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THE INTEREST RATE PASS-THROUGH OF THE PORTUGUESE BANKING SYSTEM: CHARACTERIZATION AND DETERMINANTS

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The interest rate pass-through of the Portuguese banking system: characterization and determinants

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Abstract

Using micro level data, this work characterizes the interest rate pass-through in loan and deposit retail rates of the Portuguese banking system. It concludes that the long-run impact of a change in money market rates on loans is typically around one while it is smaller than one for deposits. Moreover, differences between the long run coefficients for the corporate and household sectors also emerge. Results on the speed of adjustment show that, in general, deposit interest rates adjust faster than loan interest rates. The determinants of the heterogeneous behavior of banks in terms of interest rates' decisions are also studied. Capital and liquidity characteristics of banks turn out to be non-significant while market share proves to contribute to a slower speed of adjustment in both loan and deposit interest rates.

JEL codes: G21, E43

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1 Introduction

The speed of price adjustments to changes in market conditions is one of the factors underlying economic efficiency. Retail interest rates on bank products are an example of such a relevant price. Everyday households and firms are faced with these prices when making investment and savings decisions. In the euro area this is even more important because corporate financing is predominantly bank-based, in contrast to the United States, where market financing is more relevant. Additionally, euro area households hold most of their wealth under the form of deposits, although there has been a change in preferences towards other instruments, such as investment funds (see ECB, 2002). In this context, this study aims at understanding the interest rate pass-through of Portuguese banks, that is, how retail interest rates relate to changes in market conditions. This study has two main objectives. First, it characterizes the interest rate pass-through in retail rates of the Portuguese banking system. Second, it studies the determinants of the heterogeneous behavior of banks in terms of interest rate decisions.

The pass-through of market interest rates to retail interest rates has been studied for many years. In particular, the advent of the Economic and Monetary Union contributed to the substantial increase of articles discussing this topic in the euro area, inter alia focusing on cross section differences among countries and accessing the degreee of integration[1]. Most studies analyse the pass-through both in terms of the degree of the pass-through and of the speed of adjustment. In the majority of cases, studies consider aggregate interest rate series for different countries (and the euro area) on different interest rate categories[2] and study whether there is pass-through heterogeneity across euro area countries and across different bank products. More recently, some micro-data studies on individual countries have also been performed[3]. Studies differ because data used have different sources[4] and also because they may refer to different time periods[5]. There are also differences in terms of the market interest rates considered: some studies select market rates with short maturity while others choose a market interest rate with a maturity more in line

[1] For a survey of recent studies on this topic see Sorensen and Werner (2006).

[2] See, for instance, De Bondt, Mojon and Valla (2005), Sorensen and Werner (2006) and Leuvensteijn, Sorensen, Bikker, and van Rixtel (2008) with results for individual countries and the whole euro area.

[3] See, among others, Weth (2002) on German banks, De Graeve, de Jonghe and Vennet (2004) for Belgium, Gambacorta (2004) for Italy, Lago-González and Salas-Fumás (2005) for Spain and Fuertes and Heffernan (2006) for the United Kingdom.

[4] Most studies use national retail interest rate statistics collected by central banks. For euro area contries MFI interest rates (MIR) statistics collected by the Eurosystem of Central Banks are also used, both for studies on individual countries and the euro area as a whole. Other data sources are also used; for instance, Leuvensteijn et al. (2008) use data from Bankscope.

[5] The most recent studies may include data until 2006.

with the repricing period of the bank product. In terms of econometric methods, most studies use single equation error correction models, which have the advantage of combining a long-run equilibrium relationship and short term adjustment dynamics to the long-run equilibrium.

Although studies approach the topic very differently, two main conclusions emerge for European countries and the euro area. The first one is that there is significant heterogeneity in the degree and speed of pass-through accross euro area countries. Some tentative explanations for this interest rate heterogeneous behavior are national differences in bank competition, bank cost structures, banking ownership and legal and regulatory systems[6]. The second conclusion is that the heteregoneity in the pass-through, both in terms of degree and speed, is also substantial across bank products. Most studies suggest that rates on loans to enterprises, specially short-term loans, adjust faster and show a more complete pass-through than interest rates on loans to households or on saving deposits. Results on deposits are not as clear as results on loans. Any way, the evidence shows that interest rates on deposits are stickier than on loans. However, across studies, results are not uniform, which could happen because studies cover different time periods or because they use different market rates.

Against this background, this study develops an analysis of the interest rate pass-through of Portuguese banks. Some of the already mentioned studies present results for Portugal. These studies use aggregate data. Here, micro level data covering the period from January 1990 to December 2002 is used to study the interest rate pass through on a total of fifteen bank products (nine loan and six deposit interest rate categories). Despite the difference in data sources, type of data and time period covered, results on the size of interest rate pass-through are broadly in line with the results from previous studies[7]. We conclude that there is a clear difference in the long-run impact of a change in money market rates on loans and deposits. In the case of loans, the effect is typically around one, meaning that changes in money market rates are fully transmitted to retail rates. In contrast, the long term coefficient for deposits is smaller than one in all products considered. Under certain assumptions, this parameter can be also interpreted as a measure of competition in the industry. In this sense, the market for the corporate sector seems to be more

[6] Sander and Kleimeier (2004), Sorensen and Werner (2006) and Leuvensteijn et al. (2008) discuss several reasons to explain heterogeneity across euro area countries.

[7] See, among the most recent studies presenting individual results for Portugal Leuvensteijn et al. (2008), Sorensen and Werner (2006), De Bondt, Mojon, and Valla (2005) and Sander and Kleimeier (2004). Results are also in line with the main conclusions in Banco de Portugal (1999). Older studies with individual results for Portugal are Cottarelli and Kourelis (1994), Donnay and Degryse (2001), Heinimann and Schuller (2002), Kleimeier and Sander (2002) and Sander and Kleimeier (2002). A brief summary of the main results of these studies for Portugal can be found in De Bondt, Mijon and Valla (2005).

competitive than the one for households. Results on the speed of adjustment show that, in general, deposit interest rates adjust faster than loan interest rates.

The second part of this study aims at explaining the heterogeneity found across Portuguese banks. One advantage of using micro-data is the possibility of studying the causes of the pass-through heterogeneity across banks. Several reasons have been pointed out to explain the heterogeneity in interest rate pass-through accross banks. The most relevant ones are related to solvency, liquidity, diversification of activities, costs, liability structure, market power, concentration of the market and credit risk[8]. In this study, we try to explain the behavior of banks operating in the Portuguese market considering some of these reasons. Constraints of data do not allow a deep study on this topic, but some conclusions are obtained. The liquidity and solvency of banks do not prove to be relevant for the speed and size of the pass-through for both loan and deposit interest rates. The conclusion on the relevance of the capital ratio could be related to the restraints on banking activities in the period precendent the one under analysis. In fact, in the 80's, banking activities were constrained and banks were not always able to find profitable investments, resulting in higher levels of capital. Then, the nineties were years of adjustment reflecting the deregulation of banking activities and, simultaneouly, the convergence of nominal interest rate convergence, which help to explain the increase in bank credit. Nevertheless, capital buffers of Portuguese banks were relatively high during an important part of the period under analysis. The market share of banks seems to be relevant for the determination of the speed of adjustment for both loan and deposit interest rates. Results suggest that banks with higher market shares, which could be interpreted as a proxy for market power, adjust interest rates slower than banks with smaller market shares.

This article is organised as follows. The first part studies the interest rate pass through. It starts by presenting the data in Section 2.1 and the model underlying the analysis in Section 2.2. The results are presented in Section 2.3. The second part studies the determinants of the heterogeneity in the behavior of banks. It starts by presenting the characteristics of banks in Section 3.1 and Section 3.2 presents the empirical results. Finally, the main conclusions of this study are summarized in Section 4.

[8]See De Graeve, De Jonghe and Vennet (2004), Gambacorta (2004), Fuentes and Heffernan (2005), and Lago-González and Salas-Fumás (2005).

2 Characterisation of the interest rate pass through

2.1 Data

In Portugal, as in most countries, aggregate bank retail rates are publicly availabe but bank-specific rates are not. Since 1990, the Bank of Portugal has been conducting a monthly inquiry asking banks the rates they offer on new contracts of credits and loans. The inquiry also collects data on the amounts of the new operations. In December 2002 the inquiry changed dramatically introducing difficulties in the construction of a long-term time series of data from 1990 on[9]. Hence, the main data set used in this study comprises monthly data on retail rates and the corresponding amounts of new loan and deposit products for the period from January 1990 to December 2002.

In this study we consider nine types of loan products (including discount operations) and six deposit products. These products were chosen as the most relevant in the period both for the corporate and the household sectors and for short and long maturities. Table 1 describes the data series and the abbreviations used to present the results. It also presents some cross-section and time-series characteristics of the series. The frequency of the entire analysis is monthly. The information on interest rates for each product corresponds to a panel data where i denotes the bank and T_i denotes the number of months for which there is information for bank i. The smallest panel is the one on "Discount, households with maturity less than 3 months (DH3m)", which considers only 16 banks, and the largest is the panel on "Transferable deposits (TrD)" including 34 banks. Panels for different products may cover different banks, as expected. Each panel data is unbalanced, that is, data from different banks (i) in the same panel cover different time periods (T_i). The study considers only the banks for which there is a time series of, at least, 72 consecutive monthly observations. For 50% of the banks considered, the time series have between 114 and 156 monthly observations as reported in column (5) of Table 1 (these values correspond to products "Loans, households with maturity between 6 months and 1 year (LH6m_1y)" and "Deposits with agreed maturity betwenn 6 months and 1 year (D6m_1y)", respectively). Table 1 also presents information on the coverage of the data, as the study does not consider all banks but just a sample of banks. Bank operations included in each panel account for around 80% of the new operations for each product, although there are some differences in what concerns the coverage of the data. For instance, for 50% of the months considered, the 17 banks included in the panel

[9] At the end of 1997 the inquiry was slightly changed but it is possible to conciliate the outputs of both inquiries. The same is not true from 2002 on as, since this date, retail interest rates has been collected following the rules of the European Central Bank set in December 2001 (Regulation no 63/2002).

