Mergers, Coordinated Effects and Efficiency in the Portuguese Non-Life Insurance Industry*

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Abstract

We evaluate the impact on market power and efficiency of several mergers on three Portuguese non-life insurance markets. We specify and estimate, with a panel of firm level data, a structural model that includes: **(i)** preferences, **(ii)** technology, and **(iii)** a market equilibrium condition. We find that: **(i)** firms' demands are elastic, but not much, **(ii)** firms exhibit scale economies and high cost efficiency scores, and **(iii)** there is no evidence of changes in cost efficiency levels and of an increase in market power through coordinated behavior in the period following the mergers.

Key Words: Mergers, Market Power, Efficiency, Non-Life Insurance.

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1 Introduction

When analyzing a merger, Competition Authorities usually focus on the impact of the operation on market power and efficiency. Supposedly there is a trade-off between these two aspects. On the one hand, mergers may increase firms' incentives to increase prices, either unilaterally or through coordination. On the other hand, mergers may reduce firms' marginal costs, as argued by Williamson (1968). Economies of scale, economies of scope, or other synergies, due to the combination of complementary assets, may have this result. However, managerial slack, due to the decrease in competition, may have the opposite effect as shown by Brito and Pereira (2012). Thus, the overall impact of a merger on prices, marginal costs and welfare is potentially ambiguous.

A recent series of mergers in the Portuguese insurance industry provides a unique opportunity to measure ex-post some of these effects. In this article, we evaluate the impact of mergers on: **(i)** the exercise of market power through coordinated effects, and **(ii)** the firms' internal efficiency. We analyze three non-life insurance markets: motor vehicles, employers' liability and fire and other damage to property. Our data set consists of a rich panel of annual accounting data from 13 Portuguese insurers for the period of 1999 to 2007. On average, these firms accounted for about 80% of the premium volume in the whole non-life sector for the period of our sample.

To conduct the analysis, we specify and estimate a structural model that includes: **(i)** preferences, **(ii)** technology, and **(iii)** a market equilibrium condition.

Preferences are represented by a discrete choice model, which is used to estimate the price elasticities of demand. Firms' demands are elastic, but not much.

Technology is represented by a stochastic cost frontier, which is used to estimate marginal costs, returns to scale and efficiency levels. Firms exhibit scale economies and high efficiency scores. In the period following the mergers, there is no evidence of changes in cost efficiency.

The market equilibrium is characterized by a set of first-order conditions for prices, which nest Nash equilibrium and joint profit maximization, as well as intermediate degrees of competition between these two cases, allowing a rich characterization of strategic interaction in the industry. Given the demand and cost estimates, obtained separately, we estimate the market equilibrium condition and use it to analyze the exercise of market power through coordinated effects, before and after the mergers. We find no evidence of an increase in coordination in the period following the mergers.

Finally, note that an additional reason to use a structural model to investigate the effects of mergers on prices and costs in cases similar to ours is that mergers are not randomly assigned over time and are likely to affect the whole country. Hence, even with pre- and post-merger data available a differences-in-differences strategy would be infeasible.[1]

The way we analyze the exercise of market power differs from the new empirical industrial organization's approach, reviewed by Bresnahan (1989), because we estimate the demand, cost and coordination parameters separately, through three, rather than two equations. In fact, since we have independent demand and cost estimates, our procedure corresponds to what Corts (1999) and Genesove and Mullin (1998) refer to as the "direct" or "complete information" approach. Our procedure builds on the menu approach of Nevo (2001), and allows a parsimonious characterization of both: **(i)** the initial level of coordination, and **(ii)** how coordination changed over time.

The remainder of this article is organized as follows. Section 2 inserts the article on the literature. Section 3 gives a brief overview of the Portuguese non-life insurance industry. Section 4 presents the econometric model. Section 5 describes the data and discusses identification. Section 6 presents the basic demand and cost estimates. Section 7 conducts the analysis. Finally, section 8 concludes.

2 Literature Review

The retrospective evaluation of the impact of mergers has been of interest to industrial organization for a long time. However, more recently this theme gained an added interest as several authors, e.g., Ashenfelter et al. (2009) and Carlton (2009), called for more empirical studies evaluating the effectiveness of merger policy to guide competition authorities improve

[1] **The timing of the mergers is likely to be endogenous and correlated with prices and other determinants of demand, observed by market participants but not by the researcher, which is also a problem for the structural approach**.

the merger review process. A fundamental question facing competition authorities is whether their current merger policy is too lax, as claimed by Baker and Shapiro (2008), or too stringent, as claimed by Crandall and Winston (2003). While most articles have focused on the impact on prices: Ashenfelter and Hosken (2010), Focarelli and Panetta (2003), Hosken et al. (2011) and Taylor and Hosken (2007);[2] other articles focused on the impact on costs: Kwoka and Pollitt (2010) and Vellturo et al. (1992); and a few analyzed the impact on both prices and costs: Ivaldi and Mccullough (2010). Since merger simulation models are being increasingly used by competition authorities in the merger review process, some articles have focused on the evaluation of the predictive power of these models: Peters (2006), Weinberg (2011) and Weinberg and Hosken (2009). Finally a few articles analyzed the impact of divestitures: Friberg and Rohman (2012), Slade (1998) and Tenn and Yun (2011).

The measurement of market power under oligopoly and the identification of its determinates is one of the oldest themes of industrial organization. Some of the latest contributions, of a very long line of research, include: Argentesi and Filistrucchi (2007), Black et al. (2004), Bresnahan (1987, 1989), Clay and Troesken (2003), Corts (1999), Gasmi et al. (1992), Genesove and Mullin (1998), Ivaldi and Mccullough (2010) and Nevo (2001). See also Black et al. (2004) and Michel (2012) for alternative strategies to measure market power. Given the importance of this issue to our analysis, we defer the review of this literature until section 4.3, where we provide a detailed discussion of the main contemporary approaches and how they relate to our article.

Thirdly, our article relates to the literature that evaluates the impact of mergers or deregulation on the efficiency of insurance companies. Cummins and Xie (2008) analyzed the productivity and efficiency effects of mergers and acquisitions in the US property-liability insurance industry for the period from 1994 to 2003. Cummins and Rubio-Misas (2006) studied the effects of deregulation and consolidation in the Spanish insurance industry in the nineties. Ennsfeller et al. (2004) and Mahlberg and Url (2003) examined the efficiency of the Austrian insurance industry, also in the nineties. Cummins et al. (1996) analyzed the

[2] See also Ashenfelter et al. (2011), Borenstein (1990), Dafny (2009), Kim and Singal (1993), Kwoka and Shumilkina (2010), Prager and Hannan (1998), Sapienza (2002), Simpson and Taylor (2008), Vita and Sacher (2001) and Winston et al. (2011); or Weinberg (2007) for a survey.

effect of deregulation on technical efficiency and productivity growth in the life and non-life Italian insurance industry for the period from 1985 to 1993. Other studies where conducted by Fecher et al. (1993), for France, by Cummins et al. (1999), for the US, and by Fenn et al. (2008), for 14 European countries.

Finally, regarding the empirical literature on the Portuguese insurance industry, Barros et al. (2005a), using data envelopment analysis, concluded that increased competition, resulting from the market integration, increased the firms' efficiency. Gollier and Ivaldi (2005) developed an econometric model to simulate the unilateral effects of the acquisition of the merger that occurred in 2005. Barros (1996) analyzed the change in conduct in the auto-insurance market following the price deregulation of 1989. With the exception of Gollier and Ivaldi (2005), none of the articles mentioned above estimates a demand function.

3 Overview of the Portuguese Industry

The creation of the single market for the EU insurance industry in July 1994 brought about a potentially higher level of competition. However, firms licensed in Portugal still account for most of the business in the Portuguese industry.[3] Moreover, concentration ratios have increased substantially after 2001, as Table 1 illustrates.

[$Table$ 1]

Between 1999 and 2007, seven concentration operations took place involving firms present in non-life insurance markets, as summarized in Table 2.

