Estimating the Demand for Mortgage Loans with an Application to Merger Analysis.*

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Abstract

This article, assesses the unilateral and coordinated effects on the Portuguese mortgage loans market of the merger between the banks *BCP* and *BPI*. We use a rich cross-section of consumer level data and a discrete choice model to estimate the price elasticities of demand and the marginal costs of mortgage loans. Based on these estimates, we simulate the impact of the merger on the prices and on the welfare. Regarding unilateral effects, our results indicate that the merger would lead to an average increase in the prices of mortgage loans of 3.1%, and to an average increase in the spread of 9.9%. Regarding coordinated effects, our results indicate that the merger would increase the profitability of collusion between the three largest banks by 54.2%. We also simulate the effects of one of the remedies proposed by *BCP*: selling-off 10% of the branches of *BPI*.

Key Words: *Mortgage Loans, Merger, Prices*

JEL Classification: **L25**, **L41**, **G21, G34**.

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*The opinions expressed in this article reflect only the authors' views, and in no way bind the institutions to which they are affiliated.

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1 Introduction

In March 2006, the bank *BCP* proposed the acquisition of the bank *BPI*. The operation was approved in phase II by the Portuguese Competition authority, with remedies.[1] This article, assesses for the Portuguese mortgage loans market, the unilateral and the coordinated effects of the merger on the prices, i.e., on the *interest rates*.[2]

According to the Portuguese Banking Association, in the first semester of 2006 there were 48 active banks in Portugal. These banks owned assets worth 327.035 million euros, of which 204.334 million euros were loans. Despite their being such a large number of banks, most of the assets were concentrated in a small number of institutions. Seven banks accounted for 95% of the total loans, and 91% of the industry assets.[3] Confidentiality requirements prevent us for identifying these banks. Hence, we will refer to the two participants in the merger as banks *I1* and *I2* and to the other banks as banks *O1* to *O5*. In June 2006, mortgage loans represented 79.9% of total loans to households, which in turn, amounted to 55.1% of the loans to the private sector, i.e., loans to households and firms.[4] The same previous seven banks were responsible for more than 85% of the value of mortgage loans contracted in 2004. Considering only these seven banks, the joint market shares of the participants of the value of mortgage loans belonged to the interval $[30\% - 40\%]$.

We use a rich cross-section of consumer level data and a multinomial logit model to estimate the price elasticities of demand for mortgage loans.[5] The demand functions of the banks are elastic with respect to price, but the market demand is inelastic. Assuming that firms play a Bertrand game, we estimate marginal costs. Given the estimates of the firms' pricing strategies and the cost estimates, we simulate the unilateral and coordinated effects of the merger on prices, market shares, profits, and consumer surplus.

[1]The remedies were: **(i)** the disposal of *BCP*'s and *BPI*'s participations in the largest Portuguese credit card acquirer and the launch of an acquiring card operation, **(ii)** the sell-off of 60 branches of *BPI*, and **(iii)** the introduction of measures to reduce client switching costs.

[2]See Ivaldi, Jullien, Rey, Seabright, and Tirole (2003b) for a review of the literature on unilateral effects, and Kovacic, Marshall, Marx, and Schulenberg (2006), Ivaldi, Jullien, Rey, Seabright, and Tirole (2003a), and Davies (2006) for a review of the literature on coordinated effects. See also the EC Merger Regulation Council Regulation (EC) No 139/2004 of 20 January 2004 (OJ L 24, 29.01.2004, p.1), and the US Merger Guidelines (DoJ and FTC, 1997).

[3]These numbers could be larger because these banks control some smaller banks.

[4]Source: Boletim Estatístico do Banco de Portugal - Outubro/06

[5]According to Crooke, Froeb, Tschantz, and Werden (1999), predicted post-merger price changes vary greatly with the demand specification. The price increases predicted by the logit model are lower than those predicted by the log-linear and AIDS models, but higher than those predicted by the linear demand.

Regarding the unilateral effects, our results indicate that the merger would increase the prices of mortgage loans on average by 3.1%. The prices of *bank I1* and *bank I2* would increase by, respectively, 7.1% and 16.3%. The average increase in prices is associated with an average increase in the spread between the *Euribor* and the interest banks charge of 9.9%. For *bank I1* and *bank I2*, the spread would increase by, respectively, 17.3% and 61.5%.[6] On average, the consumer surplus per household would decrease by 87 euros per year, the profits of *bank I1* and *bank I2* per household would increase by 7 euros per year, the profits of the remaining banks per household would increase by 73 euros per year, and the social welfare per household would decrease by 7 euros per year.[7]

Regarding the coordinated effects, we follow the approach proposed by Kovacic, Marshall, Marx, and Schulenberg (2006). This approach considers that a change in market structure increases the incentives for a set of firms to collude, if the change in market structure increases the profits of the colluding firms. Our results indicate that the merger would increase the aggregate profits under collusion of the three largest banks, *bank I1*, *bank O4*, and *bank O5*, by 54.2%. On average, the merger would increase the consumer surplus loss from collusion by 37.5%, or by an additional 456 euros, per household, per year.

We also simulate the effects of one of the remedies proposed by *BCP*: selling-off 10% of the branches of *BPI*. Our results indicate that the impact of the remedy is negligible, both on the unilateral and coordinated effects of the merger.

Our methodological approach draws on the discrete choice literature, represented among others by Domencich and McFadden (1975), McFadden (1974), McFadden (1978), and McFadden (1981). In the industrial organization literature, Berry (1994), Berry, Levinsohn, and Pakes (1995), Goldberg (1995), and Nevo (2001) applied discrete choice models to the analysis of market structure. Brito, Pereira, and Ribeiro (2007), Dube (2005), Ivaldi (2005),

[6] All contracts in our sample have adjustable rates. These contracts feature adjustments of the interest rate at regular time intervals, based on the evolution of a predetermined index, e.g., the *Euribor*. The interest rate is adjusted to a rate that equals the current index value plus a predetermined margin, or spread. According to Low, Sebag-Montefiore, and Dübel (2003), variable rate contracts represented 95% of new lending in Portugal, in 1999, a figure that clearly contrasts with other European countries.

[7] We did not consider merger induced cost efficiency gains because: **(i)** *BCP* did not claim them, and **(ii)** the literature does not clearly support their existence in the banking industry. Berger and Humphrey (1992) and Srinivasan and Wall (1992) analyzed the efficiency effects of bank mergers, and found that these do not, on average, result in efficiency gains. Rhoades (1998) summarizes nine case studies on the efficiency effects of bank mergers, selected among those that seemed more likely to result in efficiency gains, and reports that only four of these were successful. Peristiani (1997) finds no evidence that in-market merger leads to improvements in bank efficiency. Wang (2003) introduces a measure of bank output, accounting for risk, that has the potential to identify merger indued cost savings.

Ivaldi and Verboven (2005), Nevo (2000), Pereira and Ribeiro (2007b) and Pinkse and Slade (2004) analyzed the impact of mergers in a framework similar to ours.[8] These studies used aggregate data, with the exception of Brito, Pereira, and Ribeiro (2007) and Dube (2005). Pereira and Ribeiro (2007a) analyzed the effects on broadband access to the Internet of the divestiture, the opposite of a merger, of the Portuguese telecommunications incumbent from the cable television industry.

To our knowledge, there are no applications of merger analysis or discrete choice models to the mortgage loans market. However, our research relates to four strands of the empirical literature on the banking industry. First, our research relates to the literature that uses discrete choice models to estimate the demand for several types of banking deposits and loans, e.g., Dick (2002), **?**, and Nakane, Alencar, and Kanczuk (2005).[9] Second, our research relates to the literature that evaluates ex-post the competitive impact of mergers, e.g., Focarelli and Panetta (2003), Prager and Hannan (1998), **?**. The findings of this literature are largely inconclusive. Third, our research relates to the literature that evaluates the level of competition for various banking products, e.g., **?**, **?**, **?**, **?**, and **?**. This literature shows that competitive conditions vary greatly across products, countries and even periods. Fourth, our research relates to studies of the mortgage loans market that analyze various aspects such as the determinants of demand or price discrimination, e.g., Jones (1995), Breslaw, Irvine, and Rahman (1996), Follain and Dunsky (1997), Ling and McGill (1998), Gary-Bobo (2003), Gary-Bobo and Larribeau (2004), Leece (2006), Moriizumi (2000), and Paiella and Pozzolo (2006).

The rest of the article is organized as follows. Section 2 describes the data. Section 3 presents the model. Section 4 describes the econometric implementation and presents the basic estimation results. Section 5 analyzes the unilateral effects of the merger, section 6 analyzes the coordinated effects of the merger, and section 7 analyses the effects of a remedy proposed by *BCP*. Section 8 concludes.

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[8] See also Baker and Bresnahan (1985), Hausman, Leonard, and Zona (1994), and **?**.

[9] Dick (2002) estimates a multinomial and nested logit models for commercial bank deposit services for the US. The results indicate that consumers respond to deposit rates, and to a lesser extent, to account fees, when choosing their depository institution. Nakane, Alencar, and Kanczuk (2005) use a multinomial logit model to study the demand for time deposits in Brazil, for an aggregate of demand and passbook savings deposits and for loans. **?** analyze competition in the Hungarian household credit and deposit markets, estimating multinomial logit deposit and loan demand functions for each bank.

2 Data

The data used in this study consists of a rich consumer level cross-section. We obtained data from seven banks, which are among the eight largest banks in terms of the value of mortgage loans, for mainland Portugal.[10]

[*Table* 2]

For each bank, we obtained two samples of client data. The first sample included $1,000$ clients from each bank, to whom the bank granted, in 2004 or 2005, some form of mortgage credit. The second sample, also of $1,000$ clients from each bank in 2004 or 2005, was extracted from the universe of clients of the bank, for the same period, regardless of the type of credit granted. We obtained for each individual: **(i)** the age, **(ii)** the income, **(iii)** the total amount of debt in the banking system, **(iv)** the amount of credit granted, **(v)** the value and type of the mortgaged asset, **(vi)** the term of the credit contract, **(vii)** the index rate, **(viii)** the spread, and (**ix**) the residence location. We also obtained the number of elements in the population from which both samples were drawn, as well as the population average for these variables, to assess the representativeness of the sample.[11]

Table 2 presents the summary statistics of the variables used in the model.[12]

We completed our data set with the number of branches of each bank by municipality on December 2004.[13]

3 Economic Model

In this section, we present the econometric model. First, we provide a brief introduction to the discrete choice model we estimate. Second, we describe the implications of the model for the welfare analysis. Third, we present the assumptions about the behavior of firms.

[10] Jointly, these seven banks accounted for 85.6% of the value of mortgage loans contracted in 2004. Only one bank outside our sample had a larger market share, 7.4%, than that of the smallest bank we considered. The remaining 7% were scattered among smaller banks.