Table 1: Characterization of data.

Abbreviation (1)	Product (2)	Number of banks (3)	Number time series observations (T_i) P(5) (4)	P(50) (5)	P(95) (6)	Coverage of the market P(5) (7)	P(50) (8)	P(95) (9)
LOANS								
DC3m	*Discount, corporate sector (< 3 months)*	23	81	130	156	81	98	99
DC3_6m	*Discount, corporate sector (3 - 6 months)*	21	80	131	156	80	97	99
DH3m	*Discount, households (< 3 months)*	16	99	131	156	64	92	100
LC1day	*Loans, corporate sector (1 day)*	29	78	131	156	41	88	100
LC3m	*Loans, corporate sector (< 3 months)*	24	81	128	156	49	82	97
LC3_6m	*Loans, corporate sector (3 - 6 months)*	22	93	125	156	41	83	99
LH6m_1y	*Loans, households (6 months - 1 year)*	20	75	114	156	41	75	97
LH2_5y	*Loans, households (2 - 5 years)*	17	85	126	156	42	65	97
LH5y	*Loans, households (> 5 years)*	20	95	129	156	76	93	100
DEPOSITS								
TrD	*Transferable deposits*	34	95	142	156	95	99	100
D1m	*Deposits with agreed maturity (< 1 month)*	25	85	120	153	58	81	97
D1_3m	*Deposits with agreed maturity (1 - 3 months)*	32	78	137	156	81	91	99
D6m_1y	*Deposits with agreed maturity (6 months - 1 year)*	22	103	156	156	95	98	100
Pens6m_1y	*Pensioneers'saving deposits (6 months -1 year)*	20	102	139	156	81	97	99
Emig6m_1y	*Emigrants' account (6 months -1 year)*	20	100	145	156	98	100	100

Notes: This table presents the abbreviation and a short description of each product in columns (1) and (2). Column (3) presents the number of banks included in the sample for each product. Columns (4) to (6) present the percentiles 5, 50 and 95 of the number of consecutive observations (out of 156 months) for each product. Columns (7) to (9) present percentiles 5, 50 and 95 of the value of new operations originated by the banks in the sample as a percentage of total value of new operations, for each product. All data is monthly.

"Loans, households (2 - 5 years)" account for only 65 percent of the total amount of new loans granted to households with a maturity between 2 and 5 years. In general, the coverage of the new operations of deposit products is higher than the one for loan products.

To perform this study we also use the money market interest rates of different maturities, which are publicly available. The money market interest rate series was constructed considering the information on unsecured transactions made in the domestic Interbank Money Market for the period between January 1990 and November 1992. These transactions are processed and settled through SITEME - Markets Electronic Transfer System. It then considers information on Lisbor (Lisbon Interbank Offered Rate) for the period December 1992 - December 1998 and Euribor rates from January 1999 onwards. We considered two different money market interest rate series, one with 3-month maturity and another with a 6-month maturity. It would have been interesting to consider a money market interest rate with a longer maturity, such as one year but it was not possible to construct such time series due to the lack of information for some months considered in the study. Besides, the transaction volumes at this maturity are much smaller and less representative of interbank dealings. Further, long term interest rates such as 5 or 10 year government bond yields are not used in this study because an overwhelming majority of the operations are either short-term or carry floating interest rate.

During the period under study several acquisitions and mergers of banks occurred in Portugal.

Some authors argue that the best way do deal with this type of events is to consider merged banks as just one institution in the whole sample period. This approach is not followed here. We consider banks involved in a merger as different institutions before the merger. In this way, we are allowing interest rate policies to be different before and after the merge. The disadvantage of this approach is that we will have an unbalanced panel of data as, after the merge, the merged instituition is absorbed by the acquirer and will not make interest rate decisions.

Appendix 1 presents a set of graphs depicting the retail rate series used in the study and also the money market interest rates. Data shows that interest rates have been decreasing over most of the sample period. This behavior results from the nominal convergence of the Portuguese economy in the process that led to the participation in the third stage of the Economic and Monetary Union in 1 January 1999. In general, bank retail rates tend to follow the evolution of money market interest rates except in the case of transferable deposits. There are also some differences in the retail rates charged by different banks within a panel, which suggest the study of bank specific characteristics in setting interest rates.

2.2 The model

The model follows closely the work by Hannan 1991 (see Appendix 2 for more details). The long run equations to be estimated are:

$$\begin{cases} r_L^{in} = a_{in} + b_{in} r_s + \varepsilon_{in} \\ r_D^{im} = a_{im} + b_{im} r_s + \varepsilon_{im} \end{cases}$$

where r_L^{in} (r_d^{im}) represent the interest rate associated with the nth (mth) category of loans (deposits) held by bank i and r_s is the interbank market interest rate (either a 3-month or a 6-month interest rate). Given the asumptions of this model, parameter b_{in} (b_{im}) is a function of the elasticity of demand for bank i's nth (mth) category of loans (deposits), and a_{in} (a_{im}) is a function of both the elasticity of demand for bank i's products and the corresponding marginal cost.

Under the hypotheses of the model, parameters b can be used as a measure of competition in each banking product since values close to one correspond to a more competitive market. This parameter measures also the rate of a bank transmission of changes in the money market rate to their own retail rate.

The model presented must be carefully applied to interest rate time series since these series tend to be non-stationay. In that case, this model presents a long-run equilibrium relationship between retail rates and the money market interest rate. In such case, the study of the relationship between non-stationary, but cointegraded variables, should be done by estimating an error correction model (ECM) as these models allow for a decomposition between the long-run equilibrium relationship and the short-run adjustments towards the long-run equilibrium. In this sense, this study starts by studying the stationarity of the retail rates and the money market interest rate and their cointegration relationships. If non-stationarity of the retail rates and the money market rates and cointegration between these variables is not rejected, an error correction model is estimated in order to capture both long term and short term effects.

The estimation of an error correction representation will be done in two steps. The first step consists in estimating the cointegration vector

$$r_{i,t} = a_i + b_i r_{s,t} + u_{i,t}. \tag{1}$$

The intercept parameter a is a measure of mark-up, or mark-down, that is, it measures how much a retail rate is marked above or below the money market interest rate. The parameter b captures the long run pass-through, that is, it measures the fraction, or multiple, of the money market interest rate changes that is reflected in the bank retail interest rate.

In the second step we use the estimated residual of the cointegration vector to estimate an error correction model:

$$\Delta r_{i,t} = \alpha_i + \sum_{k=1}^{p} \alpha_{ik} \Delta r_{i,t-k} + \sum_{l=0}^{q} \beta_{il} \Delta r_{s,t-l} + \gamma_i u_{i,t-1} + \varepsilon_{i,t} \tag{2}$$

where $u_{i,t-1}$ are the lagged residuals from individual cointegrating regressions. The residuals $\varepsilon_{i,t}$ are assumed to be $iid(0, \sigma^2)$. The term $\gamma_i u_{i,t-1}$ captures the adjustment towards equilibrium and a significant negative γ_i is consistent with the series being cointegrated. The error correction parameter γ_i is the speed of adjustment and shows how much of the gap created by a change in the money market interest rate is closed in one month.

2.3 Results

2.3.1 Stationarity and Cointegration Tests

We start by performing some panel unit root tests to check the stationarity of all series. It is well known that standard Dickey-Fuller-type tests lack power in small samples in distinguishing the unit root null from stationary alternatives. Adding the cross-section dimension to the time-series dimension allows for the use of unit root tests with more power.

Testing for unit roots in panel data has become more common given the development of testing procedures and their incorporation into econometric software packages[10]. However, most packages work with balanced panel data while the data used in this study is unbalanced. We used the Rats procedure developed by Peter Pedroni which computes unit root tests based on the work by Levin, Lin and Chu (2003) and Im, Pesaran and Shin (2003). All these tests take as the null hypothesis non-stationarity and test against the alternative of stationarity[11].

