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**Abstract**

Evidence is presented on the long and short run relationship between the money market interest rate and loan and deposit interest rates charged by individual Spanish banks between 1988 and 2003. The results indicate that such relationships have been determined by a mixture of adjustment costs and market power of banks, which creates interest rate rigidity and asymmetries in the speed at which increases and decreases in the money market interest rate are translated into banking interest rates. We also find that the price adjustment speed first decreases and later increases with market concentration, which is consistent with predictions from models that assume quantity adjustment costs.

**JEL:** D40, L11.

**Key words:** interest rates rigidity, quantity adjustment costs, market power, market concentration.

## 1 Introduction

The speed and symmetry of price adjustments to changes in market conditions or to macroeconomic shocks affect economic efficiency since there may be missallocation costs when prices are not in equilibrium. Price rigidity has been related to market structure [Means (1935), Hall and Hitch (1939)] and, more recently, to costs faced by firms when they change prices. The costs can be direct, for example menu costs [Rotemberg (1982); Rotemberg and Saloner (1986); Benabou and Gertner (1993)], or indirect when firms face quantity adjustment costs [Ginsburgh and Michel (1988); Pindyck (1993), (1994); Borenstein et al. (1997)]. Fixed or variable costs at changing prices, together with a price inelastic demand for the product, cause changes in the profit maximizing prices to lag behind changes in production costs. One important piece of research is to study the effect of market power on the price adjustment speed [Carlton (1986)].

In the case of loan and deposit interest rates, the flexibility in the adjustments to changes in the money market interest rate determines the effectiveness of the monetary policy and the relationship between money supply and aggregate output. Research on interest rate rigidity using bank level data started in the US with papers such as Hannan and Berger (1991), Neumark and Sharpe (1992) and Hannan (1994) on deposit interest rates; and Ausubel (1989) and Calem et al. (1995) on credit card loans. More recent pieces of work focus on European countries, such as Hofman and Mizen (2004) for the UK, Gambacorta (2004) for Italy, Weth (2002) for Germany and De Graeve et al. (2004) for Belgium.[1]

This paper develops a microeconomic analysis of price rigidity in loan and deposit markets to changes in the money market interest rate. Unlike Hannan and Berger (1991), which carries out a menu cost analysis, we do so allowing for adjustment costs in the quantity of loans and deposits [Flannery (1982)]. The empirical study uses annual interest rates, quoted on a monthly basis by individual Spanish banks, of four loan and four deposit products. In this period, nominal money market interest rates evolved from a high level of 15% in 1989 to a low rate around 3% in 2003. Our research questions include the magnitude and stability of the adjustment speed over time, its symmetry to an increase or a decrease in the money market interest rate, differences across bank products and the relationship between price rigidity and variables associated with market structure and behaviour of banks, such as market concentration, demand growth and price collusion.

As one of its relevant contributions, this paper contains a thorough discussion of the relationship between market power and the price adjustment speed under supply adjustment costs (versus direct price adjustment costs) and under alternative market structures and behaviour of banks. Theoretical results show that, when price adjustment costs are *direct* (for example menu costs), factors that lower bank market power (such as the deposit supply

**1.** Other related papers are Moore et al. (1988) and Diebold and Sharpe (1990), which study interest rates rigidity in the US using aggregate deposit interest rates. Scholnick (1999) does the same but with loan and deposit interest rates from US and Canada. Barreira et al. (1999) and Oroz and Salas (2003) perform a similar exercise for the case of Spain using aggregate loan and deposit interest rates. Hannan and Liang (1992) use the same US individual bank data on deposit interest rates as Hannan and Berger (1991) to study the relationship between market concentration and the long run pass-through parameter of changes in the base rate to changes in deposit rates. Sastre (1997) replicates the analysis for the case of Spain. Berstein and Fuentes (2003) study the relationship between price rigidity and market concentration for the case of deposit interest rates in Chile.

and loan demand slopes) increase the price adjustment speed. In this situation, conditions that favor higher bank market power also increase interest rate rigidity. However, when costs of changing interest rates are *indirect* (for example quantity adjustment costs), the relationship between market power and price rigidity is more ambiguous and higher market power can be associated with higher or lower speed in price adjustment.

This paper studies interest rate rigidity in loan and deposit products of different maturity using bank level data and actual interest rates charged by Spanish banks that represent over 90% of the Spanish retail banking industry. Unlike deposits, loan markets are affected by information asymmetries between borrowers and lenders that result in adverse selection and credit rationing [Stiglitz and Weiss (1981)]. Although much less is known about it, credit rationing may create interest rate rigidity even in the absence of adjustment costs, especially in response to upward changes in the interest rates [Berger and Udell (1992)]. The study is performed under a unified framework for both types of bank products and considering that price rigidity can be the result of quantity adjustment costs. Previous work with bank level data in the US has concentrated mainly on interest rate rigidity for deposits and focused on loans only in particular cases, such as credit cards. Moreover, the underlying theory is not always outlined in detail, especially in some papers [such as Neumark and Sharpe (1992)] that make no explicit distinction between predictions from menu and supply adjustment costs.

Papers on interest rate rigidity in other European countries are mostly concerned with banks characteristics that affect price rigidity within the broader topic of interest rate transmissions after monetary policy decisions. Papers that also use bank level data, such as De Graeve et al. (2004), study prime rates fixed by banks but not the actual interest rates at which transactions are made. As for this paper, it uses actual interest rates charged by banks in both loans and deposits and it is mainly concerned with the effects of market structure, instead of bank characteristics, on interest rate rigidity. Finally, the long period of time covered by the data permits to analyse the stability of the adjustment speed over time and evaluate the results in terms of the effects of introducing the Euro as a single European currency.

Overall, this paper is inspired by the Industrial Organisation tradition where market performance is associated, in a negative way, with relative profit margin (as measuring market power) and, positively, with price adjustment speed. Higher relative profit margin implies higher dead weight losses and therefore, it can be considered as an inverse measure of static efficiency. A higher price adjustment speed shall be an attribute of market flexibility and lower misallocation costs, and then it can be associated with dynamic efficiency. Both market power and the speed of price adjustment are endogenous variables that depend on the market structure, the behaviour of banks and the nature of the adjustment costs. Therefore, the empirical study of the interest rate adjustment over time will be highly informative about the evolution of market power of Spanish banks.

Our results give evidence for substantial and non-symmetric rigidity in Spanish interest rates, although the actual adjustment speed varies across products. We also find that the non-monotonic response of the adjustment speed to market concentration is consistent with an oligopolistic market structure where banks face quantity adjustment costs in loans and deposits. Loan interest rate rigidity is lower among commercial banks than among savings banks, but no difference is observed between both types of banks in case of deposits. Larger banks show higher interest rate rigidity than small banks, but the effect of size is consistently statistically significant only in loans. Interest rate rigidity is higher in markets with higher population growth and the economic significance of the effect of market growth on price rigidity is higher in deposits than in loan products. The Euro has not altered the basic pattern of interest rate rigidity in loans and deposits.

The paper is structured as follows. Section 2 presents the conceptual framework under which we study interest rates rigidity and its determinants. In section 3 we present the data and the methodology used; section 4 contains the empirical results from the estimation of models that measure and explain interest rate adjustments to changes in the money market interest rate; finally, section 5 presents a discussion of the main results and conclusions.

## 2 Theory and literature review

It is often assumed in the interest rate transmission literature that interest rate adjustments will take place at a lower pace in markets where firms have more market power [Hannan and Berger (1991); Rosen (2002)]. This assumption is also implicit in all the empirical literature on transmissions of changes in monetary conditions [Neumark and Sharpe (1992); Hofmann and Mizen (2004); Gambacorta (2004); De Graeve et al. (2004)]. If this was true, factors that increase market power would lower market efficiency in both static terms (higher relative profit margin or Lerner index) and dynamic terms (low price adjustment speed). However, as Borenstein and Shepard (2002) indicate, the link between market power and price adjustment speed is not as straightforward as it may seem. In this section we present an overview of factors that determine market power and their relationship with the speed of interest rate adjustments for bank deposits. We consider different combinations of banks' decision variables (price or quantity), market structures (monopoly, oligopoly), behaviour of firms (conjectural variations) and sources of adjustment costs (in price or quantity changes).

*Formal analysis of deposit markets*

Banks take savings in the form of deposits from households and lend these funds out for investment. If markets were perfectly competitive, banks would pay an interest rate on deposits equal to the marginal cost of capital, less any cost of doing business; and borrowers would pay for loans the same cost of capital plus a compensation for credit risk and marginal operating costs.[2] Actually, loan and deposit markets depart from perfect competition; thereby the study of interest rate formation in these markets will have to take into account that market characteristics may have an effect on interest rates paid or charged by banks.[3]

Assume a deposit market with a linear supply function given by $D(r^d) = a + \beta r^d$, where *D(·)* is the volume of deposits as a function of the interest rate $r^d$, and *a* and $\beta$ are parameters. The value of *a* gives the supply of deposits when $r^d = 0$ and it is expected to be positive since deposits include liquid assets for cash payments. The non-negative parameter $\beta$ is the slope of the supply curve; a value equal to zero indicates a totally inelastic supply; then, higher $\beta$ implies a more elastic supply function. Each bank is price-taker in the securities market, where it can borrow and lend any amount of funds at a given interest rate denoted by *R*. Finally, changes in *R* are taken as unexpected and permanent.

Banks face costs for changing interest rates over time. Sometimes these costs are direct, as menu costs [Hannan and Berger (1991)] or costs that arise because these changes displease customers [Okun (1981)]. Other times the costs are indirect, as when changes in interest rates induce changes in the quantities of supplied deposits and eventually produce quantity adjustment costs. Flannery (1982) describes the conditions that determine specific investment costs incurred in establishing retail deposit relationships and justifies that bank

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**2.** As in Flannery (1982), our analysis and inferences concerning deposit market behaviour are independent of the scenario that characterizes loan markets. This is due to the presumption of a competitive interbank funds market and that production of deposits is independent of that of loans.