[11] We excluded observations considered errors or outliers, according to the criteria (values in million euros): **(i)** annual income > 1, **(ii)** total debt to the banking sector $< .015$ or $> .5$, **(iii)** loan amount $< .01$ or $> .5$, **(iv)** collateral $< .02$ or $> .75$, **(v)** duration < 5 or > 45 years, and **(vi)** non-positive spread.

[12] We also obtained for each individual: **(a)** the number of years as client of the bank, **(b)** the professional occupation, **(c)** the credit rating, **(d)** the commissions paid, and **(e)** other assets, liabilities or products held at the bank. The occupation and the residence were used to impute a small number of income observations, but were otherwise not statistical significant in the model. The other variables collected had inconsistent codings across banks or a large amount of missing values, and were therefore not used.

[13] The source is the Boletim Informativo, Associação Portuguesa de Bancos, Ano 18, N^o 35, Julho de 2005.

3.1 Demand

3.1.1 Utility of Mortgage Loans

Index consumers with subscript $n = 1, ..., N$, and mortgage loan products with subscript $i = 1, ..., I$. A consumer chooses among a set of alternative mortgage loan products. The products differ in: **(i)** the price, i.e., the *interest rate*,[14] **(ii)** the bank that provides the credit, (**iii**) the distribution of bank branches throughout the country, and **(iv)** the term of the contracts. The demand of each consumer for a given alternative depends on his type. The type of a consumer is defined by a K dimensional vector of characteristics, z_n, which includes: **(i)** the age, **(ii)** the annual income, **(iii)** the amount of credit required, **(iv)** the value of the asset, **(v)** the total debt in the banking system, and (**vi**) the place of residence.[15]

Consumer n derives from alternative i utility:

$$U_{ni}(r_{in}, z_n, x_i^d, \varepsilon_{ni}, \theta) = V_{ni}(r_{in}, z_n, x_i^d, \theta) + \varepsilon_{ni},$$

where r_{in} is the price of alternative i for consumer n, x_i^d is a J dimensional vector of the other characteristics of alternative i, θ is a vector of parameters, and finally ε_{ni} is a random disturbance independent across products, consumers, and identically distributed. We assume additionally that:

$$V_{ni}(r_{in}, z_n, x_i^d, \theta) := \alpha(r_{in}, z_n, \theta_\alpha) + \lambda(x_i^d, \theta_\lambda),$$

where

$$\begin{aligned} \alpha(r_{in}, z_n, \theta_\alpha) \quad &: \quad = -\exp\left(\theta_{\alpha 0} + \theta_{\alpha r}\ln(r_{in}) + \sum_{k=1}^{K}\theta_{\alpha k}\ln(z_{nk})\right), \\ \lambda(x_i^d, \theta_\lambda) \quad &: \quad = \sum_{j=1}^{J} x_{ij}^d \theta_{\lambda j}, \\ \theta \quad &: \quad = (\theta_\alpha, \theta_\lambda), \end{aligned}$$

and where $\alpha(\cdot)$ captures the effect of price and allows this effect to depend on individual characteristics. The exponential transformation imposes the restriction that this function is negative.[16] Expression $\lambda(\cdot)$ is a linear combination that summarizes the utility component

[14] The interest rate interacts with the amount of credit required, and is therefore a proxy for the monthly installments of a given credit contract, which is what consumers care for.

[15] We treat the value of the asset being acquired and the amount of credit required as exogenous variables. Consumers make their decisions in two stages. First, they decide which asset to purchase and how much credit they require. Second, given the amount of credit required, they choose a mortgage loan product.

[16] The average α is almost unchanged by this restriction, since the restriction only binds in the tails for very low values of α. Nevertheless, imposing that the values of α are always consistent with economic theory gives more stability to the numerical simulations performed later in the paper.

associated with the product characteristics other than price. The parameters θ_α translate the effect of the characteristics of the consumers on the price coefficient. The parameters θ_λ translate the valuation of the consumers for the product characteristics other than price.

Assuming that the random disturbance ε_{ni} has an extreme value Type I distribution, one obtains the standard multinomial logit model with choice probabilities given by:

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}.$$

3.1.2 Likelihood Function

Under revision: Comments welcome

The main problem with our dataset that requires an econometric solution is that we do not observe the choice set of each individual. In principle, a consumer could have chosen any of the products observed to have been selected, possibly conditional on his individual characteristics. It is unfeasible to enumerate all possible choices and estimate models with such large choice sets. Further even conditional on the individual characteristics the characteristics of the products not chosen, which are unobserved (namely the rate), are likely to come from a different distribution than the distribution of observed characteristics due to selection.

To deal with the problem of the unknown choice set, to each individual we impute uniformly at random a bank which was not his choice and treat this plus the chosen option as his choice set. Inference is done, then, conditional on this assigned choice set (this methodology was used by, e.g., Train, McFadden, and Ben-Akiva (1987)). The characteristics of the product offered by this alternative bank are still unobserved.

We assume a pricing equation by banks given by:

$$\ln(r_{ni}) = x_n^s\beta + \sigma_i\varepsilon_{ni} \qquad \varepsilon_{ni} \sim N(0,1)$$

One could also have the coefficients β differing from bank to bank indicating different pricing strategies by the different banks.

Given this pricing equation the likelihood of an observation is given by:

$$\begin{aligned} \mathbf{ln} &= -\frac{1}{2}\ln 2\pi - \ln\sigma - \frac{1}{2}\left(\frac{\ln r_{n1} - x_n^s\beta}{\sigma}\right)^2 \\ &+ \ln\int \frac{\exp\left[V_{n1}(r_{1n}, z_n, x_1^d, \theta)\right]}{\exp\left[V_{n1}(r_{1n}, z_n, x_1^d, \theta)\right] + \exp\left[V_{n2}(y, z_n, x_2^d, \theta)\right]}\phi(y)dy \end{aligned}$$

where the first term refers to the pricing equation and the second term to the choice of product. The integral is with respect to the distribution the unobserved characteristic (i.e. the rate) of the product which was not chosen.

Other alternatives to the method described here have been implemented and have yielded the same overall results. The appendix describes an alternative procedure based on bayesian estimation which iteratively imputes choice sets to consumers.

We also note that our sample is choice based, and is, therefore, not random. Thus, without further correction the predicted probabilities will not reflect market shares, and product dummy variables reflect the sample composition, and not the market. To correct for this we resampled the observations with replacement such that the sample obtained would reflect the market shares at the time of this study. This procedure can be seen as a implementation of the WESML estimator of Manski and Lerman (1977).[17]

3.1.3 Calibration

Our data contains no information on an outside option. Consideration of an outside option is relevant for the policy exercises we which to conduct. We consider different assumptions about the market share of the outside option and report results based on these. Introducing an outside option is just an example of considering a product not present in the sample. All that is required is that one: **(i)** knows the value of the exogenous variables that characterize these products, and, **(ii)** includes new product dummy variables. The product dummy variables are then calibrated such that the predicted shares match actual/required shares using the following procedure.

Partition the vector of coefficients, θ_λ, into $(\theta_\lambda^1, \theta_\lambda^2)$, where θ_λ^1 represents the coefficients associated with product dummy variables, and θ_λ^2 represents all the remaining coefficients in θ_λ. Let s_i represent the correct market share of product i, $\widehat{\theta}_\lambda^2$ the estimated value of θ_λ^2, and $\widehat{\theta}_\alpha$ the estimated value of θ_α. The calibrated value of θ_λ^1, denoted by $\widetilde{\theta}_\lambda^1$, is defined by:

$$\widetilde{\theta}_\lambda^1 := \arg\min_{\theta_\lambda^1} \sum_{i=1}^{I} \left(s_i - \frac{\sum_{n=1}^{N} M_n P_{ni}(\widehat{\theta}_\alpha, \theta_\lambda^1, \widehat{\theta}_\lambda^2)}{\sum_{j=1}^{I} \sum_{n=1}^{N} M_n P_{nj}(\widehat{\theta}_\alpha, \theta_\lambda^1, \widehat{\theta}_\lambda^2)} \right)^2,$$

where M_n is the amount of credit required by individual n.

We use this mechanism to introduce an outside option of no demand for credit.[18] All variables that define this option are set to zero, except the dummy variable.

[17]There are several alternative techniques to deal with choice-based samples Manski and Lerman (1977) and Manski and McFadden (1981), in particular chapters 1 and 2.

[18]The outside option refers to the alternatives to mortgage loans, which are: renting or self-financing.

3.1.4 Price Elasticities of Demand

One of our goals is to determine the price changes caused by the merger. As an intermediate step, we compute the price elasticities of demand for the products of each bank. These expressions should be taken merely as indicative of the price changes that may occur, since the computation of the price, detailed below, cannot be expressed as a function of the elasticities reported here.

Denote by ε_{nij}, the elasticity of demand of product i with respect to the price of product j for consumer n:

$$\varepsilon_{nij} := \left.\frac{\partial P_{ni}(r_n \cdot t)}{\partial t_j}\right|_{t=1} \frac{1}{P_{ni}}.$$

In the multinomial logit model this expression simplifies to:

$$\varepsilon_{nij} = \begin{cases} \alpha_n r_i(1 - P_{ni}) & \text{if } i = j \\ -\alpha_n r_j P_{nj} & \text{if } i \neq j. \end{cases}$$

Let $Q_i := \sum_{n=1}^{N} M_{ni} P_{ni}(r_n)$ represent the expected total volume of credit of product i. Denote by ε_{ij}, the elasticity of the total volume of credit of product i with respect to the price of product j:

$$\varepsilon_{ij} := \left.\frac{\partial \sum_{n=1}^{N} M_{ni} P_{ni}(r_n \cdot t)}{\partial t_j}\right|_{t=1} \frac{1}{Q_i}.$$

Finally let $Q := \sum_{i=1}^{I} Q_i$ represent the total volume of credit granted. Denote by ε, the elasticity of the total volume of credit with respect to the average market price:[19]

$$\varepsilon := \left.\frac{\partial Q(rt)}{\partial t}\right|_{t=1} \frac{1}{Q} = \left.\frac{\partial \sum_{i=1}^{I} \sum_{n=1}^{N} M_{ni} P_{ni}(r_n t)}{\partial t}\right|_{t=1} \frac{1}{Q}.$$

3.1.5 Consumer Welfare Variation

Denote by V_{nj}^0 and V_{nj}^1, the utility levels before and after the merger, respectively. The merger may imply three types of changes. First, prices may change, which requires computing the market equilibrium after the merger. Second, the characteristics of the products other than price, x_i^d, may change. Third, the number of products offered, I, may change. We assume that the number of products offered, as well as the product characteristics other than price, do not change. The generalized extreme value model, of which the multinomial logit model is a particular case, provides a convenient computational formula for the exact consumers' surplus, up to a constant, associated with a policy that changes the attributes

[19] This elasticity only applies when there is an outside option.

of the products in the market. Such expression, known as the "log sum" formula, is:

$$\Delta CS_n = \frac{1}{\alpha M_n}\left[\ln \Psi\left(e^{V_{n1}^1},\ldots,e^{V_{nJ}^1}\right) - \ln \Psi\left(e^{V_{n1}^0},\ldots,e^{V_{nJ}^0}\right)\right] =$$
$$\frac{1}{\alpha M_n}\left(\ln \sum_{j=1}^{J} e^{V_{nj}^1} - \ln \sum_{j=1}^{J} e^{V_{nj}^0}\right), \quad (1)$$

where $\Psi(\cdot)$ is the probability generating function of the generalized extreme value distribution.[20]

This formula is valid only when the indirect utility function is linear in income, i.e., when prices changes have no income effects, which is the case assumed here.