Let $\{y_{it}\}$ be the data series for a panel of banks, $i = 1, ..., n$, and let each bank series contain $t = 1, ..., T_i$ time series observations. The number of time series observations is different between banks and varies between 73 and 156 months. The number of banks in each panel ranges from 16 to a maximum of 34 (see Table 1). We wish to determine whether $\{y_{it}\}$ is integrated for each individual in the panel. As in the case of a single time series, the individual regression may include an intercept only or an intercept and time trend. The basic unit root testing approach by Levin, Lin and Chu (2003), hereafter LLC, assumes that $\{y_{it}\}$ is generated by one of the following three models:

$$\text{Model 1 } \Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + e_{it} \tag{3}$$

$$\text{Model 2 } \Delta y_{it} = \alpha_i + \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + e_{it} \tag{4}$$

$$\text{Model 3 } \Delta y_{it} = \alpha_i + \beta_i t + \rho y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + e_{it}, \tag{5}$$

where y_{it} is the dependent variable of the model with dimension $\sum_{i=1}^{n} T_i$ x 1, and e_{it} are $IID(0, \sigma_e^2)$ residuals. In Model 1, the panel unit root test procedure evaluates the null hypothesis $H_0 : \rho = 0$ against the alternative $H_1 : \rho < 0$. In Model 2, the series y_{it} has an individual specific mean but does not contain a time trend. In this case, the test evaluates the null hypothesis that $H_0 : \rho = 0$ and $\alpha_i = 0$, for all i, against $H_1 : \rho < 0$ and $\alpha_i \in R$. Finally, under Model 3, the series y_{it} has an individual specific mean and time trend. The test procedure evaluates the null hypothesis that $H_0 : \rho = 0$ and $\beta_i = 0$, for all i, against $H_1 : \rho < 0$ and $\beta_i \in R$.

In this study, y_{it} is a series of monthly retail rates offered by banks in both new operations of loans and deposits during the period between 1990 and 2002. On the one hand, it is reasonable

[10]See Harris and Sollos (2003) for a discussion on stationarity and cointegration tests with panel data.

[11]Many other nonstationarity tests heave been developed, such as the ones by Harris and Tzavalis (1999), Breitung (2000) and Maddala and Wu (1999). All these tests take as the null hypothesis the presence of a unit root, and test against alternatives involving stationarity. In contrast, Hadri (2000) proposed a test for the null of stationarity against the alternative of unit roots in the panel data.

to admit that $\alpha_i \neq 0$, as each bank has its own specificities. On the other hand, although during the sample period the interest rates showed clearly to be decreasing, this behavior is not expected to persist asymptotically. Such behavior would impose nominal rates to fall below zero. Consequently, we did not consider the presence of a time trend when explaining the behavior of interest rates. To sum up, the best model to analyse $\{y_{it}\}$ seems to be Model 2 and this is the one used to test the nonstationarity of all series.

A major assumption of all LLC tests is the imposition of homogeneity by setting $\rho_i = \rho$, for all i. Thus, under the null all series in the panel contain a unit root, while the alternative is that all individual series are stationary. The alternative hypothesis is clearly restrictive since it tests if all i cross sections are stationary. Im, Pesaran and Shin (2003), hereafter IPS, relaxed the homogeneity constraint by estimating the equations of Models 1 to 3 allowing ρ_i to vary freely across the i individual series in the panel. The null hypothesis ($H_0 : \rho_i = 0$) is that each series in the panel contains a unit root and the alternative hypothesis ($H_0 : \rho_i < 0$, for at least one i) is that at least one of the individual series in the panel is stationary[12]. Essentialy, the IPS test averages the ADF-individual unit root test statistics that are obtained from estimating equations such as (3), (4) or (5), for each i. A rejection of the null hypothesis indicates stationarity of the series.

Table 2 presents the results of the LLC and IPS tests[13] developed for all panels assuming Model 2. As both LLC and IPS test statistics follow a standard normal distribution $N(0,1)$, we do not reject the null hypothesis of a unit root in bank interest rate series, at a nominal significant level of 5%, if the statistics are larger than -1.645. For the money market interest rate we computed the Augmented Dickey and Fuller test as in Said and Dickey (1984) and the Phillips Perron (1988) assuming, once again, the model of equation (4). The test statistics are shown in Table 2 and

[12]Another problem of the LLC tests is related with the power of the tests to reject the null when it is false. Harris and Tzavalis (1999) conducted Monte Carlo experiments to look at the properties of these tests when T is small. They analysed the power of the test to reject the null hipothesis when it is false. They found that the $T \to \infty$ assumption underlying LLC tests yields a test with poorer power properties, especially in finite samples with T less than 50. They suggested testing for panel unit roots based on the assumption that T is fixed. As it was not possible to implement this test with unbalanced data, we tried to surpass this problem by choosing time series with as many observations as possible.

[13]To decide about the number of lags to include in all tests, we estimated the model $\Delta y_{it} = \alpha_i + \sum_{L=1}^{\overline{p}} \theta_{iL} \Delta y_{i,t-L} + e_{it}$, for each i, choosing a maximum number of lags $\overline{p} = 12$ because data is monthly. Then we used the t-statistic on $\widehat{\theta}_{iL}$ to determine if a smaller lag order is preferred. We observed that $L = \overline{p} = 12$ was a significative lag for at least one series of each panel, although for most series the highest significative lag was smaller. As the software we used did not allow us to choose a different number of lags for each series within the panel, we decided to consider $\overline{p} = 12$ in all panels.

Table 2: Panel unit root test statistics

	LLC	IPS
LOANS		
DC3m	3.14	3.29
DC3_6m	3.12	3.11
DH3m	2.70	3.03
LC1day	3.91	1.21
LC3m	0.54	-0.44
LC3_6m	0.65	-0.17
LH6m_1y	3.09	2.55
LH2_5y	1.95	0.06
LH5y	2.75	1.95

	LLC	IPS
DEPOSITS		
TrD	1.54	-1.22
D1m	-1.35	-2.78
D1_3m	1.50	0.98
D6m_1y	2.95	3.89
Pens6m_1y	2.15	2.75
Emig6m_1y	2.37	3.12

	ADF	PP
INTERBANK RATE		
3-month	-1.82	-0.52
6-month	-2.49	-0.63

Notes: LLC stands for Levin, Lin and Chu (2003) test; IPS stands for Im, Pesaran and Shin (2003) test; ADF stands for Augmented Dickey and Fuller test proposed by Said and Dickey (1984) and PP stands for Phillips and Perron (1988) test. The lag length is set at 12 for all series. LLC and IPS test statistics are normally distributed and the 5% level critical value is -1.645. The ADF 5% and the PP 5% level critical value -2.887. The null of a unit root is not rejected at a 5% confidence level for all variables except the IPS test for Deposits with agreed maturity less than one month (D1m). The results were obtained using RATS. A short definition of each bank product can be found in Table 1.

allow us to not reject the null of a unit root in all interest rate series in the sample[14].

As with testing for unit roots using panel data, testing for cointegration by pooling information across the i members of the panel allows for power improvements. We used the cointegration tests developed by Pedroni (1999, 2004), where the null hypothesis is that there is no cointegration. Pedroni (1999, 2004) starts by computing regression residuals from the cointegration regression which, in the most general case may take the form

$$\begin{aligned} y_{it} &= \alpha_i + \delta_i t + \sum_{j=1}^{J} \beta_{ji} x_{ji,t} + e_{it} \\ \text{for } t &= 1,...T;\ i = 1,...N;\ j = 1,...J \end{aligned} \tag{6}$$

where T refers to the number of observations over time, N refers to the number of individual members in the panel, and J refers to the number of regression variables. As there are N different members in each panel, we can think of N different equations each with M regressors. The various slope coefficients β_{ji} are allowed to vary across the i members of the panel. The parameter α_i is the member specific intercept, or fixed-effects parameter, and is also permited to vary across the i member of each panel. This general form also allows to include deterministic time trends specific to individual members of the panel, captured by the term $\delta_i t$. It is also possible to include a set of common time dummies that are intended to capture disturbances which may be shared across the different members of the panel. Since α_i and β_{ji} are permited to vary, this approach allows

[14] The number of lags to include in the ADF test was decided following the same method as for the other interest rate series. In this case we concluded that $L = \overline{p} = 12$ was the lag order to consider.

for considerable short-and long-run heterogeneity.

Tests for the null of no cointegration are based on the residuals $\widehat{e}_{it}$ using

$$\widehat{e}_{it} = \rho_i \widehat{e}_{it-1} + \upsilon_{it}. \tag{7}$$

Pedroni (1999) presents seven different test statistics. The first four tests are based on what is commonly referred to as the within-dimension, and the last three tests are based on what is referred to as the between-dimension. The consequence of this distinction arises in terms of the autoregressive coefficient ρ_i. For the within-dimension statistics, also called panel statistics, the test for the null of no cointegration is implemented in equation (7) as a test of the null hypothesis $H_0 : \rho_i = 1$ for all i, versus the alternative $H_1 : \rho_i = \rho < 0$ for all i. These tests consider the existence of a common value ρ for all i. The between-dimension test statistics, also called group mean statistics, by contrast, are implemented as tests of the null $H_0 : \rho_i = 1$ for all i, versus the alternative $H_1 : \rho_i < 0$ for all i. Thus, the between-dimension statistics allow to model an additional source of potential heterogeneity across individual members of the panel. The details of each test can be seen in Pedroni (1999). Under the alternative hypothesis, the first test proposed by Pedroni diverges to plus infinity and thus the right tail of the standard normal distribuition needs to be used to reject the null hpothesis of no cointegration. For each of the other six tests, these diverge to minus infinity and large negative values imply that the null of no cointegration is rejected. To implement Pedroni's tests in unbalanced panels we used Rats[15]. The results are presented in Table 3 and are based on a model without a time trend. Cointegration tests consider the 3-month interbank rate for products with a maturity less than 6 months and a 6-month interbank rate for products with a maturity higher than 6 months[16]. All tests reject the null of no cointegration for all interest rate series. However, the test statistics for the variable "transferable deposits (TrD)" are not as high as for the other variables. The same tests were applied to a model with a time trend. In this case, the hypothesis that "transferable deposits (TrD)" is not cointegrated with the interbank rate is not rejected. This is consistent with Figure 2 of the retail rates of this product (see Appendix 1).