[$Table$ 2]

Our study includes data from 13 firms, which are highly representative of the sector. Their combined average market share between 1999 and 2007 was 83.7%, 86.2% and 77.0%

[3] For non-life insurance, they accounted for about 93.0% of total premium volume in 2006, while foreign branches and insurers operating under the free-to-provide-services regime accounted for only 4.6% and 2.4% of overall premium intakes, respectively (APS, 2007). Differences in taxation and contract law, cultural heterogeneity, and informational advantages have all been cited as reasons for this weak cross-border competition that seems to characterize most national insurance markets in the EU, see, e.g., Cummins and Rubio-Misas (2006) and Fenn et al. (2008).

in the motor vehicles, employers' liability, and fire and other damage to property markets, respectively.[4]

Confidentiality restrictions do not allow us to disclose the firms' identity. Hence, throughout the article, firms are identified as firm 01 to firm 13.

Tables 3 reports some summary statistics for the firms in our sample in 2007.

[*Table* 3]

Five firms operate in both the non-life and life markets, eight firms sell their products also through bank branches, and in eight firms the majority of the capital is Portuguese-owned. Of these 13 firms, five were involved in at least one concentration operation between 1999 and 2007.

According to their average non-life market shares in the period, *Firm 03* and *Firm 05* stand out from the rest of the firms by controlling together one third of the market. The remaining firms in our sample can be divided into two groups. First, with market shares between 6.2 and 8.7%, we have *Firm 06*, *Firm 09*, *Firm 11* and *Firm 12*. The other seven firms have market shares between 1.7 and 3.8%.

Table 4 reports some average statistics for each firm, per line of business, for the 1999 – 2007 period.

[*Table* 4]

While the biggest firms display similar average market shares in the three markets, the relevance of the smaller firms varies significantly from product to product. Similarly, the distribution of premium income by line of business is not uniform for each firm.[5]

[4] Excluding firms with little relevance operating under the free-to-provide-services regime.

[5] Motor vehicles is the most important of the three markets for all firms. Its weight in the premium volume of each firm ranges from 17.1 to 64.8%. In the employers' liability market the differences are also very large, ranging from 5.0 to 30.3%. With one exception, the joint weight of the three markets on the total non-life insurance premium income of each firm ranges from 80.7 to 96.2%.

4 The Model

In this section, we present the three blocks of our model: **(i)** preferences, **(ii)** technology, and **(iii)** the equilibrium condition.

Given the level of aggregation of our data, we assume that each firm produces a single product in each market and in each period of time. In addition, demand is independent across markets. We index firms with subscript $f = 0, 1, ..., F$, markets with subscript $j = 1, ..., J$ and time with subscript $t = 1, ..., T$.

4.1 Preferences

For notational simplicity, in the following sections we omit subscripts t and j, as well as other arguments, whenever the expressions are unambiguous.

4.1.1 Utility of Products in each Market

Denote by δ_f the mean utility level of the product sold by firm f in market j in period t, by p_f the price of the product of firm f, by $\mathbf{X}_f$ a K-dimensional vector of observed characteristics, other than price, of the product of firm f, by $\boldsymbol{\xi}_f$ a vector of unobserved characteristics of the product of firm f in period, by α the price coefficient, and by $\boldsymbol{\eta}$ a K-dimensional vector of parameters that translates the consumer valuation for the product characteristics other than price. We assume that the mean utility level of product f is common across consumers, i.e.,

$$\delta_f := \alpha p_f + \boldsymbol{\eta}'\mathbf{X}_f + \boldsymbol{\xi}_f, \tag{1}$$

Denote by $\mathcal{U}_{if}$ the utility that consumer $i = 1, ..., I$ derives from the product of firm f, and by ϵ_{if} a zero mean random disturbance, independent across products, consumers, and time, and identically distributed. We assume that:[6]

$$\mathcal{U}_{if} := \delta_f + \epsilon_{if}. \tag{2}$$

[6] Regarding the two unobserved components of the model, ξ_f and ϵ_{if}, while the former represents the mean of consumers' valuations of unobserved product characteristics, the latter represents the distribution of consumer preferences about the mean of δ_f, from which ξ_f is one of the components.

The outside good, which represents the option of not purchasing any of the J products, is denoted by $f = 0$. The mean utility level of this option is normalized to $\delta_0 = 0$, which implies $\mathcal{U}_{i0} = \epsilon_{i0}$.

4.1.2 Choice Probabilities

In each market and period, a consumer chooses a product to maximize its utility, i.e., chooses product f if $\mathcal{U}_f > \mathcal{U}_{f'}$, for all $f' \neq f$, which occurs with probability P_f:

$$P_f = \Pr\left[\delta_f + \epsilon_f > \delta_{f'} + \epsilon_{f'}, \forall f' \neq f\right].$$

We assume that the joint distribution of the errors ϵ_f follows the assumptions of the two-level nested logit (NL) model, a member of the Generalized Extreme Value class.[7]

The NL model groups all the alternatives into subsets or nests of alternatives that are more alike to each other than to other alternatives. By doing so, the correlation in the unobserved factors contained in ϵ_f across products placed in the same nest is allowed to be nonzero, while the ϵ_fs relative to products in different nests remain uncorrelated. Within a nest, the correlation is restricted to be the same for all alternatives.

Let the set of alternatives be partitioned into $G + 1$ exhaustive and mutually exclusive groups, $g = 0, 1, ..., G$, with each group g containing the products of f_g firms. The outside good is assumed to be the only member of group 0. Denote by B_g the set of products in group g, and by λ_g, a dissimilarity parameter that measures the degree of independence in ϵ_f among the alternatives in the same nest. The choices probabilities yielded by the NL model are given by:

$$P_f = \frac{\exp\left(\frac{\delta_f}{\lambda_g}\right)}{\sum_{f' \in B_g} \exp\left(\frac{\delta_{f'}}{\lambda_g}\right)} \frac{\left[\sum_{f' \in B_g} \exp\left(\frac{\delta_{f'}}{\lambda_g}\right)\right]^{\lambda_g}}{\sum_l \left[\sum_{f' \in B_l} \exp\left(\frac{\delta_{f'}}{\lambda_l}\right)\right]^{\lambda_l}}, \ f \text{ on nest } g. \tag{3}$$

For this model to be consistent with random utility maximization, each λ_g must belong to the unit interval $[0, 1]$. A higher value of λ_g implies greater independence, with $\lambda_g = 1$ for all groups indicating complete independence among all alternatives in all nests, in which case the NL model reduces to the multinomial logit (ML) model.

[7] See, e.g., Train (2009) for a thorough discussion of this class of models.

We assume also that the correlation between the unobserved parts of utility represented by ϵ_f within a nest is very similar across nests, leading λ_g to be the same for all groups.

4.1.3 Aggregate Market Shares

Denote by s_f the aggregate choice probabilities or market shares of firm f, by s_g the probability of choosing a product in group g, and by $s_{f|g}$ the probability of choosing the product of firm f conditionally on purchasing a product in group g. Following Berry (1994), first expression (3) is aggregated over consumers to obtain market-level demand functions that relate prices to shares.[8] Then, the resultant functions defining market shares are inverted, producing the following expressions for the NL model:

$$\ln s_f - \ln s_0 = \delta_f + \sigma_g \ln s_{f|g} = \alpha p_f + \boldsymbol{\eta}'\mathbf{X}_f + \xi_f + \sigma_g \ln s_{f|g}, \tag{4}$$

where $\sigma_g := 1 - \lambda_g$. Again the equivalent expression for the ML model follows if $\lambda_g = 1$. Finally, the parameters in equation (4) are estimated using standard instrumental variable methods.

When panel data are available, as in our case, the unobserved product characteristics may be decomposed as $\xi_f = \varsigma_f + \tau + \varrho\psi_f$, where ς_f denotes the set of unobserved time-invariant product-specific characteristics, τ represents product-invariant time-specific effects, and ψ_f captures residual unobserved product valuations that vary both across products and time. To account for the product- and time-specific effects, we include in the model a full set of product and time dummies. In addition, for each firm involved in a merger, we included interactions between product dummies and another dummy variable indicating the post-merger period.