3.2 Supply

3.2.1 Price Equilibrium

Index firms with subscript $b = 1, ..., B$. We assume that banks choose prices, and play a static non-cooperative game, i.e., play a Bertrand game. Denote by $c_b(z)$, the constant marginal cost of bank b providing credit to an individual with characteristics z, denote by $\phi(\cdot)$ the density of z, and denote by F_b, the fixed costs of b.[21] Assume that banks can observe the vector of consumer characteristics. In these circumstances, banks can price discriminate between types of consumers. The strategy of firm b is then a rule, $r_b(z)$, that says which price the firm should charge for each consumer with vector of characteristics, z. Denote by $r(z)$ the B dimensional vector with b^{th} element $r_b(z)$, that includes the strategies of all banks for that type of consumer. Variable M is one of the elements of z that represents the amount required by the individual and thus enters directly in each bank's profit function. The payoff of bank b, up to normalization of the market size, is given by:

$$\Pi_b = \int \left[r_b(z) - c_b(z)\right] M P_b(r(z), z)\phi(z)dz - F_b.$$

[20]Expression (1) was developed by Domencich and McFadden (1975), and McFadden (1974) for the multinomial logit model, and by McFadden (1978) and McFadden (1981) for the nested logit model. Small and Rosen (1981) discuss the connection between (1) and standard measures of consumer surplus.

[21]Most empirical articles on the cost structure of banks, e.g., Bernstein (1996), Hunter, Timme, and Yang (1990), Beard, Caudill, and Gropper (1991), Gropper, Caudill, and Beard (1999), Karafolas and Mantakas (1996), Cebenoyan (1990), and Mitchell and Onvural (1996), conclude that the technology of the banking industry presents no economies of scope, and that economies of scale can only be found in the smaller banks. Girardone, Molyneux, and Gardener (2004), however, finds economies of scale.

Given that the demand and costs of each type of consumer do not depend on the prices offered to the other types of consumers, the firms' profit maximization problem is separable across types.

We assume that the current prices are equilibrium prices, and compute the marginal costs such that the current first-order conditions are satisfied. The computation of the price changes after a merger is done by fixing the computed marginal costs, and solving the new first-order conditions that emerge when the market structure changes. Under different scenarios of ownership and collusion, the objective of bank b is to maximize the function $\widetilde{\Pi}_b = \sum_{k=1}^{B} \gamma_{bk} \Pi_k$, with respect to prices, r_b, where $\gamma_{bk} = 1$ if bank b takes bank k's profit into account when setting prices, and $\gamma_{bk} = 0$ otherwise. The property matrix Γ consists of the elements $\Gamma_{bk} := \gamma_{bk}$.

We restrict the pricing rules $r_b(\cdot)$ to belong to a certain set based on: **(i)** economic reasons, and **(ii)** statistical reasons. From an economic perspective, we conjecture that banks discriminate between individuals according to simple pricing rules. This is justified by the computational burden of setting complex price schemes, that may be prohibitive for banks, or may be unwarranted if the information on the individuals at time of contracting is incomplete or contains errors.[22] From a statistical perspective, it is unfeasible to identify complex pricing rules from a limited number of observations. Thus, even if firms follow complex pricing rules, the data limitations force one to approximate them through simple pricing rules.

Next we describe how we implement the general procedure defined above. The empirical counterpart of the objective function $\widetilde{\Pi}_b$ defined for each bank is:

$$\check{\Pi}_b = \sum_{k=1}^{B} \gamma_{bk} \frac{1}{N} \sum_{n=1}^{N} (r_{nk} - c_{nk}) \, M_n P_{nk}(r_n),$$

[22] Some regularity conditions on the set of functions to which $r_b(\cdot)$ belongs, such as that the functions do not oscillate too much, are also necessary for the stated problem to be meaningful.

where r_{nb}, c_{nb} and r_n and denote the discrete counterparts of $r_b(z)$, $c_b(z)$ and $r(z)$. Let:[23]

$$f_{nb}(r_n; c_n, \Gamma) := \frac{\partial \check{\Pi}_{nb}}{\partial r_{nb}} = M_n P_{nb} + (r_{nb} - c_{nb}) M_n \frac{\partial P_{nb}}{\partial r_{nb}} + \sum_{\substack{k=1 \\ k \neq b}}^{B} \gamma_{bk} (r_{nk} - c_{nk}) M_n \frac{\partial P_{nk}}{\partial r_{nb}},$$

Denote the period before and after the merger by, respectively, $t = 0, 1$. Regarding the pricing rule, we assume that $r_{nb}^t = r_{nb}^0 + \delta_b$. This means that after the merger, i.e., at $t = 1$, each bank increases the interest rate by a given value, common to all of its customers, i.e., the prices paid by all the customers of a bank vary by the same fixed amount, which we denote by δ_b. This reduces the dimension of the firm's problem.[24]

Regarding the cost structure, we assume that $c_{nb} = c_b$, for all n. This means that the marginal costs do not differ across customers of the same bank.

Hence, the current equilibrium can be characterized by the first-order conditions with respect to each δ_b at the point $\delta_b = 0$. Denote by c, a B dimensional vectors with b^{th} element c_b, and denote by r^t is a NB dimensional vector that results from the piling-up of vectors r_n^t. At any time t, and for $b = 1, ..., B$, the first-order conditions that characterize the Nash

[23]Function $f_{nb}(\cdot)$ measures the impact on the objective function of bank b of an increase in its interest rate, r_{nb}, which can be divided in three effects. First, by increasing its interest rate, bank b collects a higher interest from individual n's loan, M_n, with the probability that this individual selects bank b, P_{nb}. This *profit margin effect* is represented by the first term: $M_n P_{nb}$. Second, by increasing its interest rate, bank b decreases the utility of consumer n when selecting bank b. As a consequence, the probability that individual n selects bank b decreases. This *volume of sales effect* is represented by the second term: $(r_{nb} - c_{nb}) M_n \frac{\partial P_{nb}}{\partial r_{nb}}$. Third, by increasing its interest rate, bank b raises the probability that consumer n chooses another bank l. If bank b takes the profit of bank l into account when setting its prices, i.e., if $\gamma_{bl} = 1$, this effect is positive for bank b, otherwise this effect is is irrelevant. This *consumer switching effect* is represented by the third term: $\sum \gamma_{bk} (r_{nk} - c_{nk}) M_n \frac{\partial P_{nk}}{\partial r_{nb}}$.

[24]Alternatively, Brito, Pereira, and Ribeiro (2007) considered a more flexible pricing rule, by setting $r_{nb}^t = r_{nb}^0 + \sum_{k=1}^{K} \beta_{rbk}^t S_k(r_{nb}^0)$, where $S_k(r)$ is a basis-Spline function k defined on the variable r, and β_{rbk}^t are the coefficients, to be estimated, that bank b assigns to the basis function k. See **?** and **?**. Hence, the current equilibrium can be characterized by the first-order conditions with respect to each β_{rbk}^0 at the point $\beta_{rbk}^0 = 0$. The departures from this equilibrium can be made as flexible as desired by increasing the number of basis functions. The extent to which one makes the approximation more flexible, i.e., increase K, is limited by our data. Likewise, we set $c_{nb} = \sum_{k=1}^{K} \beta_{cbk} S_k(r_{nb}^0)$. The average price increase estimated under this more flexible approach with the case of cubic basis-splines with knots at quartiles of the distribution of r as basis functions, i.e., $K = 7$, does not differ much from those reported in this article using the simple pricing rule.

equilibrium are given by:[25]

$$\psi_b(r^t; c, \Gamma) := \sum_{n=1}^{N} \frac{\partial \check{\Pi}_{nb}}{\partial r_{nb}} \frac{\partial r_{nb}}{\partial \delta_b} = \frac{1}{N} \sum_{n=1}^{N} f_{nb}(r_n^t; c, \Gamma) = 0.$$

Denote by $\psi(r^t; c, \Gamma)$, the B dimensional vector with generic element $\psi_b(r^t; c, \Gamma)$. The Nash equilibrium at time t is thus characterized by $\psi(r^t; c, \Gamma_t) = 0$. At $t = 0$, if the observed prices are equilibrium prices, these conditions must be verified when $\delta_b = 0$, i.e., $\psi(r^0; c, \Gamma_0) = 0$. We use these first-order conditions to obtain estimates of the marginal costs that are consistent with the assumption that the observed prices are equilibrium prices. These estimates are given by the solution to:[26]

$$\min_c \psi(r^0; c, \Gamma_0)' \psi(r^0; c, \Gamma_0).$$

Denote by $\widehat{c}$ the estimates of the marginal costs, and denote by δ, the B dimensional vector with b^{th} element δ_b. The price increases at $t = 1$ can then be obtained by solving:

$$\min_\delta \psi(r^1; \widehat{c}, \Gamma_1)' \psi(r^1; \widehat{c}, \Gamma_1).$$

Initially there are seven firms. Thus, Γ_0 is the identity matrix: $\Gamma_0 = I_7$. In the course of the analysis, we will assume two alternative forms for the matrix Γ, associated with the cases of: **(i)** the merger of *bank I1* and *bank I2*, and **(ii)** perfect collusion between alternative sets of banks.

3.2.2 Profit Variation

The profit variation for product j is then:

$$\Delta\Pi_j = \sum_{n=1}^{N} \left[\left(r_{nj}^1 - \hat{c}_j \right) P_{nj}(r_n^1) - \left(r_{nj}^0 - \hat{c}_j \right) P_{nj}(r_n^0) \right] M_n.$$

[25] We assume that a Nash equilibrium exists. Caplin and Nalebuff (1991) proved existence in a general discrete choice model, with single product firms. Anderson and de Palma (1992) proved existence for the nested logit model with symmetric multiproduct firms.