**3.** Berger and Hannan (1989) find a negative and significant cross section link between market concentration and interest rates in deposits.

and depositor will share these costs. For convenience, it is assumed that the adjustment cost function is quadratic[4]

$$AC_t = \frac{c}{2}\left(D(r_t^d) - D(r_{t-1}^d)\right)^2 \quad (1)$$

where $c$ is a non-negative parameter.

### *2.1 Monopoly versus competitive pricing*

If we consider the collusive (or monopoly) situation in the deposit market, assuming that all operating costs are fixed and are excluded from the behavioural model[5], the monopoly profit maximising problem will be

$$\underset{r_t^d}{Max}\ (R_t - r_t^d)(a + \beta r_t^d) - AC_t\,.$$

Solving for the first order conditions we have

$$r_t^d = \mu + \lambda r_{t-1}^d + \gamma R_t\,, \quad (2)$$

where $\mu = -a/\beta(2 + c\beta),\ \lambda = c\beta/(2 + c\beta)$ and $\gamma = 1/(2 + c\beta)$.

Equation (2) implies that the money market interest rate $R_t$ is transmitted into the deposit interest rate, since $\gamma > 0$; but the transmission is lagged as long as $\lambda > 0$. A sufficient condition for the existence of this lag is a positive value of the adjustment cost parameter $c$.

The deposit interest rate in the long run equilibrium $r^{d*}$ is obtained when $r_t^d = r_{t-1}^d$. Solving (2) under this condition we obtain,

$$r_t^d * = \alpha_0 + \alpha_1 R_t\,, \quad (3)$$

where $\alpha_0 = -a/\beta$ and $\alpha_1 = \gamma/(1-\lambda) = 1/2$ is the *pass-through parameter*, which together with the constant, determines the long run relationship between the money market and the deposit interest rates. From (2) and taking into account (3) we can write,

$$r_t^d - r_{t-1}^d = \delta(r_t^d * - r_{t-1}^d)\,, \quad (4)$$

where $\delta = (1-\lambda) = 2/(2 + c\beta)$. The parameter $\delta$ gives the proportion of the difference between the desired long run interest rate and the past interest rate that is translated into

**4.** The convex cost function is assumed for convenience. Ginsburgh and Michel (1988) study more general cost functions.

**5.** This assumption is maintained throughout the paper. The conclusions would be the same if costs were variable but additive to the base interest rate and independent of it. Notice also that, in order to simplify the exposition, in the monopoly solution all deposits are assumed to be produced by only one bank.

actual changes in deposit interest rates at period *t*. We shall refer to the parameter **δ** as the *transmission parameter*.

The Lerner index in the long run profit maximising solution is given by

$$(R - r^d)/r^d = (\beta R + a)/(\beta R - a).$$

Note that the pass-through parameter $\alpha_1^M = 1/2$ is constant, and consequently, it is independent of the demand and cost function parameters. On the other hand, the transmission parameter $\delta^M = (1-\lambda) = 2/(2 + c\beta)$ decreases with the slope of the supply function ($\beta$) and the parameter of the cost function (*c*). As for the Lerner index, it decreases with $\beta$. Therefore, under the assumptions of the model, higher slope of the deposit supply function decreases both market power and speed in interest rate adjustment.

Assume now that interest rate is set at the competitive level, that is, the deposit interest rate in the equilibrium satisfies the condition of marginal revenue (*R*) net of marginal adjustment cost ($c\beta(r_t^d - r_{t-1}^d)$) equal to the interest rate ($r^d$). Solving this equation it can be shown that the transmission parameter for the competitive market solution is equal to $\delta^{PC} = (1-\lambda) = 1/(1 + c\beta)$. Thereby, under adjustment costs, price rigidity will also be observed in markets where firms set price equal to marginal cost (including marginal adjustment costs). As in the monopolistic framework, the adjustment speed under perfect competition will decrease with the parameter of the adjustment cost function and with the slope of the supply function.

Comparing the adjustment speed under monopoly and under perfect competition, we find that $\delta^{PC} < \delta^M$; that is, under quantity adjustment costs the adjustment speed is higher in a monopoly than in a perfectly competitve market.[6]

### *2.2 Oligopolistic competition*

Assume now an oligopoly with *n* banks, each of them offering deposits which are perceived as perfect substitutes among other banks' deposits in the same market (homogeneous products). Let *v* be the conjectural variation of banks which summarizes the response of each one to quantity decisions of the other competitors. It can be shown that the respective parameters of the long run equilibrium rate in equation (3) are now $\alpha_0^O = -a/\beta(n+1+v)$ and $\alpha_1^O = n/(n+1+v)$. On the other hand, the transmission parameter in the dynamic adjustment process [equation (4)] is equal to $\delta^O = (1-\lambda) = 1/(1 + c\beta/(n+1+v))$.[7] Notice that if there was just one bank (and consequently, no conjectural variations) the long and short run equilibria parameters would coincide with those obtained above in the monopoly case.

**6.** Borenstein and Shepard (2002) explain that the difference between monopoly and perfect competition is that in the former, marginal costs (including adjustment costs) are set equal to marginal revenue in the profit maximising solution, whereas in perfect competition they are set equal to price. Depending on the functional form of the demand function, its slope will be higher or lower than the slope of the marginal revenue and this will determine in which of the two situations (monopoly or perfect competition) the adjustment is faster. The results we present in the paper correspond to linear functions and extensions to other functional forms should be developed in detail.

**7.** This is the result of Ginsburg and Michel (1988).

As in the monopoly solution, the transmission parameter ($\delta$) decreases with the adjustment cost parameter (*c*) and with the slope of the supply function ($\beta$). Nevertheless, now it increases with the number of firms in the market (*n*) and with the conjectural variation (*v*). The conjectural variation can be itself endogenous and determined in a positive way by the market concentration [Stigler (1964); Rotemberg and Saloner (1986)]. Thereby, a higher *n* has a positive direct effect on the adjustment speed, but a negative indirect one as long as conjectural variations are endogenous and negatively related to the number of banks (*v* would be a decreasing function of *n*). On the other hand, it is well known that in an oligopoly with homogeneous products the long run Lerner index in the equilibrium solution is inversely related to the number of firms and to the elasticity of the supply function; and positively with the conjectural variation [Cowling and Waterson (1976)].

In oligopoly, for a given conjectural variation, a larger number of firms in the market increase price adjustment speed and decrease bank market power. Therefore, as long as the conjectural variation is given, increases in the market structure variable (*n*) have a positive effect in both aspects of efficiency –in the static one through a lower profit margin; and in dynamic terms, by achieving a higher price adjustment speed. As for the conjectural variation variable (*v*), increases in it have a positive effect on dynamic efficiency but a negative effect on static efficiency. Finally, as opposed to these effects, a higher supply function slope ($\beta$) decreases dynamic efficiency and increases the efficiency in static terms.

### *2.3 Direct price adjustment costs and product differentiation*

Let us consider now a change in the hypothesis about the nature of the adjustment cost so that the costs of changing prices are direct (like menu costs). To maintain the basic assumptions and facilitate the comparison between results, assume that the adjustment cost function is again quadratic with parameter *c*, but in terms of interest rates instead of deposit volumes.[8] Assume also that banks offer a differentiated product in two different market structures, monopoly and oligopoly with price competition.

Under *monopoly*, the pass-through parameter is again constant and equal to 1/2 ($\alpha_1=1/2$). The Lerner index in equilibrium is also the same but now the slope of the supply function refers to each individual bank. Yet, the transmission parameter for each bank is now $\delta_i^{\,M} = 1/(1 + c/2\beta_i)$ . Thus, the speed of price adjustment $\boldsymbol{\delta}$ increases with $\beta$, the opposite result found for the case of quantity adjustment costs.[9] A monopolist has the same profit maximizing solution choosing quantities than choosing prices; if the slope of the supply function reduces the speed of price adjustment in the former (quantities), it has to increase it in the later (prices) since the slopes of the direct and inverse supply functions are also inversely related. With direct price adjustment costs and monopoly, a higher slope of the supply function implies less price rigidity and lower market power.

The case of *oligopoly* and product differentiation can be studied assuming Bertrand-type competition with *n* banks symmetrically located around the Salop circle. Total demand is normalised to the length of the circle and made equal to 1; and *t* refers to the transportation cost per unit of distance.[10] It is immediate to show that, in the symmetric

**8.** Quadratic cost functions would be consistent with the type of explanation presented in Okun (1981). On hte other hand, menu costs imply a fixed cost of changing prices, not a variable one as that previously. Hannan and Berger (1991) study the case of menu costs and obtain similar qualitative results than those presented here.

**9.** Hannan and Berger (1991) assume monopolistic competition where each bank faces a slope of the deposit supply function that increases with the number of competitors in the market. Under this assumption the speed of adjustment would be an increasing function of the number of banks in the market.

**10.** See Tirole (1988), chapter 7.

transportation cost per unit of distance.[10] It is immediate to show that, in the symmetric equilibrium solution, the pass-through parameter is now equal to one ($\alpha_1=1$) and the transmission parameter is $\delta^D = (1-v)/(1-v+c/\beta)$, where $\beta = 1/t$. On the other hand, in equilibrium, the Lerner index is given by $(r-r^d)/r^d = (t+nv)/(n(R+v)+t)$. Therefore, market power increases with $t$ (lower $\beta$) and with the conjectural variation $v$; and decreases with the number of banks $n$, and the money market interest rate $R$.

Changes in the slope of the supply function and in the conjectural variation affect the interest rate adjustment speed and the market power of banks in the same direction. The number of banks does not directly affect the price adjustment speed; however, if a major number of banks implies lower conjectural variation, more banks would then also imply less price rigidity.