[15] The procedure used was "pancoint.src" downloaded from the RATS web-site written by Pedroni.

[16] In the case of deposits, the money market interest rate was corrected to consider minimum reserves requirements. Between January 1990 and October 1994 the reserve ratio was 17 percent and reserves were paid interest at a fixed rate decided by Banco de Portugal. During this period, the money market interest rate considered as the oportunity cost of deposit retail rate is $r_s(1-\rho)+\rho r_\rho$, where ρ is the reserve ratio and r_ρ measures the interest rate paid on the amount of reserves. This remuneration rate is tipically lower than a market rate. In November 1994 the reserve ratio decreased to 2%, and reserves started to be paid a remuneration at a market rate.

Table 3: Panel cointegration test statistics

	panel v-stat	panel rho-stat	panel pp-stat	panel adf-stat	group rho-stat	group pp-stat	group adf-stat
LOANS							
DC3m	10.37	-32.56	-17.51	-10.62	-32.17	-21.23	-13.28
DC3_6m	7.74	-29.93	-16.00	-11.88	-27.41	-18.23	-12.09
DH3m	7.22	-19.99	-11.70	-6.03	-24.78	-15.60	-8.79
LC1day	9.56	-24.66	-14.66	-8.24	-31.41	-19.74	-10.71
LC3m	13.48	-32.72	-18.34	-11.19	-36.76	-24.09	-14.07
LC3_6m	14.69	-41.27	-20.88	-12.09	-37.54	-23.73	-14.30
LH6m_1y	7.76	-23.96	-13.76	-6.24	-29.53	-18.13	-8.49
LH2_5y	4.99	-15.89	-9.64	-3.11	-18.17	-10.98	-4.10
LH5y	7.74	-16.75	-10.54	-4.07	-16.65	-12.19	-4.72
DEPOSITS							
TrD	3.96	-6.30	-5.35	-1.62	-10.12	-7.83	-3.63
D1m	14.86	-41.78	-21.99	-11.10	-45.21	-26.16	-13.17
D1_3m	8.89	-16.22	-11.93	-6.96	-27.46	-18.41	-11.80
D6m_1y	16.73	-31.32	-16.58	-12.21	-28.68	-18.27	-13.63
Pens6m_1y	11.67	-18.77	-10.96	-7.48	-16.17	-11.98	-7.75
Emig6m_1y	13.90	-24.37	-13.44	-10.94	-22.91	-15.29	-12.39

Note: These results were obtained for a model without a time trend. The interbank rate used for variables with a maturity smaller than 6 months is the 3-month interbank rate; for all the others it is the 6-month interbank rate. For deposit products the interbank rates were corrected to consider minimum reserve requirements. All reported values are distributed as N(0,1) under the null of no cointegration. The results were obtained using RATS. A short definition of each bank product can be found in Table 1.

2.3.2 Model estimation

The various panel cointegration estimators available include within- and between-group fully modified (FMOLS) and dynamic (DOLS) estimators. So far there is no consensus on which estimator is prefered (see, for instance, Kao and Chiang, 2000 and Pedroni, 2000). However, the group mean panel FMOLS estimator has the advantage of allowing for heterogeneity for all i in each panel. This estimator is the one used in this study. Again, we used the Rats procedure[17] developed by Pedroni which computes a group mean panel FMOLS estimator based on equation (1). The results are presented in Table 4.

Bank retail rates are not expected to deviate from the money market interest rate for long periods and the cointegration tests confirm that there is a long-run relationship between retail rates and the interbank rate. However, the impact of a unitary change in the interbank rate is different between loans and deposits. In the case of loans, the effect is typically around one, meaning that changes in money market rates are fully transmitted to retail rates. On the other hand, the transmission of a change in interbank rates to deposits is shown to be incomplete. An usual explanation to the incomplete transmission of interbank rates to deposits retail rates is the presence of minimum reserve requirements. This difference in the results for loans and deposits

[17]The procedure used was "panelfm.src" downloaded from the RATS web-site.

Table 4: FMOLS estimator of the cointegrating Vector

	b	t-stat		b	t-stat
LOANS			**DEPOSITS**		
DC3m	1.01	137.6	TrD	0.17	27.2
DC3_6m	1.07	136.2	D1m	0.82	181.3
DH3m	0.85	92.7	D1_3m	0.74	147.3
LC1day	1.10	113.8	D6m_1y	0.87	201.0
LC3m	0.98	112.7	Pens6m_1y	0.89	173.4
LC3_6m	0.98	108.7	Emig6m_1y	0.87	186.3
LH6m_1y	1.03	76.6			
LH2_5y	0.86	41.8			
LH5y	0.77	59.9			

Note: The interbank rate used for variables with a maturity smaller than 6 months is the 3-month interbank rate; for all the others it is the 6-month interbank rate. For deposit products the interbank rates were corrected to consider minimum reserve requirements. The results were obtained using RATS. A short definition of each bank product can be found in Table 1.

was already observed in other studies on the Portuguese banking industry covering different time periods and using different methodologies (see Banco de Portugal, 1999, Sorensen and Werner, 2006, and De Bondt, Mijon and Valla, 2005). Moreover, the above mentioned studies for Portugal had different data sources and considered only aggregate data.

Although cointegration between the interest rates of "transferable deposits" and the interbank rate is not rejected in a model without trend, this conclusion does not hold for a model with a time trend. This was expected from the simple observation of Figure 2 with the evolution of retail rates in Appendix 1. This type of deposits may be seen as a way of starting a banking relationship, and a way to have access to other financial instruments. As such, they are more related with a payment service rather than an investment and their remuneration is quite low. As expected, retail rates of these deposits are not so responsive to the money market rate. Given the above discussion, the "transferable deposits" interest rates will not be analysed in this work.

Additionally, the existence of a risk premium in loan products was not yet taken into account. If credit risk is incorporated in the model of Hannan (1991), it can be shown that parameter b can be higher than one. This helps explaining the estimated values of b higher than one. In this context, we also computed a default measure and used it to estimate the long run parameter. This default measure is computed for each bank and does not depend on the specific produt considered. Using this default measure as another regressor in equation (1) the long run coefficients of the interbank rate turn out to be equal or lower than the ones in Table 4, however this conclusion is not valid for each bank individually.

The long run parameter can also be interpreted as a measure of competition in each particular market segment. If the market is competitive, this parameter should be around one. Under this interpretation, it can be argued that the credit market for corporations is more competitive than for households.

The next step consists in estimating the error correction model. As the long-run parameters are different between banks, equation (2) will be estimated individually for each bank. Thus, different estimates of the long-run parameters, instead of pooling the banks with respect to this parameter, will be used. We started by estimating the general expression in equation (2) with $p = q = 6$ and used the Schwarz Information Criterion to choose the number of lags to be included. Keeping $p = 6$, the lagged terms of the difference in the money market rate turned out to be non significant in most cases. We ended up with a model with $p = 6$ and $q = 0$. Results of the estimation are presented in Table 5. All columns present the arithmetic mean of the individual values obtained estimating each series individually. Results for the mean adjustment lag[18] (mean lag) are also reported. Values for the "transferable deposits (TrD)" variable are not presented as already mentioned.

The error correction term, which can also be seen as a measure of the speed of adjustment of retail rates to changes in interbank rates is, in general, more negative for deposits than for loans[19]. It means that changes in the interbank rate result in faster changes in the retail rates of deposits than loans. This could be due to the fact that interest rates were declining over most of the sample considered. In addition, retail rates of loans to the corporate sector react faster to changes in the interbank rate. Another result is that there seems to exist a negative relationship between the maturity and the speed of adjustment for deposit rates (the error correction term for deposits with higher maturities presents lower values in absolute terms). Among loans, no clear relationship between the maturity and the speed of adjustment emerges.

The comparison of the speed of adjustment accross products needs to consider also the long-run equilibrium rates these retail rates are adjusting to. In other words, one should investigate whether retail rates are adjusting faster to a less than complete pass through, as in the case of deposits, or

[18] See Appendix 3 for a derivation of the mean lag in this model.

[19] This result contrasts with the results of Kok-Sorensen and Werner (2006) and Van Leuvensteijn et al. (2008). In the first case, the speed of adjustment of consumer loans is higher than for mortgage loans, short term loans to enterprises and time deposits. In the second case, the speed of adjustment is approximately the same for mortgage loans, short term loans to enterprises and time deposits.