[26] Solving the minimization problem is equivalent to solving a system of equations. The formulation merely defines marginal costs, and subsequently price changes, as GMM estimators.

4 Econometric Implementation

4.1 Basic Estimation Results

We estimated the model by maximum likelihood.[27] Table 3 presents the results.

[$Table$ 3]

The estimates of most coefficients are statistically significant at a 1% confidence level.

The coefficients presented in Table 3. The estimates reveal that the price coefficient is increasing in the amount of credit required and decreasing in the individual income.

The median of the distribution of the estimate of the price coefficient $\frac{\partial \alpha}{\partial r}$ is 1.9566. The estimates of product characteristics, reflect the consumer's incremental valuation of these attributes relative to those of the products of *bank I1*. These estimates are also presented in Table 3. For instance, the negative coefficient -1.1097 for *bank O1* translates into a negative median interest rate premium of $\frac{1.1097}{1.9566} = 0.5672$ for the products of this bank relative to those of *bank I1*. For the median individual, the disutility associated with the products of *bank O1* compared to those of *bank I1* can be compensated by an interest rate reduction of 57 basis points .[28]

4.2 Price Elasticities of Demand

Table **??** presents the elasticity of the total volume of credit granted by bank i with respect to changes in price j, ε_{ij}, assuming that there is no outside option. The weights used are the amount of credit required multiplied by the probability of each individual making the loan at a given bank. The last column indicates the market shares used to calibrate the model.

[$Table$ **??**]

The demand functions of the banks for the mortgage loan products are elastic with respect to price. The own-price elasticities of demand ranges from -1.47 for *bank O4*

[27]

Integration, when necessary, was performed numerically by the Gaussian-Hermite quadrature. All procedures were coded in MATLAB.

[28] The model has no bank characteristics other than the dummy variables and the number of local branches. Thus, the bank dummy variables capture most bank characteristics other than the contract characteristics. As a consequence, expressing the value of these dummy variables in an interest rate metric may generate unrealistic premiums, which reflect merely the fact that differences in market shares are due to more than differences in the prices of the mortgage loans, and that changing this variable does not, by itself, equate market shares.

to −4.55 for *bank O2*. The own-price elasticity of demand of *bank I1* and *bank I2* are, respectively, −1.99 and −2.52.

Interestingly, when *bank I1* increases its price by 1%, *bank I2* is the bank whose demand increase the most, 0.47%. If, however, *bank I2* increases its price, the demand of the other large banks increases almost in the same proportion, with a slight preference towards *bank O2*.

Tables 5-8 present the price elasticities of demand of the total volume of credit granted, for market shares of the outside option ranging from 5 to 30%, i.e., for sizes of the market for mortgage loans relative to the amount of the volume of credit granted ranging from 1.05 to 1.43, respectively.

[$Table$ 5]

[$Table$ 6]

[$Table$ 7]

[$Table$ 8]

As the share of the outside option increases, the firms' price elasticities of demand decrease, but only slightly. If the market share of the outside option is 30%, the own-price elasticities of demand for *bank I1*, *bank O4*, and *bank I2* become, respectively: −1.27, −1.23, and −1.70. *bank O1* is the bank with the highest elasticity, −2.45.

For each individual, as the market share of the outside option increases, the own-price elasticity of demand increases in absolute terms, while the cross-price elasticities of demand decrease. However, the weighted average over all individuals of the own-price elasticities, described in section 3.1.4, may decrease with the market share of the outside option.[29] The unweighted average of the individual price elasticities of demand, ε_{nij}, is reported in the Appendix, in Tables **??**-**??**, for different values of the market share of the outside option.

Table 9 presents the elasticity of the total market demand for mortgage loans, ε, for market shares of the outside option ranging from 5 to 30%.

[$Table$ 9]

[29] The weights, the amount of credit required multiplied by the probability of each individual making the loan at a given bank, change with the market share of the outside option. As the market share of the outside option rises, the more price sensitive individuals tend to be increasingly assigned to this alternative. Hence, if the probability of a high elasticity individual signing the contract with a given bank decreases with the introduction of the outside option more than the elasticity of a low elasticity individual, the bank's own-price elasticity of demand may decrease, in absolute terms, with the market share of the outside option.

The larger the size of the outside option, the more elastic the market demand is. However, the market demand is rigid and does not change much with the market share of the outside option. For market shares of the outside option in the 5 to 30% range, the market own-price elasticities of demand vary between -0.417 to -0.629, respectively. A larger share of the outside option means that it is a more attractive alternative. Hence, if the market prices increase, a higher percentage of consumers shift towards it.

The more reasonable values for the market share of the outside option are those in the range of 0 to 10%, based on the following three arguments. First, between June 2003 and June 2005, the index rates were at historically low levels. Hence, most consumers interested in obtaining mortgage loans had the ideal conditions to do so. Second, the Portuguese renting market has some peculiarities regarding rent control. As a result, the supply of housing for rent is scarce.[30] Third, the literature on the demand for mortgage loans, e.g., Moriizumi (2000) and Leece (2006), presents very inelastic demands, which are compatible with ours for small market shares of the outside option.

5 Analysis: Unilateral Effects

5.1 Merger assuming Nash ex-ante

The merger of *bank I1* and *bank I2* leads to a market with six firms: **(i)** the firm controlling the products of *bank I1* and *bank I2*, **(ii)** *bank O4*, **(iii)** *bank O3*, **(iv)** *bank O5*, **(v)** *bank O2*, **(vi)** *bank O1*. Thus, the merger consists of a change in the property matrix from Γ_0 to Γ_1, given by:

$$\Gamma_1 = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}.$$

Table 10 reports the estimates of the marginal costs and the impact of the unilateral effects of the merger on prices, for the case where there is no outside option.

[*Table* 10]

After the merger, the prices of mortgage loans increase on average 3.1%. The prices of *bank I1* and *bank I2* increase by, respectively, 7.1% and 16.3%. The prices of *bank O2*, *bank O3* and *bank O5* decrease. However, these latter price variations are not statistically

[30] According to the INE, Recenseamento Geral da População e Habitação - 2001 (Resultados Definitivos), of the 3.551.229 existing lodgings, only 605.288, i.e., 17%, were rented.

significant at a 5% level. These price variations are associated with an average increase in the spread between the *Euribor* and the interest banks charge of 9.9%.[31] For *bank I1* and *bank I2* the spread increases by, respectively, 17.3% and 61.5%.

Table 11 reports the impact of the unilateral effects of the merger on prices, for market shares of the outside option ranging from 5 to 30%.

[*Table* 11]

The average price increase is very robust to changes in the market share of the outside option. With the exception of *bank I2*, the expected increase in each bank's price after the merger does not change significantly for different values of the market share of the outside option.[32] Depending on the market share of the outside option, the estimated increase in the price of *bank I1* varies between 9.5% and 6.7%, and the estimated increase in the price of *bank I2* price varies between 19.9% and 14.2%, .

Table 12 reports the impact of the unilateral effects of the merger on welfare, for market shares of the outside option ranging from 0 to 30%.

[*Table* 12]

Without an outside option, after the merger, on average, the consumer surplus per household decreases by 87 euros per year, the profits of *bank I1* and *bank I2* per household increase by 7 euros per year, the profits of the remaining banks per household increase by 73 euros per year, and the social welfare per household decreases by 7 euros per year. As expected, in the absence of merger induced cost reductions, the merger has a larger impact on the non-merging banks than on the merging banks. The non-merging banks benefit from the larger increase in the prices of the merging banks. This increases their market shares, even when they raise their own prices.

If the market share of the outside option is 10%, on average, the consumer surplus per household decreases by 94 euros per year, the profits of *bank I1* and *bank I2* per household increase by 7 euros per year, the profits of the remaining banks per household increase by 66 euros per year, and the social welfare per household decreases by 22 euros per year.

[31] The price each individual pays is the sum of the index rate plus the spread, as explained in footnote 4. The increase in price is a weighted average of the increase in the index rate and the increase in spread. The weights are the relative importance of both terms in the pre-merger price. The index rate is assumed not to change with the merger. Hence, the percentage variation in price is equal to the percentage variation in the spread multiplied by the weight of the spread in the original price.

[32] Some prices increase more when the outside option has a larger market share because of the reduction in the banks' own-price elasticities, explained in section 4.2.

5.2 Plausibility of the Nash ex-ante Assumption

We assumed that before the merger, firms played a Bertrand game. But firms could have played a game that led to either more or less competitive outcomes, than those implied by a Bertrand game. Table 13 presents the estimates of the marginal costs consistent with Nash behavior, the quarterly average of capital costs reported by the banks, and the *Euribor* interest rates.[33]

[*Table* 13]

The estimated marginal costs do not differ much from either the reported average of capital costs, or the *Euribor*. This gives some support to the assumption that firms play a Nash equilibrium, but of course this comparison is only a very crude validation of the assumption.[34]

Assuming that firms colluded in prices before the merger results in non-positive marginal cost estimates, except when the outside option has a large market share, but even in this case they are small. We take this as indirect evidence that firms did not collude perfectly on prices.

6 Analysis: Coordinated Effects

To analyze the coordinated effects of the merger, we follow the approach proposed by Kovacic, Marshall, Marx, and Schulenberg (2006).[35] Rather than focusing on whether collusion is more easily sustained after a merger, we analyze how the merger affects the profitability of collusion.[36] More specifically, we simulate the effects of an hypothetical

[33]There is no simple relation between the marginal costs of mortgage loans and the reported costs of funding. On the one hand, the marginal costs of mortgage loans include the costs of other inputs, such as labour and physical capital, which means that the estimated marginal costs should be larger than the reported capital cost. On the other hand, mortgage loans involve a low risk, which implies that the cost of financing this type of credit may be lower than the cost of financing the bank's average credit.

[34]If we had estimates of the marginal costs we could test our estimates of the marginal costs assuming Nash behaviour against the observed marginal costs (Pereira and Ribeiro (2007b)).

[35]When cost data is available one can also use the approach of Nevo (2001) and **?**.

[36]The methodology consists of extending the procedure used to estimate the unilateral effects to the analysis of the coordinated effects. In the absence of cost synergies or changes in the products characteristics, both a merger or a collusive arrangement result in a group of firms setting their prices to maximize joint profits. In these circumstances, the prices set by firms j and k should be the same, regardless of these two firms merging or setting collusive prices. To estimate the effects of price collusion, the generic element of matrix Γ's, γ_{bk}, should be set to 1 if firms b and k either merge or collude. Following the same procedure as in the case of the merger, it is possible to estimate the increase in prices and profits resulting from a given

collusion between a set of banks in two alternative scenarios: **(i)** with the merger, and **(ii)** without the merger. First, we estimate the impact of collusion on prices and market shares for both scenarios. Second, given the previous values, we evaluate the impact of collusion on profits for both scenarios. Third, we compare the increase in profits from collusion for both scenarios to obtain a measure of the incentives firms have to collude.