Given the diversity of results depending on the assumption about market structure and behaviour of banks, table 1 presents a summary of effects of parameter changes into market power and price adjustment speed. The summary makes clear that, only under the assumption of direct price adjustment costs, the factors that lower market power increase the price adjustment speed at the same time. Therefore, only in this case, we can predict a positive association between market power and interest rate rigidity. Under quantity adjustment costs the conclusions can differ depending on the market structure parameter.

Empirical analysis should help to discern the most appropriate description or modeling of reality. For example, one of the variables observed more often is the number of banks in the market or its inverse (that is, the concentration index). If conjectural variation is meant to be an increasing function of market concentration, then from $\delta^D$ derived above, a non-monotonic effect of the number of banks on the price adjustment speed would be consistent with supply adjustment costs in the case of oligopoly with non differentiated products. On the other hand, a non-negative relationship between the number of banks and the price adjustment speed would be consistent with product differentiation and direct price adjustment costs.

### *2.4 Related literature and hypothesis*

Inspired by Rotemberg and Saloner (1986), Hannan and Berger (1991) studied deposit interest rate rigidity under the assumption of menu costs and monopolistic competition. Their main prediction is that the incentives to change prices increase with the slope of the deposit supply function.[11] Hannan and Berger (1991) also assumes that the slope parameter will increase with the number of firms in the market; then, the slope and the adjustment speed will be lower in more concentrated markets.

Other sources of market power of banks referred to in the literature are consumers' search costs [Ausubel (1989); Calem and Mester (1995); Rosen (2002); Martín et al. (2005)] and switching costs [Sharpe (1997)]. The costs and benefits –for banks' customers– of searching for product substitutes and lower interest rates may be different depending on the products and consumer groups. For example, Sorensen (2000) for drugs and Martín et al. (2005) for banking products find that the incentives of searching increase with the

**10.** See Tirole (1988), chapter 7.

**11.** This is consistent with that resulting from $\delta^M$ and $\delta^D$. Moreover, the comparison of the two transmission parameters makes clear that, under price competition and direct price adjustment costs, a monopolist will adjust prices at a lower pace than a duopolist, since $\delta^D$ is higher than $\delta^M$ for given values of cost and supply parameters.

higher volume of balances. These factors, together with the assumption that banking products with longer maturity have more substitutes both in loans (financial markets, retained earnings) and deposits (investment funds) [De Graeve et al. (2004)], should contribute to increase supply function slopes for banks. However, the effect of these factors on the adjustment speed is ambiguous since, as our model shows, it depends on whether the adjustment costs of changing interest rates are direct (price) or indirect (quantity).

The arguments are similar when borrowers and depositors face costs of changing banks, although these costs are likely to vary among products and customers groups. For example, better-informed customers may have more alternatives to choose from than those less informed [Rosen (2002)]; thereby, a market with more informed customers and lower switching costs is likely to turn out to be portrayed by a steeper deposit supply function and lower profit margins for each individual bank. However, again no prediction can be made about the effect of switching and search costs on price rigidity until we know the nature of the adjustment costs.

On the empirical side, several studies have evaluated the transmission of changes in the money market interest rate into changes of loan and deposit interest rates using bank level data from different countries: Neumark and Sharpe (1992) for the US, Berstein and Fuentes (2003) for Chile, Gambacorta (2004) for Italy, Hofmann and Mizen (2004) for the UK, De Graeve et al. (2004) for Belgium and Weth (2002) for Germany. In general, the main interests of those analyses are (1) to evaluate the responsiveness of interest rates to monetary policies and (2) to stress banks' characteristics, such as capitalisation and liquidity, as determinants of the adjustment speed. When interpreting the results in terms of variables of market competition, the implicit assumption in all papers, despite not being supported by any formal analysis or detailed theoretical discussion, is that market factors that foster a lower bank market power increase at the same time the adjustment speed. Nevertheless, as we have shown in this paper, this is not straightforward.

### *2.5 Loan interest rates*

Loan markets are affected by information asymmetries between borrowers and lenders that end up creating problems of adverse selection and moral hazard [Stiglitz and Weiss (1981)]. One of the consequences of adverse selection is the possibility of credit rationing; in other words, banks may decide to limit the credit amount given to a particular borrower before the point where interest rate would raise high enough to equal supply to demand. In such a case, banks are reluctant to raise loan interest rates in order to avoid attracting high-risk projects or borrowers. According to Berger and Udell (1992), a "key testable implication of credit rationing is that commercial loan rate is sticky, that is, it does not fully respond to changes in open market rates" (page 1,048).

Information asymmetries between borrowers and lenders will also create conditions that spark off relational lending [Boot (2000)], where banks and borrowers, especially firms, engage in exclusive and long-term relationships. The specific investment costs of establishing a borrower-lender relationship are likely to be shared between the borrower and the bank, in a similar way as it happens with the costs of building a retail depositor relationship. For this reason the credit market can be modeled under the assumption of quantity adjustment costs and, if this is the case, loan interest rate rigidity will be determined by the quantity adjustment cost model described before.

### 2.6 *Asymmetric behaviour*

The assumption that interest rate adjustments towards their long-term values is symmetric is implicit in the analysis above; in other words, we have assumed so far that the adjustment takes place at the same speed when the interest rate of the economy increases than when decreases. However, previous research has found mixed evidences on the asymmetries in the adjustment process of interest rates. For example Hannan and Berger (1991), Neumark and Sharpe (1992), and De Graeve et al. (2004) find evidence of asymmetry on deposits; and Arak et al. (1983), Ausubel (1989), and Calem and Mester (1995) find the same in the case of loans, while Berstein and Fuentes (2003) do not. Moreover, the asymmetry is often in the direction that banks take more time to adjust interest rates when such adjustment is going to favour customers (i.e. upward interest rate adjustment on deposits and downward in loans).

Asymmetry in interest rate adjustments is difficult to explain from the model presented above, where banks have always incentives to set the profit maximising price and the adjustment cost function is itself symmetric. The assumption often made to explain asymmetries is that banks tend to keep deposit interest rates low and delay rises when the money market interest rate increases. However, this would not be consistent with profit maximising behaviour if such delay is longer than the one dictated by equations (3) and (4). Thereby, asymmetries should be interpreted and explained in terms of non-symmetric costs and benefits for the banks of changing interest rates. For example, Okun's (1981) argument of negative consumers' reactions to unstable prices and, specially their negative reactions to unfavourable price changes, will imply asymmetries in the cost function resulting in upward price rigidity. In the case of deposits, this would mean downward interest rate rigidity, the contrary to what the empirical analysis find. Therefore, this reasoning does not lead to a good explanation of what is empirically observed.

Other argument might be the following. If banks collude, all of them would apparently want to adjust their interest rates at the speed determined by the transmission parameter, that is, the profit maximising one. Nevertheless, if banks have imperfect information or different believes about future evolution of monetary or real economic conditions, collusion may be more difficult to sustain. Because of this, banks will delay interest rate adjustments that might be viewed as cheating behaviour until they are sure that the other banks are aware of the fact that the change is in response to changing market conditions and consequently, it is not a violation of the collusive agreement. In accordance with this idea, in case of deposits, interest rate rises are more likely to be interpreted as cheating behaviour than interest rates decreases; then, banks may be more reluctant to raise interest rates to the point where the price adjustment model dictates than to lower them. Notice, though, that under perfect information banks' pricing behaviour would not deviate from the path determined by equation (3) and (4).

## 3 Data and methodology

The Banco de España started in 1988 to ask for detailed information on interest rates set by banks in new operations during the last month. The information requirement covers both commercial and savings banks, that is, almost the whole population of Spanish banks.[12] The interest rate reported by each bank is the average annual interest rate charged in new operations of a given product during the corresponding month (i.e. the marginal interest rate). On the asset side, the products for which interest rates are available include discounting of receivables, credit line facilities, personal loans without collateral, and mortgages. Most mortgages are long-term loans (maturity of three years or more). As for the rest of the loans, they are broken down in periods of different maturity: up to 3 months, between 3 months and 1 year, between 1 year and 3 years and more than 3 years. On the liability side, banks declare interest rates paid on current accounts (sight deposits that include check facilities), savings accounts (sight deposits that do not incorporate any check facility), term deposits, and repo-type deposits (deposits backed by the bank with a public debt instrument). On this side, the maturity break down is the following: up to 3 months, from 3 to 6 months, from 6 months to 1 year, from 1 to 2 years and more than 2 years.

We will restrict our analysis to the most common maturity of loan and deposit products. Thereby, we will consider throughout the analysis, on the one hand, discounting of receivables up to 3 months, credit line facilities with a maturity varying between 1 and 3 years, personal loans until 3 months and mortgages (as mentioned above always with a maturity superior to 3 years). On the liability side, we will consider current and savings accounts, deposits and repo-type deposits; the last two, both with a maturity of less than 3 months. Overall, we have information on monthly quoted annual interest rates for around 150 banks during 172 months (December 1988 to March 2003) and 8 different banking products. The data employed are actual transaction prices (including commissions) and contains numerous observations of increases and decreases. This allows for a complete investigation of asymmetries in the adjustment of prices up and downward.

Figure 1 shows the evolution over time of the average loan and deposit interest rates charged by Spanish banks in the sample. It also shows the time evolution of the one-year EURIBOR (MIBOR before 1999) that will be used as the money market interest rate. The figure shows that interest rates remain high and stable during the first part of the sample period (1988 to 1993); afterwards, they decline sharply in the middle of it (1994 to 1998); and finally, they remain again stable at lower values at the end of the sample period (1999 to 2003). From 1999 Spain is a member of the European Monetary Union, therefore the figure makes clear the consequences in terms of lower interest rates that produced the period of nominal convergence in Spain. In the empirical analysis we shall focus on the issue of whether the Euro has changed the pattern of interest rates adjustment in Spain.

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**12.** Information on interest rates posted by credit cooperatives is not available, but in any case, this kind of entities does not even represent a 5% of total deposits.