[8] The models presented in the previous sections cannot be estimated directly for two reasons. First, we observe the price and quantities sold by each firm, not the decisions of individual consumers. Second, we do not observe the product characteristics denoted by ξ_f in (1), in addition to the unobserved factors contained in ϵ_f. Since we assume that ξ_f is correlated with prices and both of them enter nonlinearly the models described above, any standard application of instrumental variables methods is impossible. To deal with both of these issues, we apply the methodology developed by Berry (1994).

4.1.4 Price Elasticities of Demand

The elasticity of demand of product f with respect to the price of product f' is:

$$\varepsilon_{ff'} = \frac{\partial P_f}{\partial p_{f'}} \frac{p_{f'}}{P_f}.$$

For the NL model the price elasticity of demand is given by:

$$\varepsilon_{ff'} = \begin{cases} \alpha p_f \left[\left(1 - \frac{1}{\lambda_g}\right) s_{f|g} - P_f + \frac{1}{\lambda_g} \right] & \text{if } f = f';\ f \text{ on nest } g \\ \alpha p_{f'} \left[\left(1 - \frac{1}{\lambda_g}\right) s_{f'|g} - P_{f'} \right] & \text{if } f \neq f';\ f, f' \text{ on nest } g \\ -\alpha p_{f'} P_{f'} & \text{if } f \neq f';\ f, f' \text{ on different nests.} \end{cases}$$

The price elasticity of demand For the ML model $\varepsilon_{ff} = \alpha p_f \left(1 - P_f\right)$ and $\varepsilon_{ff'} = -\alpha p_{f'} P_{f'}$.

4.1.5 Consumer Welfare Valuation

Let superscripts b and a denote the levels of variables before and after a policy change, respectively. Denote by V_i^b and V_i^a, the utility levels before and after a policy change, respectively. A policy change may imply three types of changes. First, prices may change, which requires computing the market equilibrium after the policy change. Second, the characteristics of the products may change, i.e., x_i may change. Third, the number of products offered may change. In the present study changes in price changes resulting from changes in equilibrium are considered as well as the introduction of a new product.

The generalized extreme value model, of which the multinomial and the nested logit models are particular cases, provides a convenient computational formula for the exact consumer surplus, up to a constant, associated with a policy that changes the attributes of the products in the market. This expression, known as the "log sum" formula, is:[9]

$$\Delta CS_n = \frac{1}{\alpha} \left[\ln H\left(e^{V_1^a}, \ldots, e^{V_I^a}\right) - \ln H\left(e^{V_1^b}, \ldots, e^{V_I^b}\right) \right].$$

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

[9] This expression 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) elaborate on the connection between the above measures of welfare and standard measures of consumer surplus.

4.2 Technology

4.2.1 Stochastic Cost Frontier

In each period of time, each firm f produces J products, y_{1f}, y_{2f},...,y_{Jf}, one for each market.[10] To produce these outputs, firms need to use inputs, which we assume to be common to all products and indexed with subscript $n = 1, ..., N$. Denote by ω_{nf} the price of input n for firm f. Let $\mathbf{y}_f := (y_{1f}, y_{2f}, ..., y_{Jf})$ and $\boldsymbol{\omega}_f := (\omega_{1f}, ..., \omega_{Nf})$.

Denote by c_f the observed cost of firm f. The observed cost may differ from the minimum cost. Inefficiency may prevent firms from reaching the required output level at the minimum cost. This inefficiency may be simply the result of the irreducible uncertainty that involves the creation of a new production process, or may be related to the quality of the firm's production factors. To analyze efficiency, we use a stochastic frontier model, presented in, e.g., Kumbhakar and Lovell (2000).

Denote by $\boldsymbol{\theta}$ and $\boldsymbol{\varpi}$ two vectors of technology parameters to be estimated. A stochastic cost frontier consists of two parts: **(i)** a deterministic part, $C(\mathbf{y}_f, \boldsymbol{\omega}_f; \boldsymbol{\theta}, \boldsymbol{\varpi})$, which is common to all firms, and **(ii)** a firm-specific random part, $\exp(u_f)$, which captures the effects of random shocks on each firm. A stochastic cost frontier may be written as:

$$SCF_f = C(\mathbf{y}_f, \boldsymbol{\omega}_f; \boldsymbol{\theta}, \boldsymbol{\varpi}) \exp(u_f).$$

If firms produce at minimum cost, $c_f = SCF_f$; otherwise $c_f > SCF_f$. Therefore, the observed cost for firm f is given by:

$$c_f = C(\mathbf{y}_f, \boldsymbol{\omega}_f; \boldsymbol{\theta}, \boldsymbol{\varpi}) \exp(u_f) \exp(v_f); \tag{5}$$

where $v_{ft} \geq 0$ is an asymmetric, positively skewed error term that imposes $c_f \geq SCF_f$, and represents firm-specific cost inefficiency. Denote by $CE_f := \frac{SCF_f}{c_f} = \exp(-v_f)$, the ***cost efficiency*** of firm f. If $CE_{ft} = 1$, the firm is operating on the stochastic cost frontier, producing at minimum cost, given its technology and environment. In contrast, if $CE_{ft} < 1$, the firm is not producing as efficiently as it might. The lower the value of CE_{ft}, the larger the firm's degree of inefficiency.

[10] In this section the time index t is omitted.

Assuming a simplified translog functional form for $C(\cdot)$, where all cross terms except $\ln(y_{jf})\ln(y_{if})$, $i \geq j$, are set to zero, and taking logarithms, the stochastic cost frontier model is:

$$\ln(c_f) = \ln(a_f) + \sum_{j=1}^{J} \theta_j \ln(y_{jf}) + \sum_{j=1}^{J}\sum_{i \geq j}^{J} \theta_{ji} \ln(y_{jf}) \ln(y_{if}) + \sum_{n=1}^{N} \varpi_n \ln(\omega_{nf}) + v_f + u_f. \quad (6)$$

We assume that u_f has an independent and identically distributed normal distribution $\mathcal{N}(0, \sigma_u^2)$ and that u_f and v_f are distributed independently of each other and of the covariates in the model.

4.2.2 Mergers and Efficiency

To measure the impact of mergers on the cost efficiency of firms, we use three different cost frontier models that assume that the one-sided error v_{ft} in equation (6) has a normal distribution. The first model is the standard half-normal cost frontier model, i.e., $v_{ft} \sim \mathcal{N}^+(0, \sigma_v^2)$. The second model generalizes the previous formulation by allowing time-varying cost inefficiency. In particular, we use Battese and Coelli's (1992) cost frontier model and consider $v_f \sim \mathcal{N}^+(0, \sigma_v^2)$ and $v_{ft} = \exp[\phi(t - T)] \cdot v_f$. Because this model has the limitation that it does not allow for a change in the rank ordering of firms over time, we consider also Battese and Coelli's (1995) model, which assumes $v_{ft} \sim \mathcal{N}^+(\boldsymbol{\rho}'\mathbf{Z}_{ft}, \sigma_v^2)$, where $\mathbf{Z}_f$ is a vector of exogenous variables that may be interpreted as the determinants of cost efficiency and $\boldsymbol{\rho}$ is a vector of parameters to be estimated. Therefore, in this last model the inefficiency effects have distributions that vary with firms and over time.

4.2.3 Marginal and Average Costs, Scale Economies and Efficiency Ratios

From the model described above, we can compute marginal and average costs, scale economies, and efficiency ratios. Denote by $\hat{\varkappa}$, the estimate of variable $\varkappa$.