Table 5: Error correction term estimators and mean adjustment lag

	Error correction term (1)	Mean lag (in months) (2)	Relative speed of adjustment (3)
LOANS			
DC3m	-0.22	8.99	0.21
DC3_6m	-0.16	5.50	0.17
DH3m	-0.21	9.51	0.18
LC1day	-0.21	10.25	0.23
LC3m	-0.30	6.48	0.28
LC3_6m	-0.32	5.68	0.31
LH6m_1y	-0.28	9.72	0.29
LH2_5y	-0.17	19.00	0.15
LH5y	-0.19	7.50	0.16
DEPOSITS			
TrD	--	--	--
D1m	-0.38	4.02	0.33
D1_3m	-0.28	5.33	0.24
D6m_1y	-0.25	4.06	0.22
Pens6m_1y	-0.17	5.36	0.16
Emig6m_1y	-0.21	4.65	0.19

Notes: Column (1) reports the arithmetic mean of the values γ_i obtained with the individual estimation of equation (2). Column (2) reports the arithmetic mean of the individual mean lags. Finally, column (3) reports the arithmetic mean of the individual relative speed of adjustment computed as the product of - γ_i with b_i. A short definition of each bank product can be found in Table 1.

slower to a higher value of pass-through, as in the case of loans. We then compute a measure of relative adjustment by multiplying the error correction term by the long term multiplier for each bank. The average of this measure, for each product, is presented in the last column of Table 5. Although the relative speed of adjustment measure is still higher for deposits, the difference is now smaller when compared with the same measure for loans.

3 The determinants of the interest rate pass through

Most studies on pass-through analyze the impact of changes in money market interest rates on aggregate values, without taking into account the heterogeneity in the behavior of banks. However, the availability of bank individual data allows for the estimation of each relationship individually. Such detailed data allow us to study the price-setting behavior of banks, and their incentives to adapt their retail rates to changing market conditions. Using the individual estimations performed in the previous section, it is possible to conclude that there is some heterogeneity in the behavior of banks within a panel. Table 6 presents the minimum and maximum individual values obtained for the log-run coefficient and the error correction term estimated in the previous section. It also reports a measure of the dispersion of the estimated values within each panel. As can be

Table 6: Heterogeneity of the long-run pass-through and the error correction term

	Long-run pass-through			Error correction term		
	b_{max}	b_{min}	$b_{max} - b_{min}$	γ_{max}	γ_{min}	$\gamma_{max} - \gamma_{min}$
LOANS						
DC3m	1.56	0.75	0.81	-0.03	-0.42	0.39
DC3_6m	1.55	0.85	0.70	-0.02	-0.33	0.31
DH3m	1.06	0.63	0.43	-0.05	-0.36	0.31
LC1day	2.07	0.57	1.50	-0.03	-0.64	0.61
LC3m	1.37	0.48	0.89	-0.07	-0.69	0.62
LC3_6m	1.38	0.44	0.94	-0.12	-0.82	0.70
LH6m_1y	1.65	0.64	1.01	-0.08	-0.68	0.59
LH2_5y	1.73	0.02	1.71	-0.02	-0.41	0.39
LH5y	1.12	0.20	0.92	-0.06	-0.57	0.50
DEPOSITS						
TrD						
D1m	1.04	0.33	0.71	-0.09	-1.05	0.96
D1_3m	1.08	0.33	0.75	-0.05	-0.82	0.77
D6m_1y	1.01	0.80	0.21	-0.10	-0.47	0.37
Pens6m_1y	1.00	0.78	0.22	-0.10	-0.42	0.32
Emig6m_1y	1.04	0.80	0.24	-0.11	-0.74	0.63

Notes: b_{max} (b_{min}) is the maximum (minimum) long-run coefficient estimated using equation (1), within each panel. γ_{max} (γ_{min}) is the maximum (minimum) error correction term estimated using equation (2), within each panel. A short definition of each bank product can be found in Table 1.

observed, there is heterogeneity in the behavior of banks and this motivates the study of this section. Here we investigate whether bank characteristics explain the differences obtained in the estimated coefficients. The objective is to study the different decisions of banks in terms of their own specific characteristics. In addition, other characteristics such as the Herfindahl index are also taken into account. In order to characterize the different behavior of banks, we regress the estimated value for the error correction term and the long term coefficient on several bank and product characteristics. Loan products are considered as a group and deposits as another group implying that there is a common behaviour in the loan market and in the deposits market.

In the literature, several factors have been referred to as having an impact on the interest rate pass-through. According to the traditional structure-conduct-performance hypothesis, the setting of retail rates is less favorable to costumers in more concentrated markets as a result of competitive imperfections in these markets. Consequently, bank profits are higher in more concentrated, or less competitive markets. A related theory is the relative market-power hypothesis. This theory asserts that only firms with large market shares are able to exercise market power in pricing products and, consequently, earn higher profits. These two market power hypothesis would predict a negative impact on the pass-through, as banks in more concentrated markets, or with more market power, would be able to set interest rates more autonomously. In this study, as a measure of concentration, we use the **Herfindahl** index of each product and consider only new operations. Regarding the computation of **market shares**, we opted to compute the market share of each bank in new transactions of each product instead of a single market share taking into account the global activity of the bank.

In contrast to these market power theories, there are also efficiency explanations of the positive relationship between profits and either concentration or market shares. Banks may have higher profits because they are more cost efficient, either in terms of superior management, production technologies or because they work at more efficient scales. These banks are also assumed to gain market share, resulting in more concentrated markets. However, in this case, the positive relationship between profits and market power is spurious, as it is the efficiency that is driving both profits and market structure. Following this hypothesis, efficient banks have more incentive to pass its efficiency advantage on to their customers, regardless of the evolution of market rates. A negative relationship between an efficiency measure and the pass-through would be consistent with the efficiency hypothesis. As it is not possible to construct the efficiency measures proposed by Berger (1995), we decided to consider the **cost to assets ratio as** a measure of the degree of operational efficiency.

In line with the literature on the credit channel of monetary policy transmission (for instance, Kishan and Opiela, 2000, and Kashyap and Stein, 2000), we included in the regressions an indicator of capitalization and an indicator of liquidity. Kishan and Opiela (2000) provide evidence that the loan supply of small, undercapitalized banks is more responsive to monetary policy than that of larger and well capitalized banks. As in the work by Kishan and Opiela (2000) we compute the capital ratio as **equity capital / total assets**. On the other hand, Kashyap and Stein (2000) study the monetary transmission mechanism using a data set of US commercial banks and find that the impact of monetary policy on lending is stronger for banks with less liquid assets. To test this hypothesis, we use the **coverage ratio of interbank liabilities by highly liquid assets** (interbank assets and assets eligible for monetary policy operations) as an indicatior of liquidity. Following this line of the literature, a negative relationship between the interest rate pass through and the capital and liquidity ratios would be expected.

Berlin and Mester (1999) found that banks with more core deposits (like demand and saving deposits) provide more loan rate smoothing in response to exogenous credit shocks. The stable pool of deposits leave the banks less vulnerable to exogenous interest rate shocks. In line with the work by Berlin and Mester (1999) we included a measure of a **bank's liability structure**. De Graeve, De Jonghe and Vennet (2004) argue that banks with more diversified activites are less vulnerable to shocks in market interest rates than banks which are more specialized in retail activites. As such, more diversified banks would set interest rates more autonomously than more specialized banks. The indicator used to measure the degree of diversification is the ratio of **non interest income over gross income**.

Another relevant variable in the determination of loan interest rates is the level of default risk of each bank's portfolio. The ratio of non performing loans to toal loans is often used as a measure of default risk. However, this measure is quite sensitive to the evolution of credit and to write-off policies. In the first case, the growth of credit in the up stages of the economic cycle contribute to a (mechanic) decrease in non performing loans ratios, when usually it is in these stages of the cycle that credit risk builds up. In the second case, the write-off of loans totally provisioned will make this ratio to decrease, specially in later stages of the cycle when loan delinquencies tend to increase. In this context, the variable used to measure credit risk is computed as the ratio of the value of **new non performing loans (over a year) to total loans**. We expect a negative relationship between default risk and the pass through of market rates as the setting of loan interest rates tends to follow less closely the evolution of market rates in situations where credit risk is more important.

Finally, other variables were introduced to consider some Portuguese banking characteristics. Throughout the 1980's, the Portuguese banking system was subject to restrictions in several dimensions of its activities. These restrictions covered different features of the industry such as the setting of deposits and loans interest rates, the opening of new branches, the ownership of the institutions (many banks were public) and the entry of foreign banks. In the early nineties, the acceleration of the deregulation process promoted a dramatic change in the behavior of banking institutions. Between 1993 and 2002, the number of branches[20] increased around 70 per cent and the number of banks increased around 50 per cent, from 43 banks (and branches of foreign banks) by the end of 1993 to 64 banks by the end of 2002. The privatisation process progressed and in 1997 the market share of state owned banks (in credits and deposits) was lower than 30 per cent. Simultaneously, a sequence of take-overs intensified in the mid-eighties. Following

[20] The figures presented were from several annual reports of Banco de Portugal.

several acquisitions, banking business became more concentrated. The market share of the five major banking groups, in terms of assets[21], went from 68 per cent in 1992 to 78 per cent in 2002, reaching the highest value of 82 per cent in 2000. Another important fact is the increasing number of foreign bank entries in the Portuguese market. The number of foreign banks doubled in the nineties and the market share (either in assets or credits) more than doubled[22]. To sum up, during the period under analysis the Portuguese banking business has been highly concentrated in five institutions, state-owned banks decreased in importance and foreign banks increased their weight in the industry. As a consequence, we decided to introduce several control variables, namelly a dummy variable to control for the **nationality** of the bank, a dummy variable to control if the bank belongs to one of the **big five** banking groups, and a growth variable measuring the **asset growth** of the bank over time. The nationality issue is particularly relevant to take into account the fact that bank's decisions in terms of price-setting may differ whether a bank belongs to a foreign banking group as, in such case, these decisions are part of the group international decisions. The size issue is relevant as larger banks are expected to lend money to larger firms which may have more financing sources than smaller firms, which tend to be more dependent on bank loans. Thus, larger banks may follow market conditions more closely. In addition, to take into account the relevance of the new operations of the product being studied, an indicator of its **weight** to the broad category of credits or loans was also considered. Finally, the profitability of the bank was also taken into account by introducing a profitability dimension measured by the **ROE**.