The empirical econometric model behind equation (3) and (4) is the so-called Partial Adjustment Model (PAM).[13] The model determines first the long run interest rate target and later the short term adjustment process. The empirical counterpart of equation (3) will be formulated as

$$r_{it}^{l,d} = \alpha_0 + \alpha_1 R_t + \alpha_2 \Pi_t + \alpha_3 \Delta GDP_t + \nu_{it}\,, \qquad (3')$$

where $R_t$ is the EURIBOR interest rate, $\alpha_1$ is the long run adjustment proportion or pass-through rate; $\Pi_t$ and $\Delta GDP_t$ are the inflation rate and the growth rate of the real gross domestic product (GDP), respectively. The inflation rate and the GDP growth rate are introduced into the model to control for changes over time of the macroeconomic conditions that may affect the demand for loans and the supply of deposits.

Let $r_{it}^{*l,d}$ be the target level of the interest rate of the product for bank *i* in period *t*, predicted from equation (3'). The short-term adjustment process [equation (4)], is formulated according to the following empirical counterpart,

$$\Delta r_{it}^{l,d} = \delta(r_{it}^{*l,d} - r_{it-1}^{l,d}) + \omega_1 \Pi_t + \omega_2 \Pi_{t-1} + \omega_3 \Delta GDP_t + \omega_4 \Delta GDP_{t-1} + \varepsilon_{it} \qquad (4')$$

where $\Pi_t$, $\Pi_{t-1}$ are current and lagged values of the inflation rate and $\Delta GDP_t$, $\Delta GDP_{t-1}$ are current and lagged values of the GDP growth rate. These variables will control for external shocks that affect the short-term adjustment process.

The PAM of equations (3') and (4') will be estimated for the whole time period and for each of the three sub-periods, 1988-1993, 1994-1998, 1999-2003; then, the partition of the sample will allow us to test for the stability of the PAM over time. Second, equation (4') will be estimated allowing for asymmetries in the adjustment rate $\delta$ depending on whether the money market interest rate goes up or goes down. The hypothesis of symmetry will also be tested.

Beyond the estimation of the pass-through ($\alpha_1$) and the transmission parameter ($\delta$) for each bank and product, our interest is to explain the values of the transmission parameter as a function of variables that came out of the theoretical analysis. The explanatory variables of the parameter $\delta$ considered in this paper are (1) market concentration, (2) size of the bank, (3) ownership form of the bank, (4) market growth and (5) credit risk of the bank.

Each one of the fifty Spanish provinces is considered as a different geographic market. Province concentration is measured by the Herfindahl index (i.e. the sum of squared market shares of banks' loans in the province in year *t*). A bank is assigned to a province if it has at least one operating branch in it. Each bank is assigned a concentration value ($H_{it}$) equal to the weighted Herfindahl index of each of the provinces where the bank has branches, using as weights the proportion of total loans of the bank in the province. Concentration is a variable directly related to the predictions of the model. Under supply adjustment costs and oligopoly market with homogeneous products, the theory predicts that

**13.** Alternatively, the adjustment model could be formulated as a Vector Autoregressive (VAR) model that allows for different values of the transmission parameter over time. The PAM approach used in the paper is the one that comes directly from the market competition model of section 2.

the transmission parameter will decrease with the Herfindahl index at a decreasing rate. If the decision to change interest rates and the amount of the change are indistinguishable, then the observed interest rates changes may also be influenced by menu costs, but now concentration would have a non-decreasing negative effect in the adjustment speed.

As to the size of the bank ($SH_{it}$), it is equal to total assets divided by the total assets of the banking system in year *t.* Size can be a source of bank differentiation if for example, larger banks have a better reputation or a larger and more convenient network of branches. Besides, it may affect the adjustment cost function of the bank. Overall, the net effect of these forces in the adjustment speed is an empirical question.

Concerning the type of bank, the categorical variable $B_i$ takes value 1 if the finantial institution is a commercial bank and 0 in case of a savings bank. It is often argued that savings banks have more loyal customers than commercial banks; moreover their customers are often viewed as less sophisticated and less informed than customers of commercial banks. If this is true, savings banks will face flatter supply and demand functions than commercial banks and, for a given competitive behaviour and similar values of the other parameters, this would imply higher adjustment speed for savings banks under supply adjustment costs (lower under menu costs).

Finally, market growth and credit risk can be considered variables that control for markets and banks heterogeneity. Market growth is measured by the population annual growth rate in a given province in year *t*. As in the case of concentration, each bank has been assigned a market growth rate ($POP_{it}$) equal to the weighted sum of growth rates in each of the provinces with operating branches. As for the credit risk of the bank, it is measured by the doubtful debt ratio, that is, the ratio of bad loans over total loans in year *t* ($DDR_{it}$).

Since there might be other banks' unobserved characteristics that could affect price adjustment decisions (differences in adjustment costs, credit line [Berger and Udell (1992)] and capital channel [Kashyap and Stein (2000)] effects), we complete the model with individual bank fixed effects. Then, the adjustment parameter $\delta$ for bank *i* in period *t* can be written as a function of these explanatory variables as follows,

$$\delta_{it} = \phi_i + \rho B_i + \psi_1 H_{it}^P + \psi_2 (H_{it}^P)^2 + \theta DDR_{it} + \chi POP_{it} + \eta SH_{it} + \xi_{it}, \tag{5}$$

where $\phi_i$ are the bank fixed effects and $\xi$ is a random disturbance. According to the theory, the only clear predictions consistent with all explanations of price rigidity are that $\psi_1$ is expected to be negative and $\psi_2$, non-negative. The values and signs of the rest of parameters are an empirical question.

Table 2 shows, for each sub-period of time (1988-1993; 1994-1998; and 1999-2003), some descriptive statistics of the inflation and the GDP growth rates plus some statistics measures for the explanatory variables of the transmission parameter. As it can be seen, market concentration, although increasing over time, is rather low; for example, by the middle of the sample period an average bank faces around 12 competitors of equal size. The average size of the bank, measured by its market share, also shows an increasing trend over time, although the median stays more stable. Average population growth is much higher at the end of the period, probably due to the effect of immigration. Macroeconomic conditions, as shown by the time evolution of the GDP growth rate and the inflation rate, improve over time. The same happens with the doubtful debt ratio, which represent on average over 3% of total loans during the first sub-period, and only 1.5% ten years later. Finally, both the number of commercial and the number of savings banks decrease over time due to mergers.[14]

**14.** When banks merge the new entity is considered a new bank.

## 4 Empirical results

### 4.1 Pass-through and transmission parameters

Results of the estimation of the PAM [equations (3') and (4')] are presented in tables 3 A and B. Table 3A shows the estimated values of the pass-through parameter ($\alpha_1$), while table 3B shows the estimated values of the transmission parameter ($\delta$). In each case, the parameter estimates are shown for three different cases. First, the statistics of the pass-through parameter are the mean, standard deviation and median of the parameters obtained from the PAM estimated for each individual bank; these estimates are identified as "bank level". Results of the second estimation, denoted by "pool level" estimates, are obtained by pooling all banks and estimating the PAM model under the restriction of each coefficient being equal for all banks. Finally, the so-called "bank average" estimates come from a PAM where using the average monthly interest rate of all banks. In order to increase the efficiency of the estimation we use a Seemingly Unrelated Regression Estimation (SURE), stating a different equation for each bank and/or banking product.

Throughout the estimation, the null hypothesis of structural stability of the PAM over time is tested for each bank product. The hypothesis is rejected at high confidence levels; for that reason, table 3C reports the bank level estimates of the transmission parameter $\delta$ for each of the three five-year periods in which the whole sample period is divided up. In tables 3B and 3C we also report the bank level estimates of the transmission parameter for increases (+) and decreases (-) of the money market interest rate.

*Pass-through estimates*

The "pool level" and the "bank average" estimates of the pass-through parameters (table 3A) are fairly similar, and in all cases, both of them are higher than the mean and median values of the "bank level" estimates. The dispersion among the estimated pass-through parameters of individual banks is substantial in all banking products and moreover, with the exception of savings account, the median is above the mean. The distribution of estimated bank coefficients is more concentrated on the right tail and this explains why the median values are closer to the "pool" and "bank average" estimates than the means.

A reference value for the pass-through parameter ($\alpha_1$) is 1, that is, the value that the parameter would take in the perfectly competitive solution or just if changes in the money market interest rate were fully transmitted to loan and deposit interest rates. "Pool level" estimates of the pass-through parameter are close to 1 in some of the products, especially mortgages (with an estimated value of 0.973); but the null hypothesis that the coefficient is *equal* to 1 is rejected at the 5% level –or less– in all cases. Overall, estimated pass-through coefficients for loan products are larger than those for deposit products.

By looking at the "bank level estimates" the conclusions to be reached are similar. The proportion of banks for which the estimated pass-through coefficient takes a value lower than 1 goes from 65% in personal loans to 98% in savings accounts. And overall, it is higher among deposit products (96% on average) than among loan products (the highest of which is 83% in mortgages). Taking into account only those coefficients which are statistically significant at the 5% confidence level, the above proportions are lower especially in loan products (values in parenthesis). The highest proportion of coefficients that are significantly lower than 1, corresponds to current accounts (94%); and the lowest, to personal loans (47%). Overall, for deposit products, the "bank level" estimations of table 3A can be considered in line with those obtained by Hannan and Liang (1993) for consumer's deposits in the US, but with the exception of savings accounts where our results show lowerpass-through coefficients than for the US market.[15] As in the US, the conclusion is that estimated values of the pass-through parameters suggest that banks have some market power but the amount of it differs among products.