We consider the possibility that the three largest banks, *bank O4*, *bank I1* and *bank O5*, collude. The results obtained would not differ significantly: **(i)** if *bank O5* was replaced by *bank O3*, given the similarities between these banks in terms of market shares and elasticities, and **(ii)** if the smaller banks were included in the collusive agreement. Adding *bank O3* to the colluding trio would be very close to perfect collusion.

Table 14 presents the change in prices, profits, and consumer surplus caused by the collusion of *bank O4*, *bank I1* and *bank O5*, when there is no outside option.

[$Table$ 14]

Without the merger, if *bank I1*, *bank O4* and *bank O5* collude, their prices increase by, respectively: 64.7%, 59.9% and 76.3%, as can be seen in column (0) → (2). With the merger, if *bank I1*, *bank O4* and *bank O5* collude, their prices and those of *bank I2*, increase by, respectively: 74.0%, 75.0%, 99.0%, and 78.9%, as seen in column (1) → (3).[37] The price increases caused by collusion are different with and without the merger for two reasons. First, with the merger, the colluding banks take *bank I2*'s profit into account when setting their prices. Second, with the merger, the colluding banks control an additional instrument: *bank I2*'s price.

Without the merger, if *bank I1*, *bank O4* and *bank O5* collude, their aggregate profit increases by $4,099.5$ euros per million euros of total market size, as presented in column (0) → (2). With the merger, if these banks collude, their aggregate profit increases by $6,320.4$ euros per million euros of total market size, as can be seen in column (1) → (3), row AGG_2. In other words, the increase in profits of these three banks from collusion is 54.2% larger with the merger than without the merger. If the profits of *bank I2* are considered, the merger increases the change in profits from collusion of the four banks by 24.3%, because the profits of *bank I2* increase relatively less than the other colluding banks. The increase in the profits of *bank O4* and *bank O5* from the collusion between the three largest banks are,

hypothetical collusive agreement, in the presence and absence of the merger.

[37]These price increases should be accumulated to those resulting solely from the merger. If the merger occurs, the prices of *bank I1* and *bank I2* increase by, respectively, 7.1% and 16.3%, as reported in Table 10 or column (0) → (1) of Table 14.

respectively, 56.9% and 36% larger with the merger than than without the merger. This can be seen by comparing the values presented in columns (0) $\rightarrow$ (2) and (1) $\rightarrow$ (3) for each bank. As for the merging banks, the increase in their aggregate profit from collusion is almost the same with the merger than without the merger.[38]

Without the merger, if *bank I1*, *bank O4* and *bank O5* collude, the consumer surplus per household decreases by 1,217 euros per year. With the merger, if these banks collude the consumer surplus per household further decreases by 1,673 euros per year, to which should be added the loss of 87 euros per year that results from the merger alone. Hence, with the merger the effect of collusion on consumer surplus, per household, is 456 euros per year, or 37.5%, larger.

Tables 15-18 present the estimated variation in profits and consumer surplus from the collusion of *bank O4*, *bank I1* and *bank O5*, for market shares of the outside option ranging from 5 to 30%.

[*Table* 15]

[*Table* 16]

[*Table* 17]

[*Table* 18]

The effect of the merger on the increase in profits from collusion does not vary much with changes in the market share of the outside option. For instance, suppose that the outside option has a market share of 10%. Without the merger, if *bank I1*, *bank O4* and *bank O5* collude, their aggregate profits increase by 2,780.1 euros per million euros of total market size, as reported in column (0) $\rightarrow$ (2), row AGG_2 on Table16. With the merger, the profits from collusion of these banks increase by 4,594.4 euros per million euros of total market size. This is reported in the same row, column (1) $\rightarrow$ (3). Hence, with the merger the profits from collusion of these banks increase 65.3%.

[38]We compare the 2,806.1 increase in the profits from collusion of both *bank I1* and *bank I2* with the merger, with the 2,845.9 increase in profits from collusion without the merger. This last figure may overestimate the incentives to collude because it includes the gain to *bank I2*, which, without the merger, was not part of the set of colluding firms. The alternative of comparing the gains of both *bank I1* and *bank I2* from collusion with the merger, with the 1,365.2 increase in the *bank I1* profits from collusion without the merger may be misleading, as it compares the increase in the profits of two banks with the increase in the profits of a single bank. This problem occurs because the merger has two effects on collusion: **(i)** it changes the increase in profits from collusion for each bank, and **(ii)** it changes the number of colluding firms.

Table 19 summarizes the impact of the merger on the profitability of collusion between the three largest banks for different values of the market share of the outside option.

[*Table* 19]

As table 19 illustrates, the effect that the merger has on the increase in the aggregate profits from the collusion of *bank I1*, *bank O4* and *bank O5,* presented on row AGG_2, does not depend much on the market share of the outside option.

7 A Structural Remedy

In this section, we analyze the unilateral and coordinated effects of a structural remedy proposed by *BCP*: selling-off 60 branches of *BPI*, which represent about 10% of its branch network.[39] The sell-off of the branches includes the physical capital and the employees, as well as the client contracts whose demand deposits were subscribed on the branch.

There is no information on the percentage of mortgage loans contracted in 2004 and 2005 that will be transferred to other banks as a result of this remedy, nor is there any information on which banks will purchase the branches. According to *bank I1*, these 60 branches represent 11.9% of the total volume of credit, or 17.1% of the total volume of credit if the capitals of the local municipalities are excluded. First, we assume that the 60 branches of *BPI* are sold to the largest bank, *bank O4*. Second, we assume that the branches are sold to the smallest bank *bank O1.* Throughout the section, we assume that there is no outside option.

7.1 Unilateral Effects

Table 20 presents the unilateral effects of the merger if 60 branches of *BPI* are sold to *bank O4*, the largest bank.

[*Table* 20]

[39]These 60 branches were selected from those in geographical areas in which both *BCP* and *BPI* were present to ensure that, after the merger: **(i)** there is no decrease in the number of competitors in geographical areas which currently have less than four active banks, and **(ii)** *BCP* will not own, after the merger, more than 40% of the branches in any geographical area. *BCP* defines geographical areas as townships, Freguesias, unless these belong to the capital of a local municipality, sede de Concelho. In that case, the "geographical area" is the whole capital of the local municipality.

The increase in the prices of *bank I1* caused by the merger drops from 7.1%, without the remedy, to 7.0%, with the remedy, while the increase in the prices of *bank I2* drops from 16.3%, without the remedy, to 15.9%, with the remedy. The impact on the remedy on the average change in prices is small. The estimated average increase in prices caused by the merger changes from 3.1%, without remedy, to 3.2%, with the remedy. This occurs because *bank O4* hikes its price by 1.0%, with the remedy, instead of by 0.6%, without the remedy.

Table 21 presents the unilateral effects of the merger if 60 branches of *BPI* are sold to *bank O1*, the smallest bank.

[*Table* 21]

The results are similar to those of the previous case. With the remedy, the estimated increase in the prices of *bank I1* and *bank I2* caused by the merger are, respectively, 7.1% and 18.3%, and the increase in the average price is 3.4%. As expected, the prices of *bank O1* increases more.

To sum up, the increase in the average price is larger with the remedies than without the remedies although the difference is not statistically significant.

7.2 Coordinated Effects

Next, when we refer to collusion we mean the collusion between *bank I1*, *bank O4* and *bank O5*. Table 22 presents the coordinated effects of the merger if 60 branches of *BPI* are sold to *bank O4*.

[*Table* 22]

The increase in the profits of *bank I1*, *bank O4* and *bank O5* from collusion caused by the merger drops from 54.2%, without the remedy, to 53.1%, with the remedy.[40] If the profits of *bank I2* are included, the increase in the profits of the four banks from collusion caused by the merger drops from 24.3%, without the remedy, to 24%, with the remedy. Similar values hold if the banks are considered individually.

Without the remedy, the merger amplifies the reduction in consumer surplus due to collusion by 37.5%, whereas with the remedy, the merger amplifies the reduction in consumer surplus due to collusion by 37.4%, almost the same value as without the remedy

Table 23 presents the coordinated effects of the merger if 60 branches of *BPI* are sold to

[40] This value is obtained by comparing the increase in profits from collusion after the merger is approved with remedies, presented in column (1) $\rightarrow$ (3), row AGG_2 on Table 22, with the increase in profits from collusion when no merger takes place, presented in column (0) $\rightarrow$ (2), row AGG_2 on Table 14.

bank O1.

[$Table$ 23]

The increase in the profits of *bank I1*, *bank O4* and *bank O5* from collusion caused by the merger drops from 54.2%, without the remedy, to 50.7%, with the remedy. If the profits of *bank I2* are included, the increase in the profits of the four banks from collusion caused by the merger drops from 24.3%, without the remedy, to 22.2%, with the remedy.

With the remedy, the merger amplifies the reduction in consumer surplus due to collusion by 35.8%.

To sum up, if 60 branches of *BPI* are sold to *bank O4* or *bank O1*, the incentives for collusion decrease very slightly. The impact of the remedy is modest, particularly on the consumer surplus.

8 Concluding Remarks

In this article, we evaluated the unilateral and coordination effects on the mortgage loans market of the proposed merger between *BCP* and *BPI*. We used a rich cross-section of consumer level data from seven banks, that account for 85% of the mortgage loans' market, and a discrete choice model to estimate the price elasticities of demand and the marginal costs of mortgage loans. Given these estimates, we simulated the effects on prices, market shares, and welfare of the merger. The general picture that emerges is that the unilateral effects of merger are relatively small, both in terms of price increases and changes in consumer surplus. However, the merger greatly enhances the benefits from subsequent collusion between the remaining banks.

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A Alternative methodology - Bayesian procedure

A.1 Supply

For simplicity consider that each consumer is presented with one contract offer at each bank he visits. The bank i takes into account consumer n characteristics X_n^s and offers a contract (interest rate/spread) r_{ni}. Here we implicitly consider that the amount of the loan is fixed by the consumer, i.e. it is part of the consumer characteristics X_n^s. This can later be relaxed by considering that the bank offers a contract Y_{ni}^s where Y contains the rate and loan amount, and X^s does not includes the loan amount. There are $i = 1, \ldots, I$ banks and the consumer is faced with the choice of I contracts characterized by a price r_{ni}.

We assume a pricing equation by banks given by:

$$\ln(r_{ni}) = X_n^s \beta + \sigma_i \varepsilon_{ni} \qquad \varepsilon_{ni} \sim N(0,1)$$

One could also have the coefficients β differing from bank to bank indicating different pricing strategies by the different banks.