The estimated ***marginal cost*** of firm f for producing product j is:

$$\widehat{mc}_{jf} = \frac{\partial \ln(\hat{c}_f)}{\partial \ln(y_{jf})} \frac{\hat{c}_f}{y_{jf}} = \left[\hat{\theta}_j + 2\hat{\theta}_{jj} \ln(y_{jf}) + \hat{\theta}_{ji} \sum_{i \neq j} \ln(y_{if})\right] \frac{\hat{c}_f}{y_{jf}},$$

where $\hat{c}_f = C\left(\mathbf{y}_f, \mathbf{w}_f; \widehat{\boldsymbol{\theta}}, \widehat{\boldsymbol{\varpi}}\right) \exp(\hat{v}_f)$. A measure of the ***aggregate marginal cost*** per firm is given by:

$$\widehat{mc}_f = \sum_{j=1}^{J} b_{jf} \widehat{mc}_{jf},$$

where b_{jf} is the weight of costs attributable to product j on total costs of firm f and $\sum_{j=1}^{J} b_{jf} = 1$. The same weights were also used to compute ***aggregate average cost*** per firm:

$$\widehat{AvgC}_f = \frac{\hat{c}_f}{\sum_{j=1}^{J} b_{jf} y_{jf}}.$$

Scale economies for firm f is the ratio of average to marginal costs:

$$\widehat{SEc}_f = \frac{\widehat{AvgC}_f}{\widehat{mc}_f},$$

which means that a value above one indicates increasing returns to scale.

Finally, the ***efficiency ratio*** of firm f is:

$$\widehat{CE}_f = \left[\frac{\Phi\left(\frac{\hat{\mu}_{*f}}{\hat{\sigma}_{*f}} - \phi_t \hat{\sigma}_{*f}\right)}{\Phi\left(\frac{\hat{\mu}_{*f}}{\hat{\sigma}_{*f}}\right)} \right] \exp\left(-\hat{\mu}_{*f}\phi_t + \frac{1}{2}\phi_t^2 \hat{\sigma}_{*f}^2\right),$$

where $CE_f := E\left[\exp\left(-v_f | \varphi_f\right)\right]$, $\varphi_f := v_f + u_f$, $\phi_t := \exp\left[\phi\left(t - T\right)\right]$, $\Phi\left(\cdot\right)$ denotes the standard normal cumulative distribution, $\hat{\mu}_{*f} := \frac{\hat{\mu}_f \hat{\sigma}_v^2 + \sum_{t=1}^{T} \phi_t \hat{\varphi}_f \hat{\sigma}_u^2}{\hat{\sigma}_v^2 + \sum_{t=1}^{T} \phi_t^2 \hat{\sigma}_u^2}$, $\hat{\sigma}_{*f} := \sqrt{\frac{\hat{\sigma}_v^2 \hat{\sigma}_u^2}{\hat{\sigma}_v^2 + \sum_{t=1}^{T} \phi_t^2 \hat{\sigma}_u^2}}$ and $\hat{\mu}_f := \hat{\boldsymbol{\rho}}' \mathbf{Z}_f$. Note that the firm-invariant cost frontier models $\hat{\boldsymbol{\rho}} = \mathbf{0}$ and $\hat{\mu}_f = 0$ and that, except for the Battese and Coelli's (1992) model, $\phi = 0$ and $\phi_t = 1$.

4.3 Price Equilibrium

Let $\mathbf{p}_j := (p_{1j}, \ldots, p_{Fj})'$ be the vector of prices in market j. Denote by $y_{fj} = D_{fj}(\mathbf{p}_j)$ the demand of firm f in market j. The profit of firm $f = 1, ..., F$ is:

$$\pi_f = \sum_{j=1}^{J} p_{fj} D_{fj}(\mathbf{p}_j) - c_f.$$

Firms choose the prices of the products they control to maximize the sum of the associated profits. In addition, due to either explicit or implicit coordination, they may also take into account the profits of their rivals when setting their prices. Implicit coordination might emerge when firms interact repeatedly, which is the case of the insurance markets we analyze.

Firms may keep their prices above the competitive level by realizing that deviations from these prices will trigger some retaliation, which more than compensates the short term profits of deviating. The sustainability of coordination depends on several market characteristics reviewed, for instance, in Ivaldi et al. (2003). Among the factors that facilitate coordination, the literature has identified: firm's high discount factors, small number of competitors, barriers to entry, market transparency, frequent market interaction, demand growth, absence of demand fluctuations and firm cost and capacity symmetry. As these factors may differ across markets, the level of coordination may also differ across markets. We allow this possibility by letting the weight a given firm places on its rival's profits to differs across markets.

Denote by $\gamma_{ff'j}$ the weight firm f attributes to the profit of firm f', when setting it price in market j, with $\gamma_{ff'j} = 1$ for $f' = f$ and $\gamma_{ff'j}$ on $[0, 1]$ for $f' \neq f$. Let the ***weight matrix*** $\mathbf{\Gamma}_j$ consist of the elements $\mathbf{\Gamma}_{ff\prime j} := \gamma_{ff\prime j}$. The objective function of firm f when setting the price for a given market j is then:

$$\max_{p_{fj}} \Pi_f = \sum_{f'=1}^{F} \gamma_{ff'j} \pi_{f'}.$$

Adding an error term, e_f, the first-order condition with respect to price for firm $f = 1, ..., F$ is:[11]

$$D_{fj}(\mathbf{p}_j) + \frac{\partial D_{fj}(\mathbf{p}_j)}{\partial p_{fj}}(p_{fj} - mc_{fj}) + \sum_{\substack{f'=1 \\ f' \neq f}}^{F} \gamma_{ff'j} \frac{\partial D_{f'j}(\mathbf{p}_j)}{\partial p_{fj}}(p_{f'j} - mc_{f'j}) = e_{fj} \quad (7)$$

The uncertainty underlying the error term may result from shocks observed by firms before they choose prices, or from shocks unobserved by the firms before they choose prices. In the empirical application both possibilities are allowed for. Note that in case of shocks observed by firms prices are endogenous.

The left-hand side of equation (7) is similar to the familiar equilibrium condition of the merger simulation literature, e.g., Nevo (2000) and Pereira and Ribeiro (2011), with the difference that the off-diagonal terms of $\mathbf{\Gamma}_j$, instead of being constrained to be 0s and 1s, can take values on the interval $[0, 1]$.

[11] We assume that a Nash equilibrium exists for strictly positive prices. 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.

When $\mathbf{\Gamma}_j$ equals the identity matrix, in market j firms behave in a way consistent with a Nash equilibrium, while when $\mathbf{\Gamma}_j$ consists of 1s, firms maximize joint profits. In addition, since the off-diagonal elements can take values on the interval $[0, 1]$, $\mathbf{\Gamma}_j$ can capture intermediate degrees of competition between a Nash equilibrium and joint profit maximization, allowing for a rich characterization of strategic interaction of firms in the industry. In equation (7), prices and outputs are observed, and the demand and cost parameter can be estimated separately, as described in Sections 4.1.1 and 4.2.1. Hence, the estimates of $\gamma_{ff'j}$ allow one to determine which type of firm behavior is more consistent with observed prices and quantities and estimated demand and marginal cost parameters.

Matrix $\mathbf{\Gamma}_j$ consists of $F \times F - F$ elements. This means that $\mathbf{\Gamma}_j$ cannot be identified without additional restrictions.[12] Before introducing our restrictions on $\mathbf{\Gamma}_j$ it is worth recalling that our purpose is to evaluate the impact on coordinated behavior of the mergers that occurred between 1999 and 2007.

