by banks belonging to nine European countries of the old European Union during the 1997-2011, which account with a total of 1895 observations. In particular, the sample account with information about banks from: Austrian, Belgium, Denmark, France, Germany, Italy, Portugal, Spain and UK. The information needed for the definition of the variables is obtained from the balance sheet and cost and revenue information of the BankScope database.

The definition and estimation of the stochastic distance function defined by the output oriented distance function described in equation (8) requires information about bank output and input. As bank outputs are defined: (i) loans (L) y (ii) other earning assets (A) y (iii) deposits (D); and bank inputs are used: labor (N) and physical capital (K). Due to data unavailability, we use personal expenses as proxy of labor and the physical capital is measure by the book value of fixed assets. Additionally, and in order to address our goal of controlling in the definition of the output oriented distance frontier for the bank quality services and products, we measure bank quality using two proxies of the bank risk preference, Q1 y Q2 following Hughes and Mester (1993), and Berger and DeYoung (1997), among others. Particularly, Q1 is defined as the financial capital ratio of the bank and Q2 is defined as the total loan loss provisions of the bank. Table 1 present the descriptive statistic of the variables used in the estimation.

TABLE 1. DESCRIPTIVE STATISTIC OF THE VARIABLES USED IN THE ESTIMATION

Variable	Obs	Mean	Std. Dev.	Min	Max
LABOR (N)	6895	3.093.987	1.002.111	1	13360
CAPITAL (K)	6884	3.504.355	1.129.307	0	14175.5
LOANS (L)	6895	14964.16	44806.47	10	415288
OTHER EARNING ASSETS (A)	6894	12451.05	45469.86	0	527715.5
DEPOSITS (D)	6895	19222.66	58397.64	22	440546.5
FINANCIAL CAPITAL (Q1)	6895	.0816824	.0495518	.012	.3902027
LOAN LOSS PROVISIONS (Q2)	6895	233.724	3.535.374	.19	926.67

As Section 3 point out, the functional form used in the estimation is a translog output oriented distance function. The results obtained in the estimation of output oriented distance function, once we have defined the above output and input and the bank quality proxies are shown in Table 2.