3.1 Data

Bank characteristics are obtained by constructing ratios from balance sheets and profit and loss accounts of banks. The data used for the construction of all ratios matches the years studied in the previous sections. Outlier observations were considered missing and a correlation matrix was constructed to prevent the possibility of multicollinearity issues. Table 7 presents summary statistics of the data used in this section.

3.2 Results

The model to be estimated is the following

$$y_{i,j} = \alpha + \beta X_i + \gamma Y_j + \theta Z_{i,j} + \varepsilon_{i,j} \tag{8}$$

[21] Market shares based on credit present a very similar evolution.

[22] However, the biggest jump in foreign banks' market share occurred after the acquisition of a big portuguese institution.

Table 7: Summary statistics on bank and product characteristics

Variable	Definition of the variable	Number of observations	Mean	Std. Dev.	Min	P(25)	P(50)	P(75)	Max
BANK CHARACTERISTICS									
Cost to assets	staff and other administrative costs / total assets	45	0.02	0.01	0.00	0.01	0.02	0.02	0.06
Capital ratio	capital / total assets	45	0.11	0.07	0.01	0.06	0.09	0.14	0.29
Liquidity ratio	cash and interbank assets / interbank liabilities	42	1.37	0.74	0.23	0.81	1.24	1.62	3.15
Liability structure	resources from customers / total assets	45	0.41	0.23	0.01	0.23	0.42	0.58	0.78
Diversification	other current income / gross income	45	0.34	0.20	-0.03	0.22	0.29	0.41	0.93
Default risk	new non performing loans / credit to customers	45	0.05	0.11	0.00	0.01	0.02	0.04	0.73
Foreign	equal to 1 if a domestic institution	45	0.60	0.50	0.00	0.00	1.00	1.00	1.00
Big five groups	equal to 1 if a member of the big five banking groups	45	0.38	0.49	0.00	0.00	0.00	1.00	1.00
Growth	asset growth rate	45	0.22	0.15	-0.03	0.12	0.21	0.30	0.85
ROE	profit for the year / equity	43	0.06	0.06	-0.11	0.04	0.07	0.09	0.15
PRODUCT CHARACTERISTICS									
Herfindahl index	herfindahl index of new operations	14	0.19	0.07	0.10	0.13	0.15	0.24	0.38
BANK AND PRODUCT CHARACTERISTICS									
Market Share	market share of new operations	306	0.05	0.06	0.00	0.01	0.03	0.08	0.39
Weight	value of new operation / total credit or total deposits	306	0.33	0.36	0.00	0.04	0.16	0.52	1.00

Notes: These variables were computed using balance sheets and profit and loss accounts of banks. For each bank, an average of the value of each ratio over the years considered in Section 2 was computed. Outlier observations were considered as missing.

where i denotes the bank and j denotes the product. This equation will be estimated for two relevant parameters of the pass-through: the long-run coefficient and the error correction term estimated in Section 2.3. Variables X_i represent banks' characteristics, Y_j represent products' characteristics and $Z_{i,j}$ represent variables characterizing both the product and the bank. The estimation is done separately for deposits and for loans. In general, the explanatory variables are not expected to explain the heterogeneity in both parameters of both loans and deposits. For instance, the default risk parameter should mainly contribute to explain the behavior of banks when setting loan rates.

Table 8 summarises the results of the estimation of equation (8) for loans and deposits. It is relevant to keep in mind that the left hand side of the equation is already an estimated value. In addition, observations within a product have some common variance and by pooling over products each observation gets some product specific variance. For these reasons, the homoescedasticity condition is violated. To deal with this issue, we compute heteroscedasticity- consistent standard errors as suggested by White (1980). Moreover, the error correction term takes always negative values, implying that negative estimated coefficients for the explanatory variable contribute to increase the error correction term resulting in a faster pass-through.

In general, results are statistically more significant for deposits than for loans. This may result from the fact that it is more difficult to understand the setting of loan's interest rates as problems of assimetry of information are more important than for deposits. In any case, given the small number of observations, results should be used with caution.

Capital and liquidity ratios are never significant. This finding strongly contrasts with the results by De Graeve, de Jonghe and Vennet (2004). According to these authors, the capital ratio is "probably the most discerning characteristic" in explaining retail bank interest rate heterogeneity of Belgian banks. The result for Portugal may happen because, in the eighties, there were many restrictions to banking ativities and banks may not have been able to find profitable investments, resulting in an accumulation of capital. In fact, Boucinha e Ribeiro (2008) document that in 1994 capital buffers were close to 80 percent above the minimum capital required. This figure decreased significantly in 2000 as there was a strong deregulation of banking activities during the nineties. Simultaneously, the convergence in interest rates promoted the rapid increase in credit. However, on average, for the period between 1994 and 2002 capital buffers seem to be significant and, as such, the capital ratio is not a restrictive variable in the behavior of Portuguese banks.

In terms of competition, the concentration of banks across products, measured by the Herfindahl index, proves to be relevant to explain interest rate heterogeneity in loan but not deposit retail rates. Results show that for products where concentration is higher, the speed of adjustment in changes in interbank rates is higher but the long run pass-through is less complete. In turn, market share is relevant to explain the speed of adjustment of both loan and deposit rates. In this case, we conclude that banks with larger market shares will tend to adjust slower their retail rates than banks with smaller market shares. This result is in line with the relative market power hypothesis of Berger (1995). There is no evidence on the alternative hypothesis, that is, that banks with more operational efficiency would tend to pass its efficiency advantage on to their customers. In fact, results are mixed for loans as banks with higher cost to assets ratios adjust loan interest rates at a slower rate but to a more complete pass through than banks with lower cost to assets ratios.

Results on the effect of diversification are mixed. On the one hand, the estimated coefficient of diversificaton for the error correction term of deposits is significant and negative. This means that more diversified banks adjust deposit interest rates faster than less diversified banks. As the period under study is characterized by decreasing interest rates, this could be interpreted as if banks with more diversified activities were less dependent on deposits and, as such, were able to decrease interest rates on deposits faster than banks more dependent on a more tradicional funding. On the other hand, the long run coefficient for deposits is negative, in line with De Graeve, De Jonghe and Vennet (2004) predictions. As for the liability structure of banks, results on the long run multiplier of deposits are in line with the argument of Berlin and Mester (1999) that banks with a larger share of core deposits are less vulnerable to the evolution of market interest rates. Finally, as in De Graeve, De Jonghe and Vennet (2004), default risk is not a relevant variable to explain loan interest rates pass-through.

The robustness of the results has been checked in several ways (Table 9). The first test was to introduce one dummy variable per product instead of the Herfindahl index. This case corresponds to Model 1 in Table 9. The main conclusions still apply. A second test consisted in using the concentration index C4 instead of the Herfindahl index. Results are not reported as they are very similar to the ones in Table 8. Robustness tests were performed using alternative definitions of some explanatory variables. For instance, a return on assets ratio (ROA) was used instead of the return on equity (ROE) as a measure of profitability (Model 2 in Table 9). In this case, diversification effect is no longer relevant to explain the speed of adjustment of deposits interest rate. A fourth robustness test consisted in replacing the cost to assets ratio by the cost to income ratio (Model 3 in Table 9). In this case the cost measure is no longer relevant to explain the behavior of the loan interest rates.

An alternative formulation including a measure of default risk in the long term model for loans was also considered. This formulation results in a positive and significant coefficient of the long term default risk parameter. The long term coefficient of the interbank interest rate decreases although this pattern does not apply to all banks individually. In what concerns the determinants of heterogeneity, results are not significantly different from the ones presented in Table 8.

4 Conclusions

This study addresses the interest rate pass through of the Portuguese banking system. The study is performed along two main questions. First, what are the main characteristics of the interest rate pass through of the Portuguese banking system? Second, does the pass-through of interest rates vary accross banks? In order to answer these questions a data set with quantities and prices set on new operations of loans and deposits was constructed. Data covers information of nine types of loans and six types of deposits for the period between 1990 and 2002. It includes information on products offered to both the corporate sector and households, and also with short term and long term maturities.

Results on the characterization of the interest rate pass through are mostly in line with other published results for the Portuguese banking system. The interest rate pass-through is typically around one for loans and lower than one for deposits. This means that changes in money market rates are fully transmitted to loan rates but not to deposit rates. Regarding the speed of adjustment, retail rates of loans to the corporate sector adjust faster to changes in the interbank rate. In addition, we conclude that there is a negative relationship between the maturity and the speed of adjustment for deposit rates while no clear relationship between the maturity and the speed of adjustment emerges for loans.