Given our objective and dataset, we impose two restrictions on $\mathbf{\Gamma}_j$. First, we assume that $\gamma_{ff'jt} = \gamma_{jt}$, for all f and f', i.e., the weight that each firm attributes to the profit of other firms may vary across markets and over time, but not across firms. Second, we assume that $\gamma_{jt} = \gamma_{jt-1} + \delta_j$, for all t and j, i.e., in all markets, the changes of the γ_{jt}'s are constant over time. Let $TREND = 0, ..., T-1$ be a trend variable. With these restrictions, equation (7) becomes:

$$D_{fj}(\mathbf{p}_j) + \frac{\partial D_{fj}(\mathbf{p}_j)}{\partial p_{fj}}(p_{fj} - mc_{fj}) + \gamma_{0j} + \gamma_{1j} \sum_{f' \neq f}^{F} \frac{\partial D_{f'j}(\mathbf{p}_j)}{\partial p_{fj}}(p_{f'j} - mc_{f'j}) + \delta_j \cdot TREND \sum_{f' \neq f}^{F} \frac{\partial D_{f'j}(\mathbf{p}_j)}{\partial p_{fj}}(p_{f'j} - mc_{f'j}) = e_{fj}. \quad (8)$$

To sum up, our approach to evaluate the impact on the exercise of market power through coordinated effects of mergers that occurred in the period under analysis consists of: **(i)** estimating a demand function and a stochastic cost frontier, separately, and **(ii)** inserting the estimates of the demand and cost parameter, as well as observed prices and outputs, in

[12] In fact, matrix $\mathbf{\Gamma}_j$ varies not only across markets but also across periods. Assuming that the firms' behavior is constant across periods or markets, with a large enough T or J, matrix $\mathbf{\Gamma}_j$ may be identified. However, in most applications T and J are small.

equation (8) to estimate a restricted version of $\mathbf{\Gamma}_j$, in this particular case parameters $\left(\gamma_{1j}, \delta_j\right)$. The estimates of the latter parameters provide for each market, respectively: **(i)** a measure of the initial level of coordination, and **(ii)** a measure of how coordination changed over time.

Next we compare our procedure with three alternatives approaches commonly used in the literature to measure market power.

The ***new empirical industrial organization*** approach, reviewed in Bresnahan (1989), consists of estimating simultaneously a system of two equations: a demand equation and an equilibrium equation that, in addition to cost parameters, includes a conjectural variations parameter. The estimate of the conjectural variation parameter measures the degree of competition.

The ***nonnested test*** approach of Bresnahan (1987) and Gasmi et al. (1992) consists of estimating simultaneously by maximum likelihood a system of three equations consisting of: a demand equation, a cost equation, and an equilibrium condition, under both the assumption that firms play a Nash equilibrium and the assumption that firms maximize joint profits.[13] Afterwards, perform a nonnested hypotheses test, such as Vuong (1989), to select among the two models which explains the data better.

The ***menu approach*** of Nevo (2001) consists of first estimating the demand and cost functions separately. Afterwards, using the demand estimates and equilibrium equation (7) to estimate hypothetical price-marginal cost margins, under both the assumption that firms play a Nash equilibrium, and the assumption that firms maximize joint profits. Finally, compare the two hypothetical price-marginal cost margins with the observed price-marginal cost margin to determine which model explains the data better. One can construct confidence intervals for either the observed price-marginal cost margin or the hypothetical margins.

The new empirical industrial organization approach has the shortcomings pointed out by Corts (1999), Genesove and Mullin (1998) and Nevo (1998).

The nonnested test approach and the menu approach can be thought of as being equivalent, with the former having the advantage of formalizing the test with more detail, while the latter having the advantage of providing a richer economic interpretation, since it gives

[13] In terms of our model that would mean using equation (7), under the assumptions that $\gamma_{ff}{}^{\prime} = 0$, for $f \neq f'$, and $\gamma_{ff'} = 1$, for $f \neq f\prime$, respectively.

a measure of how close the observed price-marginal cost margin is to the two hypothetical margins.

For the initial year, computing the observed price-marginal cost margin and testing whether it is statistically different from either of the two hypothetical margins is equivalent to estimating $\hat{\gamma}_{1j}$ and then testing whether it is statistically different from 0 or 1. In this context, investigating how the exercise of market power changed over time requires estimating a $\hat{\gamma}_{1j}$ for every year of the period under analysis, and then testing whether each $\hat{\gamma}_{1j}$ is statistically different from 0 or 1. Instead of estimating a different $\hat{\gamma}_{1j}$ for every year, we impose the restriction that γ_{1j} can only vary at a constant rate, $\gamma_{1jt} = \gamma_{1jt-1} + \delta_j$, for all t and j, and then test whether $\hat{\gamma}_{1j} + T\hat{\delta}_j$ is statistically different from 0 or 1. The assumption that γ_{1j} varies at a constant rate is justified by the fact that we have a small sample and therefore only aspire to obtain a first-order approximation of how the parameter evolves over time. Hence, our procedure builds on the menu approach of Nevo (2001) and allows a parsimonious characterization of both: **(i)** the initial level of coordination, and **(ii)** how coordination changes over time.

4.3.1 Profit Variation

Taking a first-order approximation of the cost function of firm f around the the output level $\mathbf{y}_f^0$, the profit level of firm f is:

$$\Pi_f = \sum_{i \in I_f} \left[r_i y_i(\mathbf{r}) - c_i(\mathbf{y}_f^0)(y_i(\mathbf{r}) - y_i^0) \right] - C_f(\mathbf{y}_f^0)$$

Define the profit variation induced by the policy change for product i on I_f as:

$$\Delta\pi_i := (r_i^a - c_i(\mathbf{y}_f^0))y_i^a - (r_i^b - c_i(\mathbf{y}_f^0))y_i^b,$$

and let $\mathbf{y}_f^0 = \mathbf{y}_f^b$:

$$\Delta\pi_i = (r_i^a - c_i(\mathbf{y}_f^b))y_i^a - (r_i^b - c_i(\mathbf{y}_f^b))y_i^b.$$

4.3.2 Welfare Variation

The welfare variation induced by a policy change is then:

$$\Delta CS_n + \sum_{f=1}^{F} \Delta\Pi_f.$$

In the case of entry, one should subtract the entry costs from the expression above.

5 Data

In this section, we describe the data and discuss identification.

5.1 Data Set Description

We focus on the analysis of the three main types of non-life insurance in Portugal, "Motor Vehicle Insurance", "Employers' Liability", and "Fire and Other Damage to Property", which will be referred to as the *MOTOR*, *WORK* and *FIRE* markets, respectively. Hence, $J = 3$. The data we use were drawn mainly from the regulatory annual financial statements, including technical accounts per line of business, filed by insurers with the *Instituto de Seguros de Portugal* (ISP), the sectoral regulator. In addition, the *Associação Portuguesa de Seguradoras* (APS), the industry association, provided us with data regarding: the amount of insurance written per policy, the number of policies issued and number of claims incurred by each firm. Among the firms supervised by *ISP*, we considered only multiple-product firms and excluded those with zero or negative premia.[14] Accordingly, we selected a set of thirteen Portuguese non-life insurers, i.e., $F = 13$, which jointly had a market share in 2007 of 88.5%, 91.7% and 82.7% in the *MOTOR*, *WORK* and *FIRE* markets, respectively. Recall that for confidentiality we cannot disclose the firms' identity. Hence, throughout the article, firms are identified as *firm 01* to *firm 13*.

For each firm, we have yearly observations for the period from 1999 to 2007, which implies a total of 117 observations. All monetary variables used in this study were deflated to real 1999 values using the Portuguese GDP deflator and, unless otherwise stated, are measured in thousands of euros.

We use, as our measure of output, the number of policies for market j issued by firm f in period t, denoted by y_{jft}. We denote by $y_{MOTORft}$, y_{WORKft} and y_{FIREft} the number of

[14] We restricted our analysis to multiple-product firms for two main reasons: **(i)** they account for the vast majority of industry revenues; and **(ii)** to reduce the likelihood that specialization will be mistakenly identified as efficiency.

policies issued by firm f in the $MOTOR$, $WORK$ and $FIRE$ markets, respectively. Due to data unavailability, the use of the number of policies is uncommon in the literature, although, as stressed by Cummins et al. (1996) or Cummins and Rubio-Misas (2006), it constitutes the ideal measure of output. When the number of applications, policies issued and claims settled is unavailable, output volume is usually proxied by the amount of losses incurred, which are also considered to be a good proxy for the amount of real services provided by insurers.[15]

The aggregate market share of the inside goods for a given market in period t, s_{It}, was calculated in terms of premium volume, because for most of the firms not included in the sample we had no data on the number of policies. However, we used the observed number of policies sold by each sampled firm in each market to compute the individual market shares of each inside good:

$$s_{ft} = \frac{y_{ft}}{\sum_{f=1}^{F} y_{ft}} \times s_{It}.$$

As for the outside good, we simply considered $s_{0t} = 1 - s_{It}$.[16]

Total costs of firm f in period t, denoted by c_{ft}, is the sum of claims incurred, acquisition costs and administration costs. Claims incurred include net change in provisions and are net of reinsurance. Acquisition costs consist mainly of commissions paid to agents and brokers. Administration costs comprise items like expenditures on labor, material, energy, software and depreciation. We consider four inputs, i.e., $N = 4$: **(i)** acquisition services, **(ii)** labor and business services, **(iii)** claims, and **(iv)** financial capital. The prices of the first three items, denoted by $w_{ACQUISITION}$, $w_{ADMINISTRATION}$ and w_{CLAIMS}, respectively, were calculated as the average acquisition costs, administration costs and expenditure with claims per policy, respectively.[17] We use the ten-year Portuguese Treasury bill rate, common to all firms, as a proxy for the cost of financial capital, denoted by $w_{CAPITAL}$.