A.2 Demand

Each contract has an utility U_{ni} given by:

$$\begin{aligned} U_{ni} &= V_{ni} + u_i \\ &= \alpha_{0i} + r_{ni}\alpha_1 + u_i \end{aligned}$$

If the errors u_i follow an extreme value type I distribution the probability that the choice C_n is for contract i has the expression:

$$Pr(C_n = i) = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}.$$

A.3 Sampling

For a given consumer that choose bank i we observe $C_n = i$ and r_{ni} but do not observe $r_{n1}, \ldots, r_{ni-1}, r_{ni+1}, \ldots, r_{nI}$ (which we denote by $r_{n\not{i}}$). We always observe X_n^s.

Let $f(r_{nC_n}, C_n | X_n^s, \beta, \alpha, \sigma)$ be the density of the observed data conditional on the exogenous variables and the parameters. Our goal is to characterize the posterior distribution of (β, α, σ) given (r_{nC_n}, C_n, X_n^s), $f(.)$ and an assumed prior on (β, α, σ) which we denote by h. The Metropolis-Hastings algorithm allows one to generate samples from this posterior provided we can evaluate the joint density $f(r_{nC_n}, C_n | X_n^s, \beta, \alpha, \sigma)h(\beta, \alpha, \sigma)$.

As defined the density f:

$$f(r_{nC_n}, C_n|X_n^s, \beta, \alpha, \sigma) = \int Pr(C_n|r_{n1}, \dots, r_{nI}, \alpha) g(r_{n1}, \dots, r_{nI}|X_n^s, \beta, \sigma) dr_{n\not{C}_n}$$

is computationally extremely expensive to compute (it involves, for I banks, a $I-1$ fold integral).

Our proposal to overcome this issue is to introduce a data-augmentation step that imputes the unobserved prices and then proceed with the sampling from the posterior distribution of the parameters of interest based on the full density $f(r_{n1}, \dots, r_{nI}, C_n|X_n^s, \beta, \alpha, \sigma)h(\beta, \alpha, \sigma)$ and not just on $f(r_{nC_n}, C_n|X_n^s, \beta, \alpha, \sigma)h(\beta, \alpha, \sigma)$.

A.4 Detailed algorithm

Let the superscript t denote the iteration of the markov chain sampling procedure. Also let q generally denote a proposal distribution when one is required.

A.4.1 Sampling α

The sampling of α is a Metropolis-Hastings (M-H) step with a random walk proposal distribution and with a prior density h_α normal with mean 0 and a large variance Σ_α^0. The acceptance probability ρ_α of a new draw α^{t+1} is straight forward to evaluate:

$$\begin{aligned}
\rho_\alpha &= \min\left\{\frac{\prod_n Pr(C_n|r_{nC_n}, r^t_{n\not{C}_n}, \alpha^{t+1}) g(r_{nC_n}, r^t_{n\not{C}_n}|X_n^s, \beta^t, \sigma^t) h_\alpha(\alpha^{t+1}) h_\beta(\beta^t) h_\sigma(\sigma^t) q(\alpha^t|\alpha^{t+1})}{\prod_n Pr(C_n|r_{nC_n}, r^t_{n\not{C}_n}, \alpha^t) g(r_{nC_n}, r^t_{n\not{C}_n}|X_n^s, \beta^t, \sigma^t) h_\alpha(\alpha^t) h_\beta(\beta) h_\sigma(\sigma) q(\alpha^{t+1}|\alpha^t)}, 1\right\} \\
&= \min\left\{\frac{\prod_n Pr(C_n^t|r_{nC_n}, r^t_{n\not{C}_n}, \alpha^{t+1}) h_\alpha(\alpha^{t+1})}{\prod_n Pr(C_n|r_{nC_n}, r^t_{n\not{C}_n}, \alpha^t) h_\alpha(\alpha^t)}, 1\right\}
\end{aligned}$$

This step of the algorithm is then:

1. Generate $\alpha^{t+1} = \alpha^t + \epsilon_{t+1} \qquad \epsilon_{t+1} \sim N(0, \Omega_\alpha)$
2. Accept α^{t+1} with probability ρ_α, otherwise set $\alpha^{t+1} = \alpha^t$

A.4.2 Sampling β

The sampling of β is a Gibbs-sampling step. With a normal prior on β with mean 0 and variance Σ_β^0 and noting that conditional on prices and X^s the posterior of β is normal we can sample directly from this posterior. Denoting by Y^t the stacked $\ln r^t_{ni}$, by X the corresponding stacked X^s and by W^t a diagonal $NI \times NI$ matrix with $1 \backslash \sigma_i^{t2}$ on the diagonal, the posterior of β has a mean μ^t and variance $\Sigma_\beta^1 t$ where:

$$\begin{aligned} \mu^t &= (X'W^tX + \Sigma_\beta^{0\ -1})^{-1} X'W^tY^t \\ \Sigma_\beta^{1t} &= (X'W^tX + \Sigma_\beta^{0\ -1})^{-1} \end{aligned}$$

This step of the algorithm is then:

1. Generate β^{t+1} from $N(\mu^t, \Sigma_\beta^{1t})$

A.4.3 Sampling σ

The sampling of σ is also a Gibbs-sampling step and analogous to β. With a inverted Wishart prior on σ_i the posterior is also an inverted Wishart with parameters which are easily calculated from the available data

This step of the algorithm is then:

1. Generate σ_i^{t+1} directly from its posterior distribution

A.4.4 Sampling r_{ni} for all i with $i \neq C_n$, all n

This is a data-augmentation step with takes the form of a M-H step for each data point. The proposal distribution for the prices that are not observed is simply the supply function given above. The acceptance probability ρ_{P_n} for a new draw $(r_{n\not C_n}^{t+1})$ is:

$$\rho_{P_n} = \min \left\{ \frac{Pr(C_n | r_{nC_n}, r_{n\not C_n}^{t+1}, \alpha^{t+1})}{Pr(C_n | r_{nC_n}, r_{n\not C_n}^{t}, \alpha^{t+1})}, 1 \right\}$$

This step of the algorithm is then:

1. For each n

2. For all i with $i \neq C_n$ generate r_{ni}^{t+1} using $\ln(r_{ni}^{t+1}) = X_n^s \beta^{t+1} + \sigma_i^{t+1} \varepsilon_{ni} \qquad \varepsilon_{ni} \sim N(0,1)$

3. Accept r_{ni}^{t+1} with probability ρ_{P_n} otherwise set $r_{ni}^{t+1} = r_{ni}^t$

A.5 Preliminary results

A burn in run of 10000 draws was made. The following results are based on 1000 draws after the burn in cycle:

Table 1: Elasticities of demand - Bayes procedure

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j} \frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*
bank O1	-3,55	0,1	0,93	0,74	0,51	1,27	0,77
bank O2	0,16	-3,59	0,94	0,74	0,51	1,27	0,78
bank I1	0,12	0,07	-3,42	0,62	0,43	1,05	0,65
bank O3	0,13	0,08	0,9	-3,61	0,48	1,18	0,73
bank I2	0,14	0,09	0,96	0,72	-3,62	1,22	0,75
bank O4	0,13	0,08	0,89	0,69	0,47	-2,93	0,72
bank O5	0,14	0,08	0,93	0,71	0,49	1,22	-3,41

B Tables

Table 2: Descriptive statistics

Variable	Description	Mean	Median	Std.	Mad
mcon	Credit granted (10^6 euro)	0.095	0.085	0.054	0.044
tx	Interest rate at time of contract	0.032	0.030	0.006	0.004
praz	duration of loan (10 years)	2.920	3.000	0.807	0.741
idade	Age (10 years)	3.737	3.500	0.928	0.890
irend_a	Anual income (10^6 euro)	0.018	0.015	0.014	0.009
pava	Asset's valuation (10^6 euro)	0.158	0.138	0.081	0.059
end_b	Total debt to the banking sector (10^6 euro)	0.125	0.107	0.073	0.050
lmcon	log of mcon	-2.515	-2.465	0.603	0.515
ltx	log of tx	-3.466	-3.492	0.155	0.137
lpraz	log of praz	1.023	1.099	0.337	0.270
lidade	log of idade	1.289	1.253	0.242	0.235
lirend_a	log of irend_a	-4.224	-4.233	0.680	0.661
lpava	log of pava	-1.954	-1.981	0.462	0.448
lend_b	log of end_b	-2.235	-2.236	0.558	0.495

Table 3: Model

	Variable	Coef	t-stat	
Demand				
$\alpha(r, z)$	cnst	-0.083	-0.119	
	ltx	0.450	60.353	***
	lmcon	0.879	11.762	***
	lirend_a	-0.174	-2.193	**
$\lambda(x^d)$	znbalc	-2.230	-9.968	***
	lnbalc_NL	-3.120	-11.598	***
	lnbalc_L	-0.289	-2.915	***
	bank O1	-1.097	-7.614	***
	bank O2	0.202	2.270	**
	bank O3	-0.470	-3.834	***
	bank I2	0.023	0.188	
	bank O4	0.105	1.074	
	bank O5	0.279	3.608	***
Supply				
$x^s\beta$	cnst	1.205	116.394	***
	idade	-0.001	-2.329	**
	idade/praz	0.018	6.888	***
	mcon/pava	-0.041	-4.354	***
	end_b/pava	0.035	5.103	***
	mcon/irend_a	-0.002	-2.784	***
	end_b/irend_a	0.001	0.992	
	$\ln\sigma$	-1.985	-187.606	***
	α 25%	9.851		
	α median	14.019		
	α 75%	17.884		
	$\frac{\partial\alpha}{\partial r}$ 25%	1.320		
	$\frac{\partial\alpha}{\partial r}$ median	1.957		
	$\frac{\partial\alpha}{\partial r}$ 75%	2.585		
	Logl	-411.919		
	N	6114.000		

Table 4: Elasticities of demand

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j}\frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*
bank O1	-3.45	0.30	0.75	0.68	0.68	0.54	0.69
bank O2	0.70	-4.55	1.15	0.55	0.86	0.94	0.68
bank I1	0.18	0.12	-1.99	0.35	0.32	0.61	0.35
bank O3	0.19	0.07	0.43	-2.16	0.41	0.57	0.47
bank I2	0.26	0.14	0.52	0.56	-2.52	0.63	0.45
bank O4	0.09	0.06	0.41	0.31	0.26	-1.47	0.32
bank O5	0.19	0.08	0.40	0.44	0.32	0.55	-1.97

Table 5: Elasticities for calibrated model with outside option at 5%

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j} \frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*	OUT	mkt %
bank O1	-2.99	0.27	0.33	0.75	0.45	0.72	0.49	0.00	
bank O2	0.44	-2.74	0.34	0.62	0.34	0.70	0.39	0.00	
bank I1	0.04	0.03	-1.34	0.21	0.18	0.39	0.24	0.00	
bank O3	0.15	0.07	0.31	-1.66	0.22	0.47	0.33	0.00	
bank I2	0.13	0.06	0.40	0.33	-1.90	0.52	0.33	0.00	
bank O4	0.08	0.05	0.34	0.28	0.20	-1.29	0.31	0.00	
bank O5	0.09	0.04	0.33	0.31	0.21	0.51	-1.52	0.00	
OUT	0.19	0.09	0.29	0.18	0.50	0.38	0.17	0.00	