The values of the pass-through parameters have economic significance for the evolution of the profit margins of banks over time. For loan products, the average value of the pass-through parameter from the median estimates is 0.85, while for the same median estimates in the case of deposits the average is 0.54 (0.65 if savings are excluded). A 100 basic points (bp) increase in the money market interest rate implies an 85 bp increase in long run average loan interest rate and 54 bp increase in the average deposit interest rate. That is a net difference of 30 bp or a long-run increase in gross profits of 30 cents for each euro of deposits (20 cents if savings accounts are excluded). Of course, if the money market interest rate declines, gross profits per unit will be reduced by the same magnitude. Since during the period of study the fall in interest rates has been the general trend, differences in the pass-through parameters of loans and deposits explain a good part of the decrement in the intermediation margin of Spanish banks during this period.

*Transmission estimates*

The estimated transmission parameters ($\delta$) for the whole sample period are presented in table 3B. In comparison with the "bank level" estimates (mean and median values), the "pool" and the "bank average" level estimates for the whole period (last two columns) are substantially lower. This also stands true when we permit a different transmission parameter for every single sub-period (table 3C). Therefore, the bias from forcing a common value of the transmission parameter for all banks and sub-periods in a given market gives more distorted results in the transmission parameter than in the pass-through parameter. The mean and median of the "bank level" estimates show substantial differences among products. With respect to this, the transmission parameter $\boldsymbol{\delta}$ is particularly high for credit line facilities and personal loans. In general, loan products show a higher speed of transmission than deposit.

One way to evaluate the economic significance of the estimations in table 3 is to obtain the proportion of change in the money market interest rate that is transmitted to loan and deposit interest rates after a certain number of time periods, for example after the first month. This proportion will be equal to the ratio between the transmission parameter ($\delta$) and the pass-through parameter ($\alpha_1$). Using median values of the transmission and pass-through parameters from tables 3A and 3B, the proportion of the transmitted change in case of loan products in one month ranges from 23% in receivables to around 60% in credit lines and personal loans (30% for mortgages). Among deposit products, the proportion values cluster around 40% in all products, except savings accounts with a value of 80%. Thus, although savings accounts have a low estimated median value of the transmission parameter, they also have very low median estimate of the pass-through parameter; thereby, the transmission is completed in a short period of time.

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**15.** The null hypothesis that the pass-through parameter is equal to ½, the predicted value for linear supply and demand functions under monopoly or monopolistic competition, is rejected in the majority of cases looking at the bank level estimates.

### *4.2 Asymmetric transmissions*

Equation (3') and (4') of the PAM system are estimated allowing for asymmetric adjustment speed when money market interest rates go up or down. The estimation is performed for the whole period of time and for each sub-period.

The test of equal transmission parameters for upward or downward movements in the interest rates yielded the following results. At the pool level, the null hypothesis of equality was rejected the least at a significance level of 5%. As regards the bank level estimates, at a 5% significance level the null hypothesis was rejected for 87% of the banks in receivables and credit lines, 75% in personal loans, 92% in mortgages, 83% in current accounts, 85% in savings accounts, 80% in deposits and 83% in repo-type deposits.

Table 3B presents a summary of the asymmetric transmission parameters estimated for the whole sample period; and table 3C displays the same whereas dividing it up into the three sub-periods pointed out above. For deposit products, the mean and median values of the transmission parameters for interest rate declines (-) are systematically higher than the mean and median values for interest rate increments (+) (table 3B). That means that deposits are more upward rigid, which is consistent with the general view that prices are downward inflexible but firms react faster to shocks that imply price increases (decreases in case of deposits).

For loans, results are mixed. Looking at the means, the adjustment speed is higher in the case of upward movements in mortgages and credit lines but the reverse holds for receivables and personal loans. However, if we compare median values, loan interest rates are more upward rigid only in the case of personal loans. In the case of mortgages, the observed pattern of interest rigidity is in line with that observed in deposits after taking into account that banks apply mark downs to the money market interest rate to determine deposit rates and mark ups to loans. It may just reflect that the collateral secures the loan and therefore the credit quality of the borrower is not relevant for the loan decision.

The relative lower transmission speed in upward than in downward changes in personal loans (and receivables if we take mean values instead of medians) is consistent with the prediction from adverse selection and credit rationing theories of credit markets. Credit line is a loan with maturity up to three years and the other loans are short-term loans. Moreover, credit lines are often associated with stronger relational lending [Berger and Udell (1992)] and banks are well informed about the credit quality of those borrowers that receive this type of loans.

### *4.3 Tests for differences in pass-through and transmission parameters over time, across products and type of bank*

One of the questions of interest is the evolution, if any, of pass-through and transmission parameters over time and, in particular, if these parameters change after 1999 –when Spain joined the EMU–. In this section we explain the pass-through and the transmission parameters estimates from (3') and (4') for each of the time sub-periods (1998-1993; 1994-1998; and 1999-2003) using time, product and bank dummy variables as explanantory variables (table 4).

The first block of estimations refers to the pass-through parameter and the second one, to the transmission parameter. To model the pass-through parameter ($\alpha_1$) as a function of market structure and bank level variables, we follow Hannan and Liang (1993).

The transmission parameter is modeled according to equation (5). For each parameter a distinction is made between the pool of loans and the one of deposit products. Moreover, within loans (deposits), we present estimation with bank fixed effects and another with these effects substituted by the dummy variable ($B_i$) that takes the value 1 if the bank is a commercial bank and 0 if it is a savings bank.[16] In all models the omitted time dummy variable is the one corresponding to the period 1994-1998, when the money market interest rate follows a decreasing trend.

Concerning the pass-through parameter for loans, the first two columns of table 4, the coefficient of $D_1$ is negative and significant [-0.23 (p=0.001)], but the coefficient of $D_3$ is positive but not significant [0.057(p=0.62)]. In the period characterized by nominal interest rate convergence (1994-1998), in order to prepare for the Euro, Spanish banks increase the loan pass-through parameter with respect to its value in previous years. However, after 1998, no statistically significant evidence of further increase in the parameter is detected.[17]

Concerning deposit products (columns 3 and 4 of table 4) show that the increase in the pass-through parameter occurs during the period 1999-2003 [coefficient of $D_3$ equal to 0.201 (p=0.00)], while no change is observed from 1989 to 1994 [coefficient of $D_1$ equal to -0.014 (p=0.69)]. Now, the increase in competition coincides with the period of low nominal interest rates after Spain joined the EMU.

The same analysis for changes over time for the transmission parameter $\delta$ (last four columns of table 4) only finds clear evidence of an increase in the parameter value for loans in the period from 1994 to 1998 [coefficient of $D_1$ equal to -0.106 (p=0.00) in column 5], exactly the same period in which we see an increase in the pass-through parameter. None of the coefficients of the rest of the time dummy variables is significant at the 5% of confidence level. The conclusion is that, when we control for other variables that may affect the value of the transmission parameter, the pattern of interest rate rigidity remains unchanged for the most part during the 15 years analysed.

The comparison of the pass-through and transmission parameters across products controlling for time, bank and market effects (coefficients of product dummy variables in table 4) confirms most of the conclusions reached in table 3. Among loan products, the pass-through parameter is lower in receivables than in the rest of loans, coefficients of product dummies in column 1 significant and with values between 0.12 and 0.18. The dispersion is higher in deposits where savings accounts have the lowest pass-through and repo-type deposits, the highest; with a difference between them of 0.561 (column 3 of table 4).

In contrast, transmission parameters are very similar among deposit products; none of the coefficients of the product dummies are statistically significant in column 7 of the table. On the other hand, there are substantial differences among loans (column 5); receivables and mortgages have the lowest transmission parameters and credit lines and personal loans exhibit the highest, with a difference up to 0.31.

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**16.** The estimation of the model takes into account that the pass-through and the transmission parameter are both estimated values and therefore have a known error term. The estimation procedure is the same as that used by Hannan and Liang (1993).

**17.** Hannan and Liang (1993) give conditions under which increases in the pass-through parameter can be interpreted as less market power. For a further discussion of the evolution of market power of Spanish banks see Carbó et al. (2005), Maudos and Fernández (2004), and Maudos and Pérez (2003).

The average pass-through parameter of commercial banks is statistically higher that the average pass-through of savings banks, as the positive value and statistical significance of the coefficient of $B_i$ (columns 2 and 4). The estimated value of the coefficient is around 0.10 in loans and in deposits. According to this measure, savings banks have more market power than commercial banks.[18]

Concerning the transmission parameter the difference in the value of the estimated parameter appears as statistically significant in the case of loans (column 6); and again, commercial banks have, on average, a higher transmission parameter than savings banks [coefficient of $B_i$ equal to 0.063 (p=0.00)].

Table 4 also shows the estimated coefficients of bank and geographic market variables for the pool of loan and deposit products. We find no evidence of statistical significance for the coefficients of variables such as relative size of the bank, market concentration, market population growth and bad loans in the model that explains the pass-through parameter. This contrasts with the results of Hannan and Liang (1993) who find higher pass-through parameter for deposit products in less concentrated credit markets (our estimated coefficient of $H_{it}$ is also negative, but not significant, in column 4 of the table).

The coefficients of market concentration and its square are both statistically significant when the dependent variable is the transmission parameter. The estimated coefficient are, respectivelly, negative and positive; that is, increases in market concentration first lower the transmission parameter but increase the adjustment speed beyond certain values of $H_{it}$ [the inflexion point is around a Herfindahl value of 11%, above the median values of the concentration index in the sample data aproximately equal to 8%[19] (table 2)].

Among the rest of explanatory variables only $POP_{it}$ (population growth in the market) shows a positive and significant coefficient among loan products.

### *4.4 Joint estimation for each individual product*

Our interest now is to estimate the parameters of equation (5) for each bank product. In order to increase the number of observations and the efficiency of the estimation, equation (5) will be estimated jointly with equation (4’). To do so the transmission parameter function in (5) is substituted in (4’) and the expanded model is estimated by SURE with banks’ fixed effects. The predicted long-term interest rate $r^*$ used in the estimation is obtained from (3’) estimated separately in the three time periods considered (1988-1993; 1994-1998; and 1999-2003) to account for changes in the long-term equilibrium relationship over time. Inflation and GDP growth rates are two-year lagged to eliminate autocorrelation in the residuals. Table 5 presents the results of the estimation.