The price in period t of the output j of firm f, denoted by p_{fjt}, is the ratio of premium

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[15] See also Cummins et al. (1999), Cummins and Xie (2008), Ennsfeller et al. (2004), Fenn et al. (2008) and Mahlberg and Url (2003).

[16] The type of policies sold in the *MOTOR* and *WORK* market are compulsory in Portugal. Regarding the *FIRE* market, we simulated arbitrary increases of the market share of the outside good which, however, did not produce any relevant changes relative to the results presented in the article.

[17] Although claims are not in the direct control of firms, this variable has clearly a significant impact on the cost efficiency of a firm.

revenues to the respective number of policies.

Vector $\mathbf{X}_{ft}$ consists of: AGE, the number of years since the foundation of the firm, $CLAIMS\_RATIO$, the number of claims settled over the number of policies issued, $\ln(ASSETS)$, the logarithm of total assets, in million of euros, and $COVERAGE$, the average amount of insurance written per policy. The last variable was not included in the model for the $MOTOR$ market because reliable data were not available. Variable AGE is a proxy for the reputation and brand awareness of the firm, $CLAIMS\_RATIO$ for the risk level, $\ln(ASSETS)$ for the size of the firm, namely for the size of the network of local agencies, and $COVERAGE$ for the quality of each product.

$BANK$ is a dummy variable which is equal to 1 for firms belonging or associated to a bank-dominated financial group. We use the variable $BANK$ to define each nest because insurance firms held by banks can benefit from bank customer relationships that facilitate cross-selling and from the customer access provided by networks of branch banks. Hence, we consider two nests.

Table 5 reports some descriptive statistics for all variables used.

[*Table* 5]

The wide dispersion found for some variables confirms that the insurance industry is indeed very heterogeneous. For example, firms are clearly differentiated in terms of their average risk level, measured by the variable $CLAIMS\_RATIO$.

5.2 Demand Identification and Instruments

As in previous work, we assume that the vector of product characteristics $\mathbf{X}_{ft}$ is exogenous, while both prices and the log of the within group share, $GROUP\_SHARE$, are allowed to be correlated with unobserved product characteristics. Therefore, identification and estimation of equation (4) requires the use of a set of instrumental variables for those variables.

We used as instruments the cost shifters that vary across firms: $w_{ACQUISITIONS}$, $w_{ADMINISTRATION}$, w_{CLAIMS}.[18] We considered two alternative exogeneity assumptions: **(i)** a summation exo-

[18] Set **(i)** comprises traditional instruments in this type of analysis, while the variables contained in sets

geneity assumption, where the instrument matrix is formed exactly as in the cross-sectional framework; or **(ii)** a contemporaneous exogeneity assumption, where the instruments are assumed to be contemporaneously uncorrelated with the error term.[19]

Given the small size of our sample, we decided not to use all available instruments to avoid multicollinearity issues. To decide which instrument set to use and which exogeneity assumption to make, we computed several statistics: the first-stage partial R^2 and F statistics; Kleibergen and Paap's (2006) rank statistic[20]; and Hansen's (1982) J test of over-identifying moment conditions, which tests the overall specification of the estimated models, including the exogeneity of the instruments. In addition, we computed also the C statistic to test for the endogeneity of prices; see, e.g., Eichenbaum et al. (1988).

6 Basic Estimates

In this section, we present the basic estimation results for the demand and cost models.[21]

6.1 Demand Function Estimates

We estimated separate demand functions for the $MOTOR$, $WORK$ and $FIRE$ markets. Irrespective of the set of instruments chosen, the NL model failed to pass all tests in all cases. Because of this, we estimated three models for each market: a ML by OLS, a ML by 2SLS and a NL by 2SLS. All statistics were computed in a heteroskedasticity-robust way.

Table 6 reports the estimates of the demand models.

[$Table$ 6]

(ii) and **(iii)** are potentially valid instruments because, on the one hand, the utility function of firm f does not depend on the characteristics of firm $m \neq f$, see equation (2), and, on the other hand, they are expected to be correlated with the endogenous variables via markups in the first-order conditions. See, e.g., Berry (1994), Berry et al. (1995) and Nevo (2001) for details.

[19] See Cameron and Trivedi (2005, ch. 22) for a dicussion of exogeneity assumptions for panel data.

[20] The Kleibergen and Paap's (2006) rank statistic tests whether instruments and endogenous variables are only weakly correlated. See Staiger and Stock (1997) for the small sample properties of estimators based on weak instruments.

[21] All models were estimated with Stata.

According to the C statistic, the variable price cannot be treated, as expected, as exogenous. Thus, also as expected, using 2SLS instead of OLS to estimate the ML model moves the coefficient on price further away from 0. The J test indicates that all instruments are exogenous and that there is no evidence against the correct specification of both the ML and NL models.[22] The first-stage F statistics reveal that endogenous covariates and instruments are significantly correlated but, according to the Kleibergen and Paap rank statistic, that correlation is weak in the case of the NL models. This is probably the reason why, when using the NL model, we failed to find a significant, negative value for the price coefficient in the $MOTOR$ market. On the other hand, the substitution patterns implied by the ML model are rejected for both the $WORK$ and $FIRE$ markets. These results suggests that the ML model may be used to analyze the $MOTOR$ market and the NL model is more appropriate to study the other markets. However, given the weak identification issue present in the NL models, all demand-related results are presented for both ML and NL models for the three markets.

All the estimated coefficients have the expected signs. Consumers are willing to pay a premium to purchase insurance from older and larger firms. The only exception is the $MOTOR$ market, for which the coefficient of variable AGE is not significant.

The coefficients of variables $CLAIMS\_RATIO$ and $COVERAGE$ are both positive, although the coefficient of the former is only significant for the $MOTOR$ market. This means that consumers are willing to pay more for products that, all else equal, transfer more risk to the insurance firm.

The estimated model included firm dummies and, for firms that participated in the mergers, interactions between firm dummies and another dummy variable indicating the post-merger period. All else equal, the mergers did not have a significant impact on the way consumers value products. Table 6a in the Appendix presents the estimates of the firm dummy variables for the ML-GMM model.

[22] The J test assesses the validity of *all* moment conditions that define the demand models, including those relative to the regressors assumed to be exogenous, i.e., all regressors except price and group share. This means that any kind of misspecification that gives rise to correlations between the regressors and the residuals, e.g., random parameters, would lead to the rejection of the null hypothesis of correct specification of the ML and NL models.

6.2 Estimated Price Elasticities of Demand

Table 7 presents the median own- and cross-price elasticities of demand for the ML-GMM model of Table 6.