TABLE 2. OUTPUT ORIENTED DISTANCE FUNCTION

Variable	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Ln(N)	-.7766655	.0367424	-21.14	0.000	-.8486792	-.7046518
Ln(K)	-.182	.0313265	-5.81	0.000	-.2433988	-.1206011
Ln(L)	.4856324	.0823399	5.90	0.000	.3242492	.6470156
Ln(A)	.1490466	.0418758	3.56	0.000	.0669714	.2311217
Ln(D)	.365321	.116433	3.14	0.002	.1371165	.5935256
Ln(Q1)	.4143846	.0535292	7.74	0.000	.3094693	.5192999
Ln(Q2)	.0050965	.0276378	0.18	0.854	-.0490727	.0592656
T	-.0456378	.0355846	-1.28	0.200	-.1153824	.0241068
t.t	.0024954	.0058239	0.43	0.668	-.0089193	.0139101
Ln(N).t	-.0129501	.010303	-1.26	0.209	-.0331436	.0072433
Ln(K).t	.0148664	.0087472	1.70	0.089	-.0022777	.0320106
Ln(L).t	-.0336209	.0196044	-1.71	0.086	-.0720448	.0048029
Ln(A).t	-.0033485	.0086077	-0.39	0.697	-.0202193	.0135224
Ln(D).t	.0369694	.0257146	1.44	0.151	-.0134303	.0873691
Ln(Q1).t	.0083909	.0158294	0.53	0.596	-.0226341	.0394159
Ln(Q2).t	.0080252	.0083227	0.96	0.335	-.008287	.0243374
Ln (N).Ln(N)	.0423961	.0098841	4.29	0.000	.0230236	.0617685
Ln(K).Ln(K)	-.0419935	.007575	-5.54	0.000	-.0568403	-.0271468
Ln(L).Ln(L)	-.0144229	.0979731	-0.15	0.883	-.2064466	.1776008
Ln(A).Ln(A)	-.018826	.0144666	-1.30	0.193	-.04718	.0095281
Ln(D).Ln(D)	-.1995836	.2116579	-0.94	0.346	-.6144254	.2152582
Ln(Q1).Ln(Q1)	.2630191	.0670559	3.92	0.000	.131592	.3944462
Ln(Q2).Ln(Q2)	.0238525	.0132866	1.80	0.073	-.0021888	.0498938
Ln(N).Ln(L)	-.1482978	.0381029	-3.89	0.000	-.2229781	-.0736176
Ln(N).Ln(A)	.0064631	.0155838	0.41	0.678	-.0240806	.0370068
Ln(N).Ln(D)	.1418347	.0487166	2.91	0.004	.046352	.2373175
Ln(N).Ln(Q1)	.0970466	.0311779	3.11	0.002	.035939	.1581542
Ln(N).Ln(Q2)	-.0056384	.0156737	-0.36	0.719	-.0363583	.0250816
Ln(K).Ln(L)	.0329745	.0322781	1.02	0.307	-.0302894	.0962385
Ln(K).Ln(A)	-.0202692	.0123096	-1.65	0.100	-.0443956	.0038572
Ln(K).Ln(D)	-.0127053	.0411535	-0.31	0.758	-.0933647	.067954
Ln(K).Ln(Q1)	-.0066612	.0246194	-0.27	0.787	-.0549143	.041592
Ln(K).Ln(Q2)	.0295352	.0123543	2.39	0.017	.0053213	.0537492
Ln(L).Ln(A)	-.0831674	.0619827	-1.34	0.180	-.2046513	.0383165
Ln(k).Ln(D)	-.0127053	.0411535	-0.31	0.758	-.0933647	.067954
Ln(L).Ln(Q1)	-.3573407	.0582035	-6.14	0.000	-.4714175	-.2432638
Ln(L).Ln(Q2)	-.0101333	.0295583	-0.34	0.732	-.0680664	.0477998
Ln(A).Ln(Q1)	-.0009387	.0263358	-0.04	0.972	-.0525559	.0506784
Ln(A).Ln(Q2)	-.039677	.0149116	-2.66	0.008	-.0689032	-.0104508
Ln(D).Ln(Q1)	3582794	.0773236	4.63	0.000	.2067279	.5098309
Ln(D).Ln(Q2)	.0498103	.0406972	1.22	0.221	-.0299546	.1295753
Ln(Q1).Ln(Q2)	.1034761	.023728	4.36	0.000	.05697	.1499821

TABLE2. OUTPUT ORIENTED DISTANCE FUNCTION (cont.)

	Coefficient	Std. Err.	z	P>z	95% confident interval	
_Icountryc~2	.1101662	.0700167	1.57	0.116	-.027064	.2473965
_Icountryc~3	.1480575	.0522178	2.84	0.005	.0457125	.2504026
_Icountryc~4	.3145613	.0584277	5.38	0.000	.2000452	.4290774
_Icountryc~5	.0740258	.0566365	1.31	0.191	-.0369796	.1850313
_Icountryc~6	.3288386	.0529008	6.22	0.000	.2251548	.4325223
_Icountryc~7	-.1360563	.0587399	-2.32	0.021	-.2511844	-.0209282
_Icountryc~8	.2594249	.0569247	4.56	0.000	.1478545	.3709952
_Icountryc~9	-.1490799	.0684617	-2.18	0.029	-.2832624	-.0148974
_cons	.3148015	.0752825	4.18	0.000	.1672506	.4623524

Likelihood-ratio test of sigma_u=0: chibar2(01) = 8.40   Prob>=chibar2 = 0.002

Following our model, we have introduced a time trend variable, as well as country dummy variables. As it can be observed in Table 2, the estimation parameters show the expected sign. In particular, paying our attention to the sign of the two bank quality services, Q1 y Q2, it can be observed that both of them have a positive sign and are statistically significant. Particularly, the variable that gives information about solvency (financial capital) of the bank, Q1, has a higher impact and significance than the variable regarding loan loss provisions, Q2.