Table 6: Elasticities for calibrated model with outside option at 10%

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j} \frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*	OUT	mkt %
bank O1	-2.84	0.24	0.28	0.65	0.38	0.65	0.45	0.00	
bank O2	0.40	-2.56	0.30	0.56	0.29	0.63	0.37	0.00	
bank I1	0.04	0.02	-1.30	0.20	0.16	0.36	0.22	0.00	
bank O3	0.13	0.07	0.29	-1.62	0.20	0.45	0.31	0.00	
bank I2	0.11	0.05	0.36	0.30	-1.84	0.47	0.31	0.00	
bank O4	0.07	0.04	0.31	0.26	0.18	-1.26	0.29	0.00	
bank O5	0.08	0.04	0.31	0.29	0.20	0.47	-1.48	0.00	
OUT	0.15	0.06	0.26	0.21	0.35	0.36	0.17	0.00	

Table 7: Elasticities for calibrated model with outside option at 20%

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j} \frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*	OUT	mkt %
bank O1	-2.61	0.21	0.25	0.55	0.28	0.56	0.39	0.00	
bank O2	0.35	-2.42	0.26	0.48	0.24	0.54	0.32	0.00	
bank I1	0.03	0.02	-1.28	0.18	0.14	0.32	0.20	0.00	
bank O3	0.11	0.06	0.27	-1.56	0.18	0.40	0.28	0.00	
bank I2	0.08	0.04	0.31	0.26	-1.77	0.42	0.28	0.00	
bank O4	0.06	0.04	0.27	0.23	0.16	-1.24	0.25	0.00	
bank O5	0.07	0.04	0.28	0.26	0.17	0.41	-1.43	0.00	
OUT	0.09	0.04	0.20	0.16	0.21	0.29	0.15	0.00	

Table 8: Elasticities for calibrated model with outside option at 30%

$\varepsilon_{ij} = \frac{\partial Q_i}{\partial p_j} \frac{p_j}{Q_i}$	*bank O1*	*bank O2*	*bank I1*	*bank O3*	*bank I2*	*bank O4*	*bank O5*	OUT	mkt %
bank O1	-2.45	0.18	0.23	0.49	0.22	0.48	0.34	0.00	
bank O2	0.29	-2.33	0.23	0.42	0.20	0.46	0.28	0.00	
bank I1	0.03	0.02	-1.27	0.16	0.12	0.29	0.18	0.00	
bank O3	0.10	0.05	0.24	-1.52	0.16	0.36	0.25	0.00	
bank I2	0.06	0.03	0.28	0.24	-1.70	0.37	0.25	0.00	
bank O4	0.05	0.03	0.25	0.21	0.14	-1.23	0.22	0.00	
bank O5	0.06	0.03	0.25	0.24	0.16	0.37	-1.40	0.00	
OUT	0.06	0.03	0.17	0.12	0.15	0.24	0.12	0.00	

Table 9: Market elasticity

mkt % ouside option	0.050	0.100	0.150	0.200	0.250	0.300
mkt elasticity	-0.417	-0.477	-0.521	-0.559	-0.594	-0.629

Table 10: Marginal cost and price variation estimates

Bank	mc	σ_{mc}	[95% CI for mc]		p_0	Δp	$\frac{\Delta p}{p_0}$	$\frac{\Delta p}{\text{spread}}$	$\sigma_{\frac{\Delta p}{p_0}}$	[95% CI for $\frac{\Delta p}{p_0}$]	
bank O1	0.0203	0.0005	0.0194	0.0212	0.0275	0.0003	0.0095	0.0487	0.0101	-0.0103	0.0293
bank O2	0.0191	0.0006	0.0179	0.0203	0.0274	-0.0008	-0.0276	-0.1305	0.0242	-0.0750	0.0198
bank I1	0.0102	0.0006	0.0091	0.0113	0.0362	0.0026	0.0710	0.1734	0.0142	0.0432	0.0988
bank O3	0.0134	0.0004	0.0126	0.0143	0.0325	-0.0002	-0.0061	-0.0185	0.0095	-0.0247	0.0125
bank I2	0.0167	0.0006	0.0155	0.0179	0.0297	0.0049	0.1633	0.6151	0.0363	0.0921	0.2345
bank O4	0.0080	0.0005	0.0071	0.0089	0.0313	0.0002	0.0061	0.0205	0.0058	-0.0052	0.0174
bank O5	0.0116	0.0004	0.0108	0.0125	0.0314	-0.0005	-0.0163	-0.0539	0.0215	-0.0585	0.0259
Avg	0.0116	0.0003	0.0110	0.0123	0.0321	0.0010	0.0314	0.0994	0.0056	0.0204	0.0424

Table 11: Percent change in prices with alternative outside option assumptions

Market % of the outside option	0%	5%	10%	20%	30%
bank O1	0.010	0.001	-0.008	-0.005	-0.011
bank O2	-0.028	-0.012	-0.014	-0.002	-0.003
bank I1	0.071	0.095	0.082	0.075	0.067
bank O3	-0.006	-0.003	-0.007	0.003	0.000
bank I2	0.163	0.177	0.187	0.199	0.142
bank O4	0.006	0.009	0.002	0.006	0.011
bank O5	-0.016	-0.002	-0.005	-0.001	0.010
Avg	0.031	0.040	0.033	0.032	0.024

Table 12:

Market share of the outside option:	0%	5%	10%	20%	30%
Change in consumer surplus†	-87	-114	-94	-92	-71
Change in BCP and BPI profit†	7	11	7	9	8
Change in the other banks profit†	73	83	66	58	39
Change in welfare†	-7	-20	-22	-25	-24
Change in consumer surplus‡	-915.8	-1200.0	-989.5	-968.4	-747.4
Change in BCP and BPI profit‡	76.8	120.8	71.2	93.6	82.9
Change in the other banks profit‡	769.8	870.3	691.1	609	414.4
Change in welfare‡	-69.2	-208.9	-227.2	-265.8	-250.1

†Euros per household (mortgage contract); ‡Euros per 10^6 euros of total market size

Table 13: Estimated and Reported Capital Costs

	mc	2004†	2005†
bank O1	0.0203	0.0223	0.0250
bank O2	0.0191	0.0220	0.0208
bank I1	0.0102	0.0290	0.0248
bank O3	0.0134	0.0208	0.0221
bank I2	0.0167	0.0294	0.0308
bank O4	0.0080	0.0136	0.0126
bank O5	0.0116	0.0180	0.0183
Euribor 6M		0.0214	0.0229
Euribor 3M		0.0210	0.0223

†Average of quarterly values reported by the banks

Table 14: Coordination effects with no outside option

Banks	(0) $\rightarrow$ (1)	(0) $\rightarrow$ (2)	(0) $\rightarrow$ (3)	(1) $\rightarrow$ (3)
Change in prices				
bank O1	0.010	0.048	0.107	0.098
bank O2	-0.028	-0.017	0.028	0.056
bank I1	0.071	0.647	0.811	0.740
bank O3	-0.006	0.080	0.125	0.131
bank I2	0.163	0.098	0.952	0.789
bank O4	0.006	0.599	0.756	0.750
bank O5	-0.016	0.763	0.974	0.990
Change in banks profits				
bank O1	42.2	312.0	683.1	640.9
bank O2	22.6	243.2	541.2	518.6
bank I1	110.8	1365.2	2303.6	2192.9
bank O3	168.1	2640.0	4788.8	4620.8
bank I2	-33.9	1480.7	579.3	613.2
bank O4	328.7	1958.9	3401.4	3072.7
bank O5	208.2	775.4	1263.0	1054.8
AGG_1	76.8	2845.9	2882.9	2806.1
AGG_2	647.7	4099.5	6968.1	6320.4
AGG_3	613.8	5580.2	7547.4	6933.6
Change in consumer surplus				
ΔCS	-87	-1217	-1761	-1673

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1*+*bank I2* collude; (2) - *bank I1*+*bank O4*+*bank O5* collude; (3) - *bank I1*+*bank I2*+*bank O4*+*bank O5* collude; AGG_1 - *bank I1*+*bank I2*; AGG_2 - *bank I1*+*bank O4*+*bank O5*; AGG_3 - *bank I1*+*bank I2*+*bank O4*+*bank O5*

Table 15: Coordination effects with outside option at 5%

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	0.001	0.038	0.076	0.075
bank O2	-0.012	0.031	0.026	0.038
bank I1	0.095	0.606	0.788	0.633
bank O3	-0.003	0.068	0.133	0.136
bank I2	0.177	0.062	0.899	0.613
bank O4	0.009	0.565	0.774	0.758
bank O5	-0.002	0.746	0.985	0.990
Change in banks profits				
bank O1	31.7	311.3	616.2	584.5
bank O2	19.4	203.5	416.5	397.1
bank I1	128.3	1152.6	2141.8	2013.6
bank O3	195.3	2232.3	4106.6	3911.3
bank I2	-7.5	1430.1	688.5	696.0
bank O4	394.4	1637.2	2912.2	2517.8
bank O5	229.5	577.4	1099.0	869.5
AGG_1	120.8	2582.7	2830.3	2709.5
AGG_2	752.2	3367.2	6153.0	5400.8
AGG_3	744.7	4797.3	6841.4	6096.8
Change in consumer surplus				
ΔCS	-114	-1088	-1667	-1552

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1*+*bank I2* collude; (2) - *bank I1*+*bank O4*+*bank O5* collude; (3) - *bank I1*+*bank I2*+*bank O4*+*bank O5* collude; AGG_1 - *bank I1*+*bank I2*; AGG_2 - *bank I1*+*bank O4*+*bank O5*; AGG_3 - *bank I1*+*bank I2*+*bank O4*+*bank O5*; -

Table 16: Coordination effects with outside option at 10%

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	-0.008	0.037	0.069	0.078
bank O2	-0.014	0.023	0.023	0.037
bank I1	0.082	0.551	0.727	0.596
bank O3	-0.007	0.056	0.115	0.123
bank I2	0.187	0.055	0.908	0.607
bank O4	0.002	0.504	0.728	0.724
bank O5	-0.005	0.707	0.950	0.959
Change in banks profits				
bank O1	22.9	254.0	495.5	472.7
bank O2	13.3	166.7	329.2	315.9
bank I1	100.3	945.0	1844.2	1743.9
bank O3	152.0	1843.3	3401.5	3249.5
bank I2	-29.1	1155.5	516.7	545.8
bank O4	320.1	1410.2	2454.1	2134.0
bank O5	182.8	424.9	899.2	716.5
AGG_1	71.2	2100.5	2360.9	2289.7
AGG_2	603.1	2780.1	5197.5	4594.4
AGG_3	574.0	3935.6	5714.2	5140.2
Change in consumer surplus				
ΔCS	-94	-945	-1487	-1393