Most of the estimated coefficients are now statistically significant. For each product the relationship between transmission parameter and market concentration is first decreasing and later increasing as in the pool estimations of table 5. Moreover, in all cases the inflexion point of the Herfindahl index is also around 11%. Therefore the empirical evidence of a non monotonic association between the transmission parameter that measures

**18.** For further discussion, see Maudos and Pérez (2003).

**19.** From equation (5), the derivative of the transmission parameter with respect to $H$ is equal to $\psi_1 - 2\psi_2 H$. The value of $H$ for which the derivative is equal to 0 is $H^* = -\psi/\psi 2$. Substituting for the estimated values of the coefficients for loans for example, -0.036 and 0.0032, from table 5, we obtain the value of 11%.

the interest rate adjustment speed and the market concentration is robust to the method of estimation. The result follows the theoretical prediction from a model of bank competition with positive conjectural variations in an oligopoly market with homogeneous products. As we saw in the theoretical section, under these assumptions and if we expect higher conjectural variations in more concentrated credit market, the effect of higher concentration in the speed of price adjustment can be first negative and later positive, just what we observe in the empirical estimations.

The negative and significant coefficient of $SH_{it}$ indicates that the transmission parameter of each individual bank decreases with the bank size. However, among deposit products, the relationship between relative size and transmission parameter is only statistically significant for deposits. The transmission parameter is higher in high growth markets for all deposit products and for mortgages and credit lines (positive coefficient of $POP_{it}$). Finally, banks that take more risks in their loans (i.e. higher proportion of doubtful loans) exhibit higher transmission parameters [positive coefficient of $DDR_{it}$; significant except for personal loans (negative) and current accounts (not significant)].

Table 5 also shows the estimated coefficients for the inflation rate and the change in the GDP growth rate, contemporaneous and one-month lagged. The coefficients of inflation rate are all positive and highly significant, which indicates that price level changes enter into the short-term interest rates adjustment process beyond the inflation induced changes in the long run equilibrium interest rate $r^*$. The contemporaneous GDP growth rate shows a negative and highly significant coefficient in all products but the coefficient of lagged growth is positive although of lower absolute value. Therefore, interest rate adjustments tend to be counter cyclical.

## 5 Conclusions

The relationship between market power of banks and interest rate adjustment speed is a complex issue since predictions about the expected sign of the effect of the former on the later depend on structural characteristics of the markets and, in some cases, on banks' characteristics. This paper presents a thorough analysis of the determinants of the interest rate adjustment speed (1) under monopoly and competitive behaviour in fixing prices, (2) under oligopoly with no product differentiation, and (3) under the assumption that adjustment costs obey to changes in prices –as in menu costs– or alternatively, to changes in the quantity supplied. The variety of situations suggests that the actual relationship between sources of market power and price rigidity is an empirical question where the interpretation of the results has to be made with a precise description of the theoretical results.

The results of the paper confirm that Spanish banks have some market power in the sense that the long run relationship parameter between the majority of loan and deposit interest rates and the money market interest rate (pass-through parameter) is lower than 1. Additionally, this parameter is higher in loans than in deposits, which means that the marginal long-run gross profit margin (difference between loan and deposit interest rates) under changes in the money market interest rate is positive (it is approximately 30 bp during the studied period). Therefore, banks'gross profits increase (decrease) when the money market interest rate increases (decreases).

The pass-through parameter increases in loans during the period of nominal convergence of the Spanish economy (1994 to 1998) but remains stable afterwards during the Euro years. In deposits the increase in the estimated value of the parameter is observed after 1999 (Euro years). Therefore, we have mixed results on whether banks have decreased their market power in the period after Spain joined the EMU and nominal money market interest rates are historically low. The pass-through parameter tends to be higher for commercial banks than for savings banks. However, contrary to Hannan and Liang (1993) for deposits in the US, we find no statistical significance for the relationship between the pass-through parameter and market concentration.

As for the transmission parameters, the empirical analysis confirms that interest rates are rigid to changes in the money market interest rate and also confirms asymmetries in the speed at which loan or deposit interest rates adjust to the money market one. In the case of deposits, shocks that imply interest rate decreases are translated into actual interest rate decisions at a lower speed than those shocks that produce interest rate increases. In the case of loans the evidence suggests that the observed asymmetry can also be the consequence of adverse selection and credit rationing by banks since for unsecured loans the transmission parameter is lower in interest rate increases than in decreases.

The transmission parameters vary systematically as a function of variables that can be related with parameters of the theoretical model. In particular, we find a non-monotonic negative effect of market concentration on the adjustment speed consistent with a combination of structural (number of competitors) and behavioural (collusion) effects of opposite direction on the relationship between market concentration and price rigidity obtained in the theoretical analysis. The convex relationship between the transmission parameter and market concentration suggests that banks face quantity adjustment costs and that they compete in oligopoly markets on rather homogeneous products. Moreover, it contrasts with the linear positive relationship between interest rates rigidity and market concentration found by Hannan and Berger (1991) in deposit interest rates in US under the assumption of menu costs.

We also find that savings banks tend to show lower values of the transmission parameters for loan products than commercial banks. In a model of quantity adjustment costs this evidence would be consistent with higher slope of the loan demand (less market power) of savings banks than of commercial banks. In addition, it might be due to the fact that savings banks tend to specialize more in mortgages (a less differentiated product than loans to business firms and therefore a more competitive market) than commercial banks. In deposit products we observe the opposite result, that is, lower transmission parameter for savings banks, but the coefficient is not statistically significant.

The transmission parameter decreases with size of banks especially in loan products. Again, in a situation of quantity adjustment costs this evidence is consistent with higher slope of the loan demand (in absolute values) for large banks than for small banks. Maybe larger banks deal with larger borrowers with more opportunities to choose (banks, capital markets and generated cash flow) than small banks, and for this reason, they end up with higher slope and less market power. As for the rest of the control variables, the results show that banks in high growth geographic markets tend to adjust interest rates faster than banks in low growth markets, especially in deposit products. Banks which are willing to take more credit risk tend to have a higher transmission parameter and generate less interest rate rigidity than more conservative banks. Finally, controlling for market power and cost adjustment effects, changes in interest rates are counter-cyclical, negatively related to increases in GDP growth and respond positively to inflation beyond the effect of price level changes incorporated in the long-term interest rate.

The results of the paper have some policy implications. Under quantity adjustment costs that come out of depositors and borrowers, specific investments in their relationship with banks there can be a trade-off between static efficiency (relative profit margin) and dynamic efficiency (less price rigidity). This trade-off does not occur in sitituations of direct costs of changing prices since here, factors that favour less market power also imply less price rigidity. One of the variables affected by this trade-off is market concentration, since the paper finds that beyond reasonable concentration levels higher concentration implies lower interest rate rigidity and possibly more market power of banks.

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**Table 1. Comparative statics of the effect of market structure and bank behaviour on the profit margin and the transmission parameter, under different assumptions on adjustment costs and product characteristics**

A positive (negative) sign indicates that the Lerner index and/or the transmission parameter increases (decreases) with an increase of the deposit supply slope, the number of firms and the conjectural variations parameter. By "indirect effect" we refer to the effect of increasing the number of competitors through changes in other parameters, such as conjectural variations or the slope of each individual bank supplies. Results follow from the findings of section two.

| | **Profit margin (Lerner index)** | **Transmission parameter** | | | |
|---|---|---|---|---|---|
| | | Quantity adjustment costs | | Price adjustment costs | |
| | | Monopoly and Competition | Oligopoly (homogeneous product) | Monopoly | Oligopoly (spatial differentiation) |
| MARKET STRUCTURE | | | | | |
| Slope of the supply function ($\beta$) | - | - | - | + | + |
| Number of competitors | | | | | |
| *Direct effect (n)* | - | na | + | na | na |
| *Indirect effect [$\nu(n)$]* | - | na | - | na | + |
| *Indirect effect [$\beta(n)$]* | - | - | na | na* | na |
| COLLUSIVE BEHAVIOR ($\nu$) | + | na | + | na | - |

*Note: na: not applicable.*

** Increasing in n under Monopolistic Competition, Hannan and Berger (1991)*

**Figure 1. EURIBOR (interbank market interest rate) and loan and deposit interest rates and from 1988 to 2002**

Loan and deposit interest rates reported are linear averages of actual interest charged by Spanish banks. Interest rates refer to December of each year.