Once the output oriented distance function is estimated, taking information about revenues on bank loan and other earning asset, on deposit cost and the interbank interest rate from the data, it is possible to identify and estimate the conduct parameter (mark-up), following the equations (12) and (13) shown in Section 4. Tables 3 and 4 present the information of those parameters, for each year (Table 3) and for each country (Tabla 4).

TABLE 3. MARK-UP PARAMETER BY YEAR

Year	Mean ϴD	Mean ϴL
1997	2.4296	1.1237
1998	2.025	1.6712
1999	2.4608	1.1355
2000	1.3584	1.2397
2001	1.8901	1.344
2002	2.7371	1.2118
2003	3.108	1.3477
2004	2.5281	1.2522
2005	2.9983	1.4052
2006	1.3667	1.6467
2007	0.8826	1.7611
2008	0.8644	1.5741
2009	1.4966	0.9279
2010	2.4761	1.0167
2011	2.1972	1.0872

TABLE 4. MARK-UP PARAMETER BY COUNTRY

Country	Mean ϴD	Mean ϴL
AT	0.9464	1.2719
BE	1.8242	1.9056
DE	1.2362	1.2885
DK	1.4913	1.4475
ES	1.4287	1.64
FI	1.8553	0.8671
FR	1.8471	1.5202
GB	1.9876	2.0154
GR	2.7376	2.5473
IT	1.5908	1.2884
LU	1.5644	1.8425
NL	3.2326	2.029
PT	2.3113	2.0201
SE	1.2016	1.0095

The results show that the European banks operate with market power, in the loan and deposit market during the analyzed period (Tabla 3). Moreover, we can observe that the market power is higher in the deposit market than in the loan market. Those results are hold by some countries but others appear with higher markup in the loans market, Tabla 4. Thus, overall it seems that the banking industry of each European country has market power since the mark-up parameter is higher than one. Thus, those results suggest that the liberalization and the deregulation of the banking industry in Europe did not get the expected outcome, i.e. to reach a perfect competitive banking market. Those results are in line with those obtained by Maudos and Guevara (2004) and Kumbakhar y Lozano-Vivas, 2005, and Casu and Girardone (2009), among others.

The estimation of the conduct parameters (mark-up) give information about whether market power exists or not, but the methodology constructed allows to obtain some additional information, as well. That is, to know the effect of the specific characteristics related with the signal that the banks give to the consumers in terms of quality of their bank services and products on mark-up. In particular, our model permits to estimate not only mark-up but also to know how the mark-up changes when the bank differentiate in higher-quality, i.e. to estimate, $\frac{\partial \theta_L}{\partial Q_1};\frac{\partial \theta_L}{\partial Q_2}$. Given that our methodology is using equilibrium set those changes are given us information about how much the borrowers are willing to pay for higher-quality. The expected sign for each quality proxy is as follow: $\frac{\partial \theta_L}{\partial Q_1} \succ 0;\frac{\partial \theta_L}{\partial Q_2} \prec 0$. That is, if the bank is more solvent, higher Q_1, the bank should have less probability for bankruptcy and that will permit a longer relationship with the client. At the same time, a signal of higher solvency of the bank imply that the borrower accept to pay for it as higher markup, as precludes the refinancing effect. Contrary, as loan loss provision seems to be a quality proxy for a bank's ability to screen and monitor, i.e. to avoid losses (or in the opposite case the bank's willingness to take on risk in its loan portfolio), if banks have low (high) loan loss provisions then they have a high-quality (low-quality) loan portfolio, in which case borrowers should be willing to pay a higher (lower) mark-up to those banks, i.e. the certification effect.

The results obtained are $\frac{\partial \theta_L}{\partial Q1} = 0.3244$ and $\frac{\partial \theta_L}{\partial Q2} = -0.1702$. Those results suggest that the banks include in their markup the cost that they assume for increasing the quality of their services and products and the borrowers are willing to pay for it. In particular, those results seem to show that the borrowers preferences on banking quality are more related with solvency, that is with the ability of banks to prevent fragility and to their ability to generate loans in the future and , therefore, to maintain stable relationships with them given the higher impact of Q_1 over the markup, than account with information about the risk of the bank loan portfolio. In terms of the banking theory, those results are in line with the hypothesis of the *refinancing effect* described in the Introduction. Those results are similar to those obtained by Lozano-Vivas (2009) where the structural banking model obtained from the theoretical model of Kim et. al (2005) was estimated.