[*Table* 7]

In general, price elasticities of demand are low. Indeed, only for the FIRE market are the own-price elasticities of demand significantly different from -1 in most cases (NL model). This contrasts with the results by Gollier and Ivaldi (2005) that present elasticities between 2.5 and 4.5 for the whole non-life insurance industry. They used data from 1999 to 2003 and imposed the Nash equilibrium condition.[23]

6.3 Cost Frontier Estimates

We estimated by maximum likelihood four specifications. Model I represents a cost function that assumes that all firms operate on the frontier. The other models were described in Section 4.2.2: model II is the standard half-normal cost frontier model; model III is Battese and Coelli's (1992) half normal cost frontier model with time-varying cost inefficiency; and model IV is Battese and Coelli's (1995) cost frontier with firm- and time-varying cost inefficiency. The vector $\mathbf{Z}_{ft}$ required for the implementation of the last model consists of: $\ln(AGE)$; $\ln(ASSETS)$; $SPECIALIZED$, which takes value 1 for firms only present in the non-life insurance business and 0 otherwise; $TREND$, which is a trend variable; and the interaction variable $TREND * MERGER$, where $MERGER$ is a dummy variable which takes value 1 for firms in mergers after the year the merger took place, and 0 otherwise. The last variable allows one to examine whether the effects of mergers differ or not between firms involved and firms not involved in mergers.

Table 8 reports the estimates of the cost models.

[*Table* 8]

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[23] Imposing a Nash equilibrium when firms do play a Nash equilibrium increases efficiency; imposing a Nash equilibrium when firms are not playing a Nash equilibrium biases the elasticities' estimates. We are agnostic about the true cause for the difference in estimates.

All explanatory variables are significant and have the expected sign. Costs increase with input prices and production and there is homogeneity of degree one in input prices.[24] In addition, there are economies of scope.

The estimate of $\frac{\sigma_v^2}{\sigma_v^2+\sigma_u^2}$, the weight of variance of the inefficiency term on the total variance of the error, is significantly different from 0 in Models II to IV, which indicates that some degree of cost inefficiency is likely to affect the firms operating in the Portuguese non-life insurance industry. Hence, Model I is not adequate. This conclusion is also corroborated by Coelli's (1995) likelihood ratio test.

In turn, the correct specification of Model II is never rejected in favor of the more flexible models III and IV (see the last row of Table 8). This reveals that cost efficiency levels have not changed significantly over time, as the analysis of the significance of the estimates of the coefficient of $(t-T)$ in Model III and of the variables $TREND$ and $TREND * MERGER$ in Model IV also indicates. Hence, we base the rest of our analysis on Model II.

6.4 Marginal Cost, Average Cost and Economies of Scale Estimates

Table 9 reports median values, for Model II of Table 8, of: **(i)** marginal costs per product, **(ii)** marginal costs per firm, **(iii)** average costs and **(iv)** scale economies per firm.

[*Table* 9]

For most firms, marginal costs are higher in the *WORK* market than in the other markets. Despite some important differences among firms within each market, in aggregate terms the predicted marginal costs are very similar for all firms, ranging from 0.264 to 0.303, with the exception of *firm 07*. In contrast, the average cost function seems to present more differences across firms, with its range spreading over the interval between 0.541 and 0.865, even after excluding again *firm 07* from the analysis. Finally, given that in all cases average costs are substantially higher than marginal costs, all firms exhibit increasing returns to scale.

[24] In Model IV, for instance, we have, $\sum_{n=1}^{N} \varpi_n = 0.984$.

7 Analysis

In this section, we conduct the analysis of the model. First, we evaluate the impact of the mergers on coordinated effects and, second, we evaluate the impact of the mergers on cost efficiency.

7.1 Coordinated Effects

Next we evaluate the impact on coordinated effects of the mergers that occurred between 1999 and 2007, assuming that the behavior may differ across markets. With data on prices and outputs, and having estimates for marginal costs per firm/product/period and own- and cross-price elasticities per period, we estimated equation (8) by GMM. Table 10 reports the results for both the cases of an ML and NL formulation of the demand function.[25]

[$Table$ 10]

According to both the first-stage and structural model statistics, all models produce consistent estimates of (γ_1, δ) and, in fact, as discussed next, similar conclusions are achieved in most cases. Nevertheless, note that the weak instrument issue appears again in the *WORK* market case.

At the bottom of Table 10, we report results for the null hypotheses: **(i)** in 1999 firms behaved in a way consistent with Nash equilibrium, i.e., $\gamma_1 = 0$, **(ii)** in 1999 firms behaved in a way consistent with joint profit maximization, i.e., $\gamma_1 = 1$, **(iii)** in 2007 firms behaved in a way consistent with Nash equilibrium, i.e., $\gamma_1 + 8\delta = 0$, and **(iv)** in 2007 firms behaved in a way consistent with joint profit maximization, i.e., $\gamma_1 + 8\delta = 1$.[26]

Consider first the *WORK* and *FIRE* markets. In 1999 firms behaved an intermediate way between a Nash equilibrium and joint profit maximization. In 2007 firms behaved in a way consistent with a Nash equilibrium.

[25] **The estimates of (γ_1, δ) should be analyzed with care. They should be regarded as averages, and are hence subject to Corts' (1999) criticisms when interpreted as conduct parameters or as measuring marginal effects.**

[26] If, e.g., one fails to reject both $H_0 : \gamma_1 = 0$ and $H_0 : \gamma_1 = 1$, then the test is inconclusive for the year 1999. If one rejects both that $H_0 : \gamma_1 = 0$ and $H_0 : \gamma_1 = 1$, then it follows that $0 < \gamma_1 < 1$.

Relative to the *MOTOR* market, while in 1999 firms we cannot reject neither a Nash equilibrium nor joint profit maximization, in 2007 firms behaved in a way consistent with a Nash equilibrium.

Summing up, the results in Table 10 suggest that between 1999 and 2007 there was a decrease in the level of coordination between firms in the three markets analyzed.[27]

To be sure, we did not establish that the mergers were the cause for the decrease in the level of coordination between firms. In order to establish this causality relation, one would have to compare the estimated γ_1, with the γ_1 that would have emerged, had the mergers not taken place. In turn, computing the latter γ_1 would require simulating the prices and quantities that would have emerged, had the mergers not taken place. However, given that, in all but the last merger, we only have aggregate data for the participating firms after the merger, we cannot obtain estimates for this contrafactual. Note, in particular, that the observation that the level of coordination decreased over time, as the mergers unfolded, does not rule out the possibility of a larger decrease in the level of coordination, had the mergers not taken place.

An advantage of our approach is that it also provides a measure of how close the observed price-marginal cost margin is of the two hypothetical margins. More specifically, the estimate $\hat{\gamma}_1$ is useful first of all to test the hypotheses $\gamma_1 = 0$ and $\gamma_1 = 1$. In addition, the estimate $\hat{\gamma}_1$ is also a measure of how close the firms' behavior is to a Nash equilibrium or joint profit maximization. Although we do not use it in our article, in some circumstances this information may be of independent interest.

[27] We estimated a constant, γ_0, for each firm in each market. With the exception of the *WORK* and the *FIRE* markets, the estimates of γ_0 are, in general, significantly different from zero and negative. This indicates that there is potentially another source of deviation from the Nash equilibrium, in addition to coordinated behavior. This may have occurred for several reasons. E.g., the period to which our sample refers involved a merger wave, during which firms were out-of-equilibrium. However, note that, unlike slope parameters, in short panels the estimates $\hat{\gamma}_0$ are inconsistent, since they average only T observations, 9, in our case; see, e.g., Cameron and Trivedi (2005, p. 727).

7.2 Efficiency

Next we evaluate the impact of the mergers on cost efficiency. In Section 6.3 we concluded that cost efficiency levels have not changed significantly over time. Now, we discuss the cost efficiency scores, reported in Table 11, which were calculated for each firm in each year based on Model II of Table 8.

[*Table* 11]

The average efficiency score is 99.0%. This value is very high but is not out of line with other studies of the Portuguese insurance industry.[28] Most firms exhibit high efficiency scores. However, one firm stands out as the least efficient (*firm 07*). It is the only firm whose main non-life line of business, Health, which accounted for about 55% of their 2007 total non-life premium income, is not one of the three insurance products analyzed in this article. Nevertheless, even in this case, we cannot reject at the 5% level that this firm is also on the efficiency frontier.