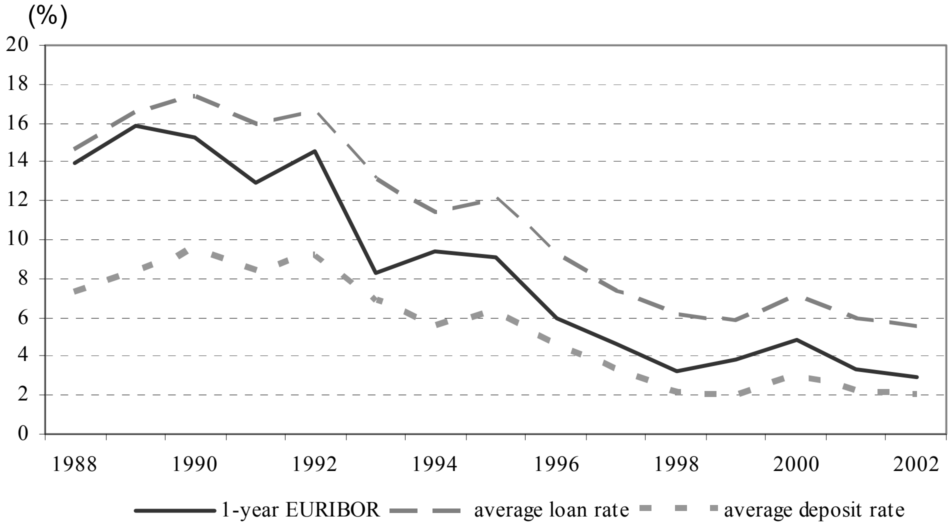

**Table 2. Mean, standard deviation and median values of the explanatory variables of the pass-through and the transmission parameters in three time sub-periods**

*Herfindahl index* and annual *population growth* rates refer to the fifty Spanish provinces. *Relative size* (bank *i* assets over total bank assets) and *doubtful debt ratio* (defaulted loans over total loans) are variables computed at bank level. *GDP growth* and *inflation* rates are values for the Spanish economy as a whole. *Commercial banks* are for profit companies, while *savings banks* are not for profit commercial institutions.

| | 1988-1993 | | | 1994-1998 | | | 1999-2003 | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Average* | *Std. dev.* | *Median* | *Average* | *Std. dev.* | *Median* | *Average* | *Std. dev.* | *Median* |
| ***Herfindahl . index (%)*** | 5.377 | 3.177 | 5.511 | 7.518 | 3.015 | 7.552 | 8.595 | 4.015 | 9.713 |
| ***Relative size (%)*** | .487 | 1.082 | .149 | .619 | 1.293 | .183 | .720 | 1.587 | .185 |
| ***Pop. growth (%)*** | .395 | .312 | .443 | -.245 | .265 | -.264 | 1.703 | .766 | 1.859 |
| ***Doubt. debt ratio (%)*** | 2.715 | 2.794 | 2.293 | 3.121 | 3.954 | 2.355 | 1.147 | 3.218 | .605 |
| ***GDP growth rate (%)*** | 2.155 | 1.085 | 2.251 | 3.132 | .256 | 3.190 | 3.379 | .376 | 3.265 |
| ***Inflation rate (%)*** | 5.953 | .399 | 5.988 | 3.443 | .422 | 3.353 | 3.056 | .259 | 3.138 |
| ***No. of comm. banks*** | 103 | | | 99 | | | 81 | | |
| ***No. of savings banks*** | 67 | | | 52 | | | 50 | | |

**Table 3A. Statistical distribution of the pass-through rate estimates ($\alpha_1$)**

$\alpha_1$ is the estimated coefficient of the variable money market interest rate (*R*) in a model where the dependent variable is the product interest rate and we include the GDP growth and the inflation rates as control variables [equation (3')]. "Bank level estimates" are obtained by fitting model (3') to monthly individual bank data for each product. Additionally, in order to avoid the effect of outliers, we assign observations below the 5th and above the 95th percentile to its respective percentile value. "Pool level estimates" are obtained forcing an equal pass-through rate for each bank in a given product, although including bank dummies and estimating by SURE a different equation for assets and deposits. "Bank average estimates" are obtained from a SURE estimation of model (3') using as dependent variable the average interest charged by all banks in month *t* for each individual product. "Significantly <*1*" refers to the percentage of bank level estimated coefficients for which the null hypothesis (that is, value less than one) could not be rejected at the 5% confidence level). *N* indicates number of monthly observations used in the estimation.

| | **Bank level estimates** | | | | | **Pool level estimates** | | **Bank average estimates** | |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | *Average coeff.* | *Average std. dev.* | *Median* | *Percent of $\alpha_1$<1 (significantly <1)* | *Coeff.* | *Std. dev.* | *Coeff.* | *Std. dev.* |
| ***Receivable*** | 159 | .688 | .359 | .808 | 78 (77) | .900 | .008 | .932 | .040 |
| ***Credit line*** | 162 | .768 | .250 | .822 | 81 (62) | .920 | .007 | .935 | .026 |
| ***Personal loan*** | 153 | .746 | .424 | .874 | 65 (47) | .891 | .019 | .870 | .026 |
| ***Mortgage*** | 150 | .736 | .336 | .879 | 83 (67) | .973 | .006 | .938 | .029 |
| ***Current acc.*** | 181 | .457 | .235 | .478 | 97 (94) | .568 | .008 | .557 | .020 |
| ***Savings acc.*** | 155 | .209 | .224 | .179 | 98 (83) | .353 | .009 | .282 | .018 |
| ***Deposit*** | 140 | .641 | .238 | .686 | 93 (56) | .754 | .005 | .747 | .023 |
| ***Repo-type*** | 151 | .736 | .219 | .805 | 96 (80) | .793 | .007 | .808 | .023 |

**Table 3B**. **Statistical distribution of the transmission rate estimates ($\delta$)**

$\delta$ is the estimated coefficient of the variable constructed as the difference between predicted interest rates ($r^*$) from equation (3') and current interest rates. The estimation follows from a model where the dependent variable is the change in interest rate in month $t$ and including the GDP growth and the inflation rates (current and one period lagged) as control variables [equation (4')]. "Bank level estimates" are obtained by fitting equation (4') to monthly individual bank data for each product and using SURE; besides, in order to avoid the effect of outliers, we assign observations below the 5th and above the 95th percentile to its respective percentile value. "Pool level estimates" are obtained forcing an equal pass-through rate for each bank in a given product. "Bank average estimates" are obtained from a SURE estimation of equation (4') using as dependent variable the average interest charged by all banks in month $t$ for each individual product. "Bank average estimates" are obtained from a SURE estimation of equation (4') for each individual product, using monthly averages of bank interest rates. Columns $\delta^{+(-)}$ correspond to the parameters of the distribution of SURE bank level transmission parameters from equation (4'), when the adjustment towards the long run interest rate requires an increase (decrease) in current interest rate. $N$ is the number of monthly observations used in the estimation.

| | ***Bank level estimates*** | | | | | | | ***Pool level estimates*** | | ***Bank average estimates*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | $\delta_{iT}$ | | $\delta^{+}_{iT}$ | | $\delta^{-}_{iT}$ | | | | | |
| | | *Mean* | *Median* | *Mean* | *Median* | *Mean* | *Median* | *Coeff.* | *Std. dev.* | *Coeff.* | *Std. dev.* |
| ***Receivable*** | 159 | .255 | .198 | .249 | .194 | .267 | .151 | .080 | .003 | .107 | .011 |
| ***Credit line*** | 162 | .503 | .467 | .557 | .522 | .440 | .431 | .279 | .003 | .191 | .019 |
| ***Personal loan*** | 153 | .535 | .523 | .474 | .488 | .574 | .525 | .181 | .006 | .228 | .023 |
| ***Mortgage*** | 150 | .331 | .261 | .369 | .298 | .288 | .222 | .203 | .005 | .127 | .013 |
| ***Current*** | 180 | .261 | .189 | .210 | .143 | .305 | .224 | .075 | .003 | .101 | .014 |
| ***Savings*** | 155 | .211 | .144 | .186 | .095 | .239 | .163 | .042 | .003 | .070 | .012 |
| ***Deposits*** | 140 | .303 | .271 | .239 | .169 | .278 | .225 | .147 | .004 | .163 | .013 |
| ***Repo-type deposits*** | 150 | .346 | .317 | .309 | .258 | .376 | .368 | .162 | .005 | .240 | .028 |

**Table 3C**. **Statistical distribution in three sub-periods of the transmission rate estimates ($\delta$)**

$\delta$ is the estimated coefficient of the variable constructed as the difference between predicted interest rates ($r^*$) from equation (3') and current interest rates. The estimation follows from a model where the dependent variable is the change in interest rate in month $t$ and including the GDP growth and the inflation rates (current and one period lagged) as control variables [equation (4')]. "Bank level estimates" are obtained by fitting equation (4') to monthly individual bank data for each product and using SURE; besides, in order to avoid the effect of outliers, we assign observations below the 5$^{th}$ and above the 95$^{th}$ percentile to its respective percentile value. "Pool level estimates" are obtained forcing an equal pass-through rate for each bank in a given product. "Bank average estimates" are obtained from a SURE estimation of equation (4') using as dependent variable the average interest charged by all banks in month $t$ for each individual product. "Bank average estimates" are obtained from a SURE estimation of equation (4') for each individual product, using monthly averages of bank interest rates. The columns $\delta^{+(-)}$ correspond to the parameters of the distribution of SURE bank level transmission parameters from equation (4'), when the adjustment towards the long run interest rate requires an increase (decrease) in current interest rate. $N$ is the number of monthly observations used in the estimation.

| | *1988-1993* | | | | | | | *1994-1998* | | | | | | | *1999-2003* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | $\delta_{iT}$ | | $\delta^+_{iT}$ | | $\delta^-_{iT}$ | | *N* | $\delta_{iT}$ | | $\delta^+_{iT}$ | | $\delta^-_{iT}$ | | *N* | $\delta_{iT}$ | | $\delta^+_{iT}$ | | $\delta^-_{iT}$ | |
| | | *Mean* | *Median* | *Mean* | *Median* | *Mean* | *Median* | | *Mean* | *Median* | *Mean* | *Median* | *Mean* | *Median* | | *Mean* | *Median* | *Mean* | *Median* | *Mean* | *Median* |
| ***Receivable*** | 148 | .374 | .288 | .351 | .304 | .385 | .298 | 121 | .370 | .300 | .422 | .369 | .329 | .243 | 101 | .416 | .349 | .466 | .421 | .345 | .276 |
| ***Credit line*** | 145 | .586 | .541 | 1.147 | 1.058 | .495 | .479 | 123 | .783 | .755 | 1.552 | 1.496 | .696 | .667 | 105 | .782 | .767 | 1.552 | 1.534 | .739 | .722 |
| ***Personal loan*** | 136 | .668 | .678 | .619 | .616 | .716 | .710 | 118 | .718 | .679 | .662 | .578 | .740 | .699 | 93 | .766 | .763 | .670 | .635 | .822 | .850 |
| ***Mortgage*** | 135 | .460 | .364 | .538 | .455 | .379 | .277 | 115 | .456 | .414 | .389 | .329 | .464 | .420 | 99 | .346 | .305 | .444 | .419 | .276 | .208 |
| ***Current*** | 160 | .371 | .274 | .318 | .267 | .385 | .302 | 146 | .421 | .364 | .315 | .253 | .475 | .448 | 124 | .342 | .285 | .281 | .232 | .386 | .331 |
| ***Savings*** | 137 | .387 | .317 | .343 | .222 | .393 | .364 | 122 | .351 | .283 | .198 | .137 | .412 | .396 | 102 | .359 | .301 | .287 | .290 | .337 | .299 |
| ***Deposits*** | 103 | .355 | .276 | .314 | .249 | .377 | .252 | 113 | .339 | .289 | .307 | .201 | .374 | .328 | 99 | .398 | .324 | .374 | .259 | .405 | .347 |
| ***Repo-type deposits*** | 138 | .496 | .493 | .446 | .429 | .519 | .516 | 119 | .202 | .168 | .172 | .081 | .245 | .232 | 104 | .294 | .258 | .196 | .171 | .376 | .317 |