Overall, the results seems to suggest that the banks in Europe attempt to use the vertical product differentiation strategy to obtain a good reputation for quality in regard to their banking services and products, and thus seek to soften competition from rival banks. That is, they acquire a market power that turn out to be great enough for borrowers to be willing to pay a premium over the loan interest rate in exchange for assurances that they are working with banks with adequate levels of solvency and less but also for banks that are willing to screen their loan portfolio. These results suggest that in the European banking industry there seems to be a trade-off between competition and banking stability.

As last exercise, we are interested to take advantage of the estimation of an stochastic output oriented distance function that give us information also about the technical efficiency of the banks as we pointed out in Section 2.

The technical inefficiency level for each European country are around the 24%. Interesting enough it is to observe that the banking industry that account with higher loan mark-up are not more inefficient. Those results seem to suggest that given the willingness of bank customers to pay, those banks that invest in quality are more efficient and, at the same time, have greater market power. Thus it seems that contrary to what is expected in the traditional IO that postulates that only competition is important for efficiency, it seems that for the banking industry market power may also provide some benefits.

5. CONCLUSIONS

The contribution of this paper haves been to define a new methodology that permits to measure the markup using the advantages that the duality between the output oriented distance function and the cost function haves. That allows to estimate the markup without the needs to account for information on prices that is an important disvantages when the markup is measure using the Lerner index. Moreover, the new methodology allows to disentangle which part of the banking markup should be attributed to a higher investment of the banks in quality of their services and products.

This new mark-up measurement haves been used to test whether the banking industry in Europe are operating with markup and whether in this markup is due to the fact that the banks are investing in higher quality. By recurring to the Banking microeconomic and defining the refinancing and the certification effect that the banks can use as signal to show to the borrowers a higher quality of their services and their products, we have introducing the loan loss provisions and the capital to assets ratio as proxies of a signal of the banks that they are investing in quality.

The empirical exercise has been orientated to evaluate the market power intensity of the European banking industry for the period 1999-2003. The results point out that the banking industry in Europe has developed their activity with market power, and this market power is higher in the loan than in the deposit market. Moreover, this market power is partially due to the capacity that the banks in Europe have had in order to invest for differentiate from the rivals in terms of quality of their services and products. The loan loss provisions and the solvency ratio have been used as proxies of quality. Taking into account those two quality proxies the results our new methodology also permits us to determinate the intensity which what the mark-up changes when the banks decide increase their investment on those quality. Overall, the results show that the markup in loans change with more intensity when face changes of solvency than on loan loss provisions. Thus, it seems that overall the banks in Europe attempt to use the vertical product differentiation strategy to obtain a good reputation for quality in regard to their banking services and products by acquiring a market power that turn out to be great enough for borrowers to be willing to pay a premium over the loan interest rate in exchange for assurances that they are working with banks with adequate levels of solvency and less but also for banks that are willing to screen their loan portfolio. It seems that in the European banking industry shows a trade-off between competition and banking stability. Interesting enough are the finding that show that even the banking industry in Europe operate with market power however the managers seems not to follow the "quite life" since the banking industry with higher market power also reach higher technical efficiency. Thus, in contrary with the expected from the traditional IO, not only competition but the banking industry market power may also provide some benefits.

REFERENCES

Allen, F. and Gale, D. (2000): “Bubbles and crisis”, *Economic Journal*, 110, 236-255.

Becl.T. A., Demirguc-Kunt and R. Levine (2005): “Bank concentration and fragility: Impact and mechanics”. NBER Working Papers.

Bell, F. W., and Murphy N.B. (1968): “Economies of scale and division of labor in commercial banking”, *National Banking Review*, 5, 131-139.

Benston, G. J. (1965): “Branch banking and economies of scale”, *Journal of Finance*, 20, 312-331.

Berger, A. N. and DeYoung, R. (1997): Problem loans and cost efficiency in commercial banks”, *Journal of Banking and Finance* 21, 849–870.