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1*+*bank I2* collude; (2) - *bank I1*+*bank O4*+*bank O5* collude; (3) - *bank I1*+*bank I2*+*bank O4*+*bank O5* collude; AGG_1 - *bank I1*+*bank I2*; AGG_2 - *bank I1*+*bank O4*+*bank O5*; AGG_3 - *bank I1*+*bank I2*+*bank O4*+*bank O5*; -

Table 17: Coordination effects with outside option at 20%

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	-0.005	0.042	0.049	0.054
bank O2	-0.002	0.025	0.031	0.033
bank I1	0.075	0.479	0.640	0.526
bank O3	0.003	0.055	0.101	0.098
bank I2	0.199	0.064	0.830	0.527
bank O4	0.006	0.440	0.703	0.692
bank O5	-0.001	0.656	0.841	0.842
Change in banks profits				
bank O1	20.7	191.8	355.7	335.0
bank O2	12.1	120.3	220.6	208.5
bank I1	109.1	722.2	1394.3	1285.2
bank O3	134.6	1343.4	2414.5	2279.8
bank I2	-15.5	828.5	430.8	446.4
bank O4	277.4	1097.8	1616.4	1339.0
bank O5	164.2	295.5	761.4	597.2
AGG_1	93.6	1550.7	1825.1	1731.5
AGG_2	550.7	2115.5	3772.0	3221.3
AGG_3	535.1	2944.0	4202.8	3667.7
Change in consumer surplus				
ΔCS	-92	-762	-1204	-1113

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1*+*bank I2* collude; (2) - *bank I1*+*bank O4*+*bank O5* collude; (3) - *bank I1*+*bank I2*+*bank O4*+*bank O5* collude; AGG_1 - *bank I1*+*bank I2*; AGG_2 - *bank I1*+*bank O4*+*bank O5*; AGG_3 - *bank I1*+*bank I2*+*bank O4*+*bank O5*; -

Table 18: Coordination effects with outside option at 30%

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	-0.011	0.040	0.046	0.058
bank O2	-0.003	0.030	0.033	0.037
bank I1	0.067	0.419	0.577	0.478
bank O3	0.000	0.047	0.078	0.078
bank I2	0.142	0.062	0.771	0.551
bank O4	0.011	0.402	0.651	0.634
bank O5	0.010	0.588	0.774	0.757
Change in banks profits				
bank O1	14.2	139.9	251.5	237.3
bank O2	8.0	84.9	152.4	144.3
bank I1	74.5	536.4	994.0	919.4
bank O3	98.2	962.4	1710.7	1612.6
bank I2	8.3	597.1	305.9	297.6
bank O4	184.7	770.7	1129.4	944.7
bank O5	109.3	220.8	545.5	436.3
AGG_1	82.9	1133.5	1299.9	1217.0
AGG_2	368.5	1528.0	2668.9	2300.5
AGG_3	376.8	2125.1	2974.8	2598.0
Change in consumer surplus				
ΔCS	-71	-602	-960	-889

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1+bank I2* collude; (2) - *bank I1+bank O4+bank O5* collude; (3) - *bank I1+bank I2+bank O4+bank O5* collude; AGG_1 - *bank I1+bank I2*; AGG_2 - *bank I1+bank O4+bank O5*; AGG_3 - *bank I1+bank I2+bank O4+bank O5*

Table 19: Merger impact on the profitability of collusion

Market % of the outside option	0%	5%	10%	20%	30%
bank O1	105.4%	87.8%	86.1%	74.7%	69.6%
bank O2	113.2%	95.1%	89.5%	73.3%	70.0%
bank I1	60.6%	74.7%	84.5%	78.0%	71.4%
bank O3	75.0%	75.2%	76.3%	69.7%	67.6%
bank I2	-58.6%	-51.3%	-52.8%	-46.1%	-50.2%
bank O4	56.9%	53.8%	51.3%	22.0%	22.6%
bank O5	36.0%	50.6%	68.6%	102.1%	97.6%
AGG1	-1.4%	4.9%	9.0%	11.7%	7.4%
AGG2	54.2%	60.4%	65.3%	52.3%	50.6%
AGG3	24.3%	27.1%	30.6%	24.6%	22.3%

C Tables - Remedies

Table 20: Marginal cost and price variation estimates

Bank	mc	σ_{mc}	[95% CI for mc]		p_0	Δp	$\frac{\Delta p}{p_0}$	$\frac{\Delta p}{\text{spread}}$	$\sigma_{\frac{\Delta p}{p_0}}$	[95% CI for $\frac{\Delta p}{p_0}$	
bank O1	0.0203	0.0005	0.0194	0.0212	0.0275	0.0002	0.0079	0.0401	0.0102	-0.0122	0.0279
bank O2	0.0191	0.0006	0.0179	0.0203	0.0274	-0.0006	-0.0222	-0.1050	0.0220	-0.0653	0.0209
bank I1	0.0102	0.0006	0.0091	0.0113	0.0362	0.0025	0.0699	0.1705	0.0139	0.0425	0.0972
bank O3	0.0134	0.0004	0.0126	0.0143	0.0325	-0.0002	-0.0059	-0.0181	0.0093	-0.0242	0.0124
bank I2	0.0167	0.0006	0.0155	0.0179	0.0297	0.0047	0.1590	0.5988	0.0357	0.0891	0.2289
bank O4	0.0080	0.0005	0.0071	0.0089	0.0313	0.0003	0.0099	0.0332	0.0055	-0.0009	0.0208
bank O5	0.0116	0.0004	0.0108	0.0125	0.0314	-0.0005	-0.0157	-0.0520	0.0202	-0.0554	0.0240
Avg	0.0116	0.0003	0.0110	0.0123	0.0321	0.0010	0.0319	0.1012	0.0054	0.0214	0.0424

Table 21: Marginal cost and price variation estimates

Bank	mc	σ_{mc}	[95% CI for mc]		p_0	Δp	$\frac{\Delta p}{p_0}$	$\frac{\Delta p}{\text{spread}}$	$\sigma_{\frac{\Delta p}{p_0}}$	[95% CI for $\frac{\Delta p}{p_0}$	
bank O1	0.0203	0.0005	0.0194	0.0212	0.0275	0.0010	0.0379	0.1938	0.0111	0.0162	0.0597
bank O2	0.0191	0.0006	0.0179	0.0203	0.0274	-0.0009	-0.0332	-0.1568	0.0352	-0.1022	0.0359
bank I1	0.0102	0.0006	0.0091	0.0113	0.0362	0.0026	0.0709	0.1731	0.0147	0.0421	0.0997
bank O3	0.0134	0.0004	0.0126	0.0143	0.0325	-0.0003	-0.0087	-0.0267	0.0139	-0.0359	0.0184
bank I2	0.0167	0.0006	0.0155	0.0179	0.0297	0.0054	0.1831	0.6898	0.0570	0.0714	0.2949
bank O4	0.0080	0.0005	0.0071	0.0089	0.0313	0.0002	0.0070	0.0233	0.0074	-0.0075	0.0215
bank O5	0.0116	0.0004	0.0108	0.0125	0.0314	-0.0006	-0.0193	-0.0639	0.0311	-0.0802	0.0416
Avg	0.0116	0.0003	0.0110	0.0123	0.0321	0.0011	0.0338	0.1103	0.0069	0.0202	0.0474

D Tables - Appendix

Table 22: Coordination effects with no outside option

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	0.008	0.047	0.107	0.099
bank O2	-0.022	-0.014	0.028	0.050
bank I1	0.070	0.651	0.811	0.742
bank O3	-0.006	0.081	0.125	0.131
bank I2	0.159	0.094	0.935	0.776
bank O4	0.010	0.609	0.762	0.752
bank O5	-0.016	0.768	0.974	0.990
Change in banks profits				
bank O1	43.6	313.5	682.9	639.3
bank O2	22.5	243.1	541.1	518.6
bank I1	119.1	1372.3	2304.1	2185.0
bank O3	172.6	2657.9	4792.4	4619.9
bank I2	-27.4	1496.1	611.7	639.1
bank O4	323.6	1938.3	3364.6	3041.0
bank O5	213.0	779.3	1264.6	1051.6
AGG_1	91.7	2868.4	2915.8	2824.1
AGG_2	655.6	4089.9	6933.3	6277.7
AGG_3	628.2	5586.0	7545.0	6916.8
Change in consumer surplus				
ΔCS	-90	-1225	-1762	-1672

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1+bank I2* collude; (2) - *bank I1+bank O4+bank O5* collude; (3) - *bank I1+bank I2+bank O4+bank O5* collude; AGG_1 - *bank I1+bank I2*; AGG_2 - *bank I1+bank O4+bank O5*; AGG_3 - *bank I1+bank I2+bank O4+bank O5*

Table 23: Coordination effects with no outside option

Banks	(0) → (1)	(0) → (2)	(0) → (3)	(1) → (3)
Change in prices				
bank O1	0.038	0.062	0.117	0.079
bank O2	-0.033	-0.029	0.024	0.057
bank I1	0.071	0.644	0.802	0.731
bank O3	-0.009	0.078	0.119	0.128
bank I2	0.183	0.098	0.933	0.750
bank O4	0.007	0.603	0.754	0.747
bank O5	-0.019	0.764	0.968	0.987
Change in banks profits				
bank O1	40.5	305.8	665.3	624.8
bank O2	29.8	248.0	543.6	513.9
bank I1	127.0	1374.7	2298.9	2171.9
bank O3	191.8	2651.4	4763.1	4571.4
bank I2	-42.8	1484.5	596.5	639.3
bank O4	352.9	1940.4	3345.2	2992.3
bank O5	232.1	773.9	1247.0	1014.8
AGG_1	84.2	2859.1	2895.4	2811.2
AGG_2	712.1	4089.0	6891.1	6179.0
AGG_3	669.3	5573.5	7487.6	6818.3
Change in consumer surplus				
ΔCS	-92	-1217	-1745	-1653

Euros per 10^6 euros of total market size. (0) - no collusion; (1) - *bank I1+bank I2* collude; (2) - *bank I1+bank O4+bank O5* collude; (3) - *bank I1+bank I2+bank O4+bank O5* collude; AGG_1 - *bank I1+bank I2*; AGG_2 - *bank I1+bank O4+bank O5*; AGG_3 - *bank I1+bank I2+bank O4+bank O5*