**Table 4**. **Estimation of the pass-though rate (columns 1 to 4) and the transmission rate (columns 5 to 8) on their determinants**

*P*-values are shown in parentheses. In columns 1 to 4 the dependent variable is the estimated coefficient of the explanatory variable (*R*) in equation (3') for each bank and product in each of the three time sub-periods (1988-1993; 1994-1998; and 1999-2003). In columns 5 to 8 the dependent variable is the estimated coefficient of the explanatory variable $(r^*-r_{t-1})$ in equation (4') for each bank and product in each of the three time sub-periods. The explanatory variables are: time dummies ($D_1$ and $D_3$); product type dummies (receivable, credit line, personal loans and mortgages for loan products; and current account, savings account, deposit and repo-type deposit for deposit products); bank ownership ($B_i$); Herfindahl index ($H_{it}$) and squared Herfindahl index ($H_{it}^2$); population growth rate ($POP_{it}$); bank relative size ($SH_{it}$), and doubtful debt ratio ($DDR_{it}$). SURE is run separated for loans and deposits. Pooled estimation means that the model is estimated assuming equal slopes of the explanatory variables for all loan or deposit products. Columns 1, 3, 5 and 7 include bank dummies with estimated coefficients, although they are not reported. In all cases the estimation includes an error correction variable to take into account that the dependent variables are estimated with a known standard error.

| *Cross section regression with α as the dependent variable* | | | | | | *Cross section regression with δ as the dependent variable* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pooled loans** | | | **Pooled deposits** | | | **Pooled loans** | | | **Pooled deposits** | | |
| | *Controlling for individual effects* | *Including a type-of-bank dummy* | | *Controlling for individual effects* | *Including a type-of-bank dummy* | | *Controlling for individual effects* | *Including a type-of-bank dummy* | | *Controlling for individual effects* | *Including a type-of-bank dummy* |
| $D_1$ | -.228 (.001) | -.223 (.000) | $D_1$ | -.009 (.779) | -.052 (.070) | $D_1$ | -.103 (.000) | -.106 (.000) | $D_1$ | .020 (.290) | .022 (.171) |
| $D_3$ | .054 (.633) | .129 (.109) | $D_3$ | .216 (.000) | .192 (.000) | $D_3$ | -.058 (.092) | -.023 (.371) | $D_3$ | -.012 (.727) | -.008 (.746) |
| *Credit line* | .185 (.000) | .156 (.003) | *Savings account* | -.114 (.000) | -.112 (.000) | *Credit line* | .319 (.000) | .303 (.000) | *Savings account* | -.015 (.302) | -.009 (.560) |
| *Personal loan* | .180 (.001) | .171 (.002) | *Deposit* | .239 (.000) | .228 (.000) | *Personal loan* | .317 (.000) | .304 (.000) | *Deposit* | -.004 (.801) | -.014 (.401) |
| *Mortgage* | .118 (.021) | .115 (.033) | *Repo-type dep.* | .448 (.000) | .444 (.000) | *Mortgage* | .040 (.006) | .020 (.213) | *Repo-type dep.* | -.007 (.651) | -.018 (.265) |
| $B_i$ | - | .112 (.005) | $B_i$ | - | .090 (.000) | $B_i$ | - | .063 (.000) | $B_i$ | - | -.014 (.269) |
| $H_{it}$ | .002 (.909) | .003 (.696) | $H_{it}$ | -.000 (.995) | -.003 (.349) | $H_{it}$ | -.034 (.000) | -.047 (.000) | $H_{it}$ | -.035 (.000) | -.037 (.000) |
| $(H_{it})^2$ | - | - | $(H_{it})^2$ | - | - | $(H_{it})^2$ | .001 (.026) | .002 (.000) | $(H_{it})^2$ | .001 (.035) | .002 (.000) |
| $DDR_{it}$ | .009 (.327) | .004 (.608) | $DDR_{it}$ | .009 (.030) | .008 (.038) | $DDR_{it}$ | .002 (.524) | .003 (.227) | $DDR_{it}$ | .002 (.454) | .001 (.763) |
| $POP_{it}$ | .039 (.539) | -.006 (.863) | $POP_{it}$ | -.044 (.164) | -.024 (.208) | $POP_{it}$ | .049 (.009) | .019 (.099) | $POP_{it}$ | .027 (.138) | .018 (.101) |
| $SH_{it}$ | -.014 (.716) | .008 (.530) | $SH_{it}$ | .003 (.854) | .000 (.979) | $SH_{it}$ | -.007 (.556) | -.014 (.000) | $SH_{it}$ | -.018 (.115) | -.004 (.339) |
| $\chi^2$ | 309.30 | 77.54 | $\chi^2$ | 1,172.65 | 498.11 | $\chi^2$ | 1,407.35 | 772.26 | $\chi^2$ | 540.63 | 104.12 |
| *N* | 1,258 | 1,258 | *N* | 1,258 | 1,258 | *N* | 1,255 | 1,255 | *N* | 1,255 | 1,255 |
| *Parms.* | 179 | 10 | *Parms.* | 179 | 10 | *Parms.* | 180 | 11 | *Parms.* | 180 | 11 |

**Table 5**. **Joint estimation of the Partial Adjustment Model with equation (5) plugged into equation (4')**

*P*-values are shown in parentheses. SURE is run separately for each bank product. The dependent variable are changes of bank *i*'s interest rate in month *t*. The explanatory variables are: Herfindahl index ($H_{it}$); squared Herfindahl index ($H_{it}^2$); population growth rate ($POP_{it}$); bank relative size ($SH_{it}$); and doubtful debt ratio ($DDR_{it}$). All of them multiplied by the difference $(r^*-r_{t-1})$ –expressed in percentage–, where $r^*$ is predicted from equation (3') estimated in each time sub-period (1988-1993; 1994-1998; 1999-2003). All regressions include current and one-period lagged values of GDP growth and inflation rates and bank specific effects (coefficients not reported).

| | Receivable | Credit line | Personal loan | Mortgage | Current account | Savings account | Deposit | Repo-type deposit |
|---|---|---|---|---|---|---|---|---|
| $(r^*_{it}-r_{it-1})\cdot const.$ | 44.130 | 27.307 | 14.674 | 43.642 | 13.033 | -66.665 | .010 | -6.324 |
| | (.000) | (.016) | (.255) | (.000) | (.223) | (.000) | (.907) | (.593) |
| $(r^*_{it}-r_{it-1})\cdot H_{it}$ | -23.366 | -14.972 | -11.409 | -22.713 | -17.584 | -4.769 | -.141 | -13.978 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.057) | (.000) | (.000) |
| $(r^*_{it}-r_{it-1})\cdot (H_{it})^2$ | 1.090 | .736 | .576 | 1.127 | .796 | .248 | .635 | .745 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.067) | (.000) | (.000) |
| $(r^*_{it}-r_{it-1})\cdot SH_{it}$ | -3.461 | -2.915 | -2.484 | -1.703 | -1.110 | -.389 | -2.653 | -.854 |
| | (.000) | (.000) | (.010) | (.001) | (.111) | (.570) | (.000) | (.289) |
| $(r^*_{it}-r_{it-1})\cdot POP_{it}$ | -.370 | 1.895 | .983 | 2.782 | 4.445 | 5.800 | 2.004 | 3.547 |
| | (.471) | (.003) | (.180) | (.000) | (.000) | (.000) | (.000) | (.000) |
| $(r^*_{it}-r_{it-1})\cdot DDR_{it}$ | .684 | 1.359 | -1.999 | .828 | .536 | 1.662 | 1.512 | 3.113 |
| | (.001) | (.000) | (.000) | (.000) | (.124) | (.000) | (.000) | (.000) |
| $\Pi_t$ | .700 | .759 | .614 | .757 | .442 | .231 | .553 | .388 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| $\Pi_{t-1}$ | 1.208 | 1.289 | 1.303 | 1.323 | .731 | .326 | .991 | 1.071 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| $\Delta GDP_t$ | -.805 | -.590 | -.676 | -.842 | -.424 | -.264 | -.698 | -.971 |
| | (.000) | (.000) | (.036) | (.000) | (.000) | (.000) | (.000) | (.000) |
| $\Delta GDP_{t-1}$ | .259 | .101 | .216 | .380 | .147 | .003 | .224 | .296 |
| | (.000) | (.156) | (.103) | (.000) | (.003) | (.938) | (.000) | (.000) |
| $\chi^2$ | 424,539.86 | 354,820.96 | 204,350.76 | 331,503.34 | 158,062.72 | 100,747.28 | 255,978.45 | 198,733.41 |
| *N* | 8,763 | 8,763 | 8,763 | 8,763 | 8,763 | 8,763 | 8,763 | 8,763 |
| *Parms.* | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 109 |

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