Berger A.N. and Hannan, T. H. (1998): “The Efficiency cost of market power in the banking industry: a test of the “quite life” and related hypotheses”, The Review of Economics and Statistics, 80 (3), 454-465.

Bikker J. and Haaf, K. (2002): “Competition, Concentration and their relationship: An empirical analysis of the Banking Industry*”, Journal of Banking and Finance* 26, 2191-2214.

Coelli, T.J., Prasada Rao, D.S., O`Donnell, C.J. and Battese, G.E. (2005): *An introduction to efficiency and productivity analysis.* 2nd ed. Springer: New York.

Colwell, R. J., and Davis, P. (1992). “Output and productivity in banking”, *Scandinavian Journal of Economics*, 94, 111-129.

Corvoisier, S. and Gropp, R. (2002): “Bank concentration and retail interest rates”, *Journal of Banking and Finance* 26, 2155-2189.

Cuesta, R.A. and Orea, L. (2002): “Mergers and technical efficiency in Spanish savings banks: a stochastic distance function approach”. *Journal of Banking and Finance*, 26, 2231 - 2247.

De Bandt, O. and Davis, P. (2000): “Competition contestability and Market Structure in European Banking Sectors on the eve of EMU”, *Journal of Banking and Finance* 24, 1045-1066.

Färe, R., and Primont, D. (1990): “A distance function approach to multi-output technologies”, *Southern Economic Journal* 56, 879–891.

Färe, R., and Primont, D. (1995): *Multi-output production and duality: Theory and applications*. Kluwer Academic Publishers: Norwell.

Freixas, X. and Rochet, J.C. (1997): *Microeconomics of Banking*, The MIT Press, Cambridge, MA.

Hannan T. (1991): "Bank commercial loan markets and the role of market structure: Evidence from surveys of commercial lending", *Journal of Banking and Finance* 15, 133-149.

Hughes, J.P. and Mester, L.J. (1993): "A quality and risk-adjusted cost function for banks: Evidence on the Too-Big-to-Fail doctrine", *Journal of Productivity Analysis*, 4(3), 293-315.

Kim, M., Kristiansen, E. G. and Vale, B. (2005): "Endogenous product differentiation in credit markets: What do borrowers pay for?", *Journal of Banking and Finance*, 29(3), 681-699.

Klein, M., (1971): "A theory of the banking firm", *Journal of Money, Credit and Banking* 3, 205-18.

Kumbhakar, S. (2006): "Productivity and Efficiency Measurement Using Parametric Econometric Method", en Bagella, M. , Hasan, I. y Becchetti, L. (ed.), *Transparency, Governance and Markets,* Elsevier, Oxford.

Kumbhakar, S., and Lovell, C.A.K. (2000): *Stochastic frontier analysis.* Cambridge University Press. New York, 2000.

Kumbhakar, S. and Lozano-Vivas, A. (2004): "Does deregulation make markets more competitive? Evidence of mark-ups in Spanish savings banks", *Applied Financial Economics,* 14: 507–15.

Maudos, J. and Fernández de Guevara, J. (2004): "Factors explaining the interest margin in the banking sectors of the European Union", *Journal of Banking and Finance* 28 (9), 2259–2281.

Molyneux P., Lloyd-Williams, D.M. and Thornton, J. (1994): "Competitive conditions in European Banking", *Journal of Banking and Finance* 18, 445-459.

Monti, M. (1972): "Deposit, credit, and interest rate determination under alternative bank objectives", en G.P. Szego and K. Shell (eds.), *Mathematical methods in investment and finance*, Amsterdam, North-Holland.

Sastre, M.T. (1991): *La determinación de los tipos de interés activos y pasivos de bancos y cajas de ahorro,* Estudios Económicos 51, Banco de España.

Shaeck,K., Cihak M. and Wolfe, S. (2006): "Are more competitive banking systems more stable?, IMF Working Paper.

Schaeck, K. and Cihak M. (2007): "Banking competition and capital ratios", IMF Working Paper.

Shephard, R.W. (1970): *Theory of Cost and Production Functions*. Princeton University Press, Princeton.