The availability of micro-level data allows a study on the determinants of the heterogeneity in the pass-through accross banks. The empirical findings presented in this work have to be interpreted with caution because the sample period is short and the interest rate cycle covered is limited. Notwithstanding this, some conclusions emerge which seem to be quite robust. First,

Table 8: The determinants of heterogeneity

LOANS	**Long run pass-through**		**Error corrector term**	
	Coeff.	**t-stat**	**Coeff.**	**t-stat**
Cost to assets	7.51 **	2.61	6.27 ***	3.29
Capital ratio	-0.21	-0.42	-0.54	-0.98
Liquidity ratio	0.03	0.59	0.01	0.39
Liability structure	0.12	0.63	-0.02	-0.17
Diversification	-0.37 *	-1.93	0.04	0.34
Default risk	-0.31	-1.24	0.21	1.26
Herfindahl index	-0.69 *	-1.75	-0.69 ***	-2.66
Market Share	0.25	0.92	0.54 ***	3.10
Foreign	-0.07	-1.34	0.02	0.52
Big five groups	0.07	1.41	0.04	1.18
Growth	0.13	0.78	-0.07	-0.52
Weight	0.14 **	2.55	-0.03	-0.95
ROE	-0.12	-0.35	-0.06	-0.27
number of observations	168		168	
R^2	0.17		0.22	

DEPOSITS	**Long run pass-through**		**Error corrector term**	
	Coeff.	**t-stat**	**Coeff.**	**t-stat**
Cost to assets	-0.16	-0.10	-0.05	-0.02
Capital ratio	-0.10	-0.27	-0.03	-0.06
Liquidity ratio	0.02	0.65	0.01	0.33
Liability structure	-0.50 **	-2.51	-0.03	-0.12
Diversification	0.01	0.05	-0.32 **	-2.09
Default risk				
Herfindahl index	-0.13	-0.71	-0.12	-0.92
Market Share	0.41	1.32	0.66 ***	3.10
Foreign	-0.02	-0.53	0.08 *	1.76
Big five groups	0.00	0.07	0.05	1.39
Growth	0.41 **	2.51	-0.38 ***	-2.84
Weight	-0.02	-0.50	-0.09 *	-1.68
ROE	-0.22	-0.68	-0.73 **	-2.31
number of observations	107		107	
R^2	0.25		0.45	

Notes: The long run coefficient corresponds to b in equation (1) and the error corrector term corresponds to γ in equation (2). Standard errors are computed according to White (1980) heteroscedasticity-consistent estimators. * = significance at the 10 per cent level; ** = significance at the 5 per cent level; *** = significance at the 1 per cent level.

Table 9: Robustness tests

	Model 1		Model 2		Model 3	
LOANS	**Long run**	**ECT**	**Long run**	**ECT**	**Long run**	**ECT**
Cost to assets	9.90 ***	6.14 ***	8.49 ***	6.43 ***		
Cost to income					0.40	0.27
Capital ratio	-0.34	-0.55	-0.29	-0.64	0.73	0.19
Liquidity ratio	0.02	0.01	0.04	0.00	0.04	0.02
Liability structure	0.10	-0.03	-0.03	0.01	0.26	0.10
Diversification	-0.46 **	0.06	-0.31 **	0.03	-0.38 *	0.04
Default risk	-0.27	0.24 *	-0.52	0.31	-0.33	0.18
Herfindahl index			-0.63	-0.70 ***	-0.63	-0.65 **
Market Share	0.30	0.61 ***	0.32	0.49 ***	0.23	0.52 ***
Foreign	-0.06	0.01	-0.07	0.01	-0.06	0.03
Big five groups	0.08	0.03	0.08	0.03	0.09 *	0.05 *
Growth	0.04	-0.03	0.20	-0.09	0.20	-0.01
Weight	0.06	-0.07	0.16 ***	-0.04	0.14 **	-0.03
ROE	-0.16	-0.07			0.16	0.08
ROA			-7.98	2.71		
number observations	168	168	172	172	168	168
R^2	0.29	0.29	0.21	0.23	0.15	0.18
DEPOSITS	**Long run**	**ECT**	**Long run**	**ECT**	**Long run**	**ECT**
Cost to assets	-1.06	-0.16	0.23	-0.52		
Cost to income					0.01	0.01
Capital ratio	-0.15	-0.11	0.16	0.32	-0.10	-0.02
Liquidity ratio	0.04 *	0.01	0.02	0.00	0.02	0.01
Liability structure	-0.36 *	-0.02	-0.45 **	0.06	-0.51 ***	-0.03
Diversification	0.12	-0.33 **	-0.01	-0.24	0.00	-0.32 **
Default risk						
Herfindahl index			-0.14	-0.14	-0.13	-0.12
Market Share	0.13	0.62 **	0.38	0.52 ***	0.41	0.66 ***
Foreign	-0.05	0.07 *	-0.02	0.07 *	-0.02	0.08 *
Big five groups	0.01	0.05	-0.01	0.04	0.00	0.05
Growth	0.53 ***	-0.37 ***	0.35 **	-0.45 ***	0.40 **	-0.38 ***
Weight	0.19 ***	-0.07	-0.03	-0.09	-0.02	-0.09 *
ROE	-0.17	-0.74 **			-0.19	-0.72
ROA			1.24	-5.57 *		
number observations	107	107	110	110	107	107
R^2	0.56	0.46	0.24	0.47	0.25	0.45

Notes: The long run coefficient corresponds to b in equation (1) and the error corrector term corresponds to γ in equation (2). Model 1 considers product dummies; Model 2 replaces the ROE measure by ROA and Moodel 3 replaces the cost to assets ratio by the cost to income ratio. * = significance at the 10 per cent level; ** = significance at the 5 per cent level; *** = significance at the 1 per cent level.

liquidity and capital ratios do not seem relevant for the determination of the speed and long run pass-through. In the case of the capital ratio, this could be due to the fact that capital ratios of Portuguese banks were still relatively high during the 90's, following a period of many constraints in banking activities which prevented banks from allocating capital to profitable investments. Second, banks with higher market shares are shown to adjust both loan and deposit interest rates at a slower speed than banks with lower market shares. However, the effect of market share occurs only in the short-term as this variable is not relevant to explain the long-run coefficients.

For further research, it would be interesting to investigate if there is any evidence that within a bank the speed of adjustment and the pass through is different accross products. To analyse this question, it would be necessary to have a more balanced panel. In this work, only a very small number of banks is operating in several of the products considered. Another extension would be to construct a longer time-series in order to consider a complete business cycle. There is some evidence that the degree of price stickiness is likely to be assymetric over the interest rate cycle. This analysis is not possibe to perform with the data available as it only captures a period of decreasing interest rates.

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5 Appendixes

5.1 Appendix 1

Figure 1: Loan retail rates from 1990 to 2002. Monthly data.

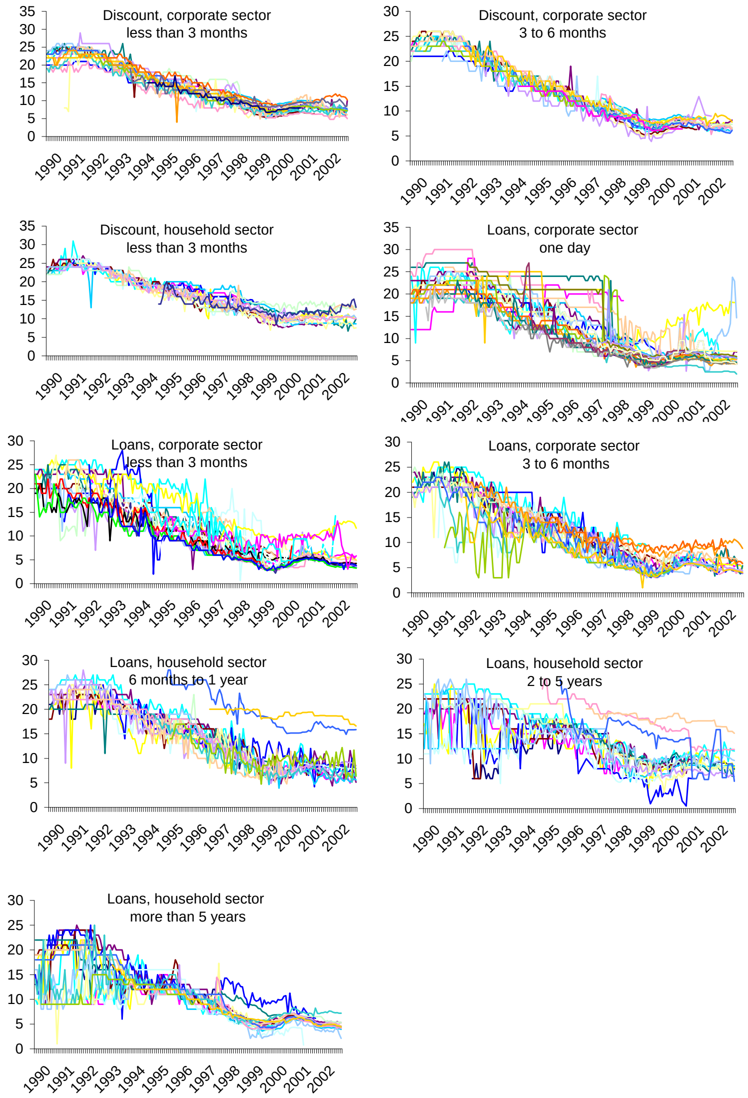


Figure 2: Deposit retail rates from 1990 to 2002. Monthly data.

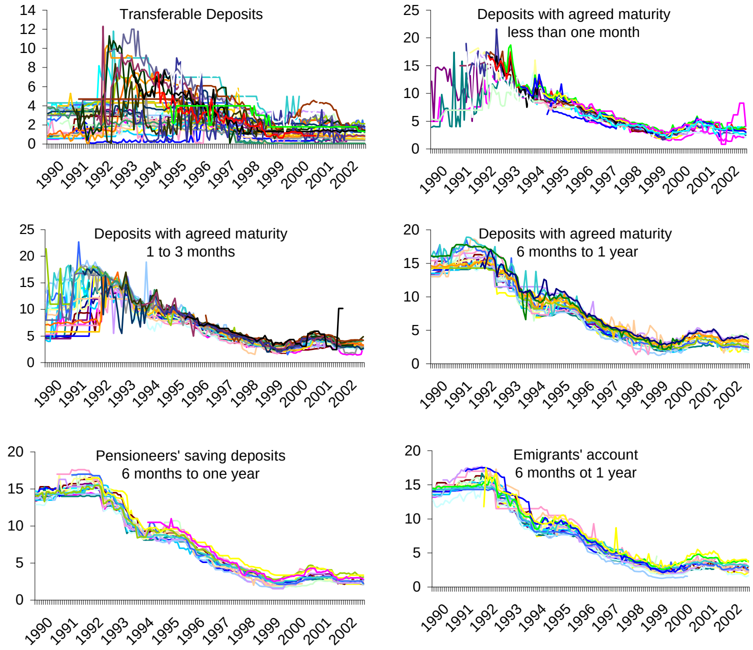
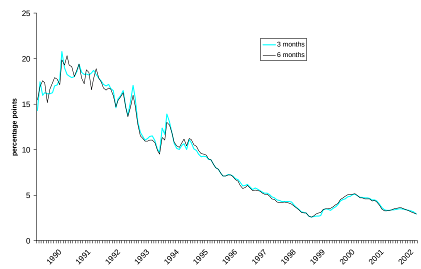


Figure 3: Three-month and six-month money market interest rates.



5.2 Appendix 2

Consider a bank i that has M different types of deposits, uses deposits and capital funds to purchase securities and make N different categories of loans. Bank i's variable costs are assumed to be separable by activity. Then, the profit function of bank i can be expressed as

$$\pi^i = \sum_n^N r_L^{in} L^{in} + r_s S^i - \sum_m^M r_d^{im} D^{im} - VC^i(D^i, L^i) - FC^i, \tag{9}$$

where r_L^{in} and L^{in} represent the interest rate and the dollar amount associated with the nth category of loans held by bank i; r_d^{im} and D^{im} denote the same concepts in relation to the mth category of deposits of bank i; and r_s and S^i are equivalentely defined for the securities held by bank i (securities are treated as a single aggregate value). Terms VC^i and CF^i represent bank i's variable and fixed costs.

Banks maximize profits by freely choosing prices in both the deposits and credit markets. However, each bank individually accounts for a very small part of the market for securities. In this sense, banks decide on r_L^{in} and r_d^{im} but act as price takers in the securities market accepting r_s as fixed. Because of product differentiation, banks face a demand for loans depending on both the price they set (r_L^{in}) and the price all other banks set for the same type of loans (r_L^{-in}). In an analogous way, each bank faces a demand for deposits which depends on both the price they set (r_d^{im}) and the price all other banks set for the same type of deposit (r_d^{-im}). The variable S^i may take positive values, when the bank invests in the interbank market, or negative when the bank finances its activity through the interbank market. The opoortunity cost for boths credits and deposits is the interbank market rate r_s.

The balance constraint that bank i faces is given by

$$\rho D^i + L^i + S^i = D^i + K^i, \tag{10}$$

where K^i represents bank i's capital and ρ represents the reserve ratio, assumed to appply to all categories of deposits.

Solving (10) for S^i, substituting in (9) and differentiating with respect to r_L^{in} and r_d^{im} (assuming that the price decision is taken seperately for each category of deposits and credits) and that variable costs are separable, yields the first order conditions of a Nash equilibrium

$$\begin{cases} r_L^{in} = \frac{\varepsilon_L^{in}}{\varepsilon_L^{in}-1}\left(r_s + c_L^{in}\right) \\ r_D^{im} = \frac{\varepsilon_d^{im}}{\varepsilon_d^{im}+1}\left[r_s\left(1-\rho\right) - c_D^{im}\right] \end{cases} \tag{11}$$

where $\varepsilon_L^{in} = -\frac{r_L^{in}}{L^{in}}\frac{\partial L^{in}}{\partial r_L^{in}} > 0$ is the elasticity of demand for bank i's nth category of loans, $\varepsilon_d^{im} = \frac{r_d^{im}}{D^{im}}\frac{\partial D^{im}}{\partial r_d^{im}} > 0$ is the elasticity of demand for bank i's mth category of deposits, c_L^{in} is the marginal cost of bank i's nth category of loans and c_D^{im} is the marginal cost of bank i's mth category of deposits. Conditions (11) determine the optimal price levels for each bank i. This results from several assumptions, such as, separable variable costs and separable loan and deposit demands. Assuming constat elasticity demand curves, $\frac{\varepsilon_d^{im}}{\varepsilon_d^{im}+1}$ shoud take values between zero and one. In the case of loans, with elastic demand of loans, that is, with $\varepsilon_L^{in} > 1$, which is required for $r_L^{in} > 0$, $\frac{\varepsilon_L^{in}}{\varepsilon_L^{in}-1}$ should take values higher than one. Moreover, as ε_L^{in} approaches infinity, which would be the case of perfect competition between banks, both $\frac{\varepsilon_L^{in}}{\varepsilon_L^{in}-1}$ and $\frac{\varepsilon_d^{im}}{\varepsilon_d^{im}+1}$ equal one. However, it is usually accepted that in this market there is product differentiation. In this case, even in a market where concentration is not very high, $\frac{\varepsilon_L^{in}}{\varepsilon_L^{in}-1}$ $(\frac{\varepsilon_d^{im}}{\varepsilon_d^{im}+1})$ would be higher (lower) than one. Another factor not considered in this model is the existence of credit risk in the loans market. In such case, we expect that, even in a competitive market, the responsiveness of loan retail rates to changes in the money market rate would exceed one[23]. In order to estimate the model, equations (11) must be rewritten since we do not observe the mth type deposit (nth type loan) marginal cost of each bank. Then, the equations to be estimated are

$$\begin{cases} r_L^{in} = a_{in} + b_{in} r_s + \varepsilon_{in} \\ \\ r_D^{im} = a_{im} + b_{im} r_s + \varepsilon_{im} \end{cases}.$$

[23] When a bank contracts a loan it lends an amount L for n periods and has a positive cost C lower than L. At the maturity of the contract, the bank will receive $L(1+r_L)^n$ with probability p and zero with probability $(1-p)$. In a competitive market, the Net Present Value of this contract must be zero, that is $NPV = -L - C + \frac{L(1+r_L)^n}{(1+r_s)^n}p = 0$.Solving this equation for r_L we obtain $r_L = (1+r_s)\left(\frac{1+C/L}{p}\right)^{\frac{1}{n}} - 1$.Then, $\frac{\partial r_L}{\partial r_s} = \left(\frac{1+C/L}{p}\right)^{\frac{1}{n}}$ which is higher than one as long as $C > 0$ or $p < 1$.

5.3 Appendix 3

Let us start with an error correction model written in the following form

$$\Delta r_t = \alpha + \sum_{k=1}^{p} \alpha_k \Delta r_{t-k} + \beta_0 \Delta r_{s,t} + \sum_{l=1}^{q} \beta_l \Delta r_{s,t-l} + \gamma u_{t-1} + \varepsilon_t$$

with $u_{t-1} = r_{t-1} - a - br_{s,t-1}$, where b measures the estimated long term effect, and is obtained in the first step of the estimation. This model can be written in levels when $q = 1$

$$r_t = \alpha - \gamma a + (1+\alpha_1+\gamma) r_{t-1} + \sum_{k=2}^{6} (\alpha_k - \alpha_{k-1}) r_{t-k} - \alpha_6 r_{t-7} + \beta_0 r_{s,t} - (\beta_0 - \beta_1 + \gamma b) r_{s,t-1} - \beta_1 r_{s,t-2} + \varepsilon_{t},$$

which is equivalent to

$$\begin{aligned}
A(L) r_t &= \alpha - \gamma a + B(L) r_{s,t} + \varepsilon_t \\
& \quad \text{where} \\
A(L) &= 1 - L\left(1 + \alpha_1 + \gamma\right) - L^2\left(\alpha_2 - \alpha_1\right) - L^3\left(\alpha_3 - \alpha_2\right) \\
& \quad -L^4\left(\alpha_4 - \alpha_3\right) - L^5\left(\alpha_5 - \alpha_4\right) - L^6\left(\alpha_6 - \alpha_5\right) + L^7 \alpha_6 \\
B(L) &= \beta_0 - (\beta_0 - \beta_1 + \gamma b) L - \beta_1 L^2 \\
& \quad \text{and } L \text{ is the lag operator.}
\end{aligned}$$

The mean lag is given by

$$\begin{aligned}
\overline{Lag} &= \frac{B'(1)}{B(1)} - \frac{A'(1)}{A(1)} \\
&= \frac{\beta_1 + \beta_0}{b\gamma} - \frac{1 - \alpha_1 - \alpha_2 - \alpha_3 - \alpha_4 - \alpha_5 - \alpha_6}{\gamma}
\end{aligned}$$

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