Summing up, our results are in line with the scant literature that studies the Portuguese non-life insurance industry. Average levels of cost efficiency are very high, meaning that firms are, on average, very close to the industry's efficiency frontier. In particular, the firms that took part in the four most relevant mergers were, at the outset, among the most efficient in the industry. This left little room for efficiency increases.[29]

8 Conclusion

This article evaluated, for the Portuguese non-life insurance industry, the impact of several mergers on: **(i)** the exercise of market power through coordinated effects, and **(ii)** the firms'

[28] Fenn et al. (2008) report values of 88.5%, 93.1% and 96.0% for the mean cost efficiency scores of Portuguese life specialists, non-life specialists, and composite firms, respectively, between 1995 and 2001. Barros et al. (2005b) report average cost efficiency scores for Portuguese life specialists of 91.5%, between 1995 and 2003. Most studies reveal lower efficiency levels for life specialists than for non-life specialists or composite firms. See, e.g., Amel et al. (2004) and Fenn et al. (2008).

[29] Amel et al. (2004), commenting on efficiency scores between 80-90% for US property/casualty insurance companies, say that: "significant improvements from M&As are likely only for the firms in the worst condition".

internal efficiency.

We used a rich panel of annual accounting data of 13 Portuguese insurers from 1999 to 2007 to estimate a structural model that includes: preferences, technology, and a market equilibrium condition. The procedure we developed builds on the menu approach of Nevo (2001) and allows a parsimonious characterization of both: **(i)** the initial level of coordination, and **(ii)** how coordination changed over time.

We reached two conclusions. First, we found no evidence of an increase in the exercise of market power through coordinated effects in the period following the mergers. Second, we also found no evidence of significant changes in cost efficiency levels from 1999 to 2007.

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9 Appendix

Table 6a presents the firm dummy variables for the ML-GMM model.

$[Table\ 6a]$

With the exception of the firms that participated in the mergers that occurred in the year 2000, all the other firms involved in mergers were assigned a dummy variable before the merger and another one after the merger. All else equal, the mergers did not have a significant impact on the way consumers value products, as ten of fifteen coefficients were not significantly different before and after the mergers.[30]

As for the coefficients of the dummy variables for all firms, we conclude that the coefficients do not vary much across firms in the case of the $MOTOR$ market. This means that firm specific variables other than those included in the model do not affect the way consumers value their products. The $WORK$ market presents the larger heterogeneity, with three firms clearly below the average. The same three firms also present lower than average dummies in the$FIRE$ market.

[30] There were five firms involved in mergers in three markets: $5 \times 3 = 15$.

Tables

Table 1: Concentration in the Portuguese non-life insurance market

Companies	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Non-life insurance (total)														
Top 1	12.1	11.6	11.9	11.3	10.8	11.0	11.2	17.3	22.5	21.9	21.3	20.5	19.5	18.6
Top 3	34.1	33.5	33.5	32.8	32.0	31.1	30.7	38.7	43.3	40.4	43.7	42.1	40.6	39.0
Top 5	53.7	52.7	52.7	51.7	50.9	49.5	49.5	57.4	58.5	55.7	59.1	57.6	55.8	54.2
Top 10	73.3	73.9	73.0	75.1	75.0	76.2	77.6	80.0	79.2	77.7	79.2	78.1	76.7	75.4
Motor Vehicle Liability														
Top 1	12.8	12.5	12.5	11.9	11.7	11.4	11.9	18.3	24.7	23.6	22.9	21.8	20.8	19.5
Top 3	35.5	35.2	35.2	34.5	33.7	32.9	33.7	41.8	49.1	45.3	45.1	43.3	42.4	40.6
Top 5	56.8	56.7	56.5	55.4	54.1	52.3	53.1	61.2	65.9	63.0	62.9	61.5	60.4	58.8
Top 10	78.2	79.0	78.4	80.3	79.5	81.1	82.5	83.5	84.7	83.1	84.0	83.9	82.2	81.5
Employers' Liability														
Top 1	12.3	12.5	12.2	12.1	11.9	11.6	11.2	17.2	21.6	21.0	20.3	19.7	19.4	18.7
Top 3	34.9	33.2	32.9	33.0	33.3	32.6	32.8	39.4	43.6	41.4	44.3	43.4	42.4	41.8
Top 5	53.7	52.7	52.6	52.2	52.2	51.3	52.8	60.3	60.7	58.3	60.3	59.1	58.4	58.2
Top 10	76.3	76.1	74.9	77.5	77.9	80.3	82.9	84.4	86.6	85.6	88.3	86.8	85.8	84.9
Fire and Other Damage to Property														
Top 1	12.9	12.9	12.4	12.3	11.7	12.2	12.2	17.0	22.2	21.8	21.3	20.9	19.6	19.3
Top 3	34.1	34.4	34.9	34.1	31.9	30.6	30.9	38.8	42.2	39.3	45.1	44.2	41.1	39.4
Top 5	50.5	50.3	51.4	51.1	48.6	47.2	47.5	55.8	56.6	54.3	59.0	58.0	55.3	53.9
Top 10	69.1	70.3	71.9	73.4	73.1	73.1	74.5	79.3	78.6	79.0	79.8	79.3	77.6	76.3

Note: market shares (%) are measured by premium volume and do not take into account firms operating under the free-to-provide-services regime.

Table 2: Mergers and acquisitions in the Portuguese insurance market between 1999-2007

Merger year	Acquiring company/group	Acquired company	Non-life market share (%)		Ranking in the non-life market	
			Pre-merger year	Merger year	Pre-merger year	Merger year
			Mergers			
2000	Açoreana	Oceânica	[0 – 5] / [0 – 5]	[0 – 5]	18 / 27	13
2000	AXA	Royal Exchange	[5 – 10] / [0 – 5]	[5 – 10]	6 / 13	4
2001	Império	Bonança	[5 – 10] / [5 – 10]	[15 – 20]	2 / 6	1
2002	Fidelidade	Mundial Confiança	[10 – 15] / [5 – 10]	[20 – 25]	2 / 3	1
2002	Açoreana	O Trabalho	[0 – 5] / [0 – 5]	[0 – 5]	12 / 15	9
2004	Tranquilidade	ESIA	[5 – 10] / [0 – 5]	[5 – 10]	4 / 21	4
			Acquisitions			
2005	CGD group	Império-Bonança	— / [10 – 15]	[10 – 15]	2	2

Note: market shares are measured by premium volume and do not take into account companies operating under the free-to-provide-services regime.

Table 3: Summary statistics for sample firms in 2007

Company	Number of employees	Assets (M€)	Market share (%)	Type of firm		
				Composite	Portuguese	Bank-related
firm 01	[500 – 1000]	[750 – 1000]	[0 – 5]	yes	yes	yes
firm 02	[0 – 500]	[500 – 750]	[0 – 5]	yes	no	no
firm 03	> 1000	> 1000	[15 – 20]	yes	yes	yes
firm 04	[0 – 500]	[0 – 250]	[0 – 5]	no	yes	no
firm 05	> 1000	> 1000	[10 – 15]	yes	yes	yes
firm 06	[0 – 500]	[500 – 750]	[5 – 10]	no	no	no
firm 07	[0 – 500]	[0 – 250]	[0 – 5]	no	yes	yes
firm 08	[0 – 500]	[250 – 500]	[0 – 5]	no	yes	yes
firm 09	[500 – 1000]	> 1000	[5 – 10]	yes	no	yes
firm 10	[0 – 500]	[0 – 250]	[0 – 5]	no	yes	yes
firm 11	[500 – 1000]	[750 – 1000]	[5 – 10]	no	yes	yes
firm 12	[500 – 1000]	[750 – 1000]	[5 – 10]	no	no	no
firm 13	[0 – 500]	[0 – 250]	[0 – 5]	no	no	no
Mean	643	1 508	6.4	—	—	—
St. deviation	523	2 831	4.6	—	—	—

Note: market shares are relative to the whole non-life market, are measured by premium volume, and do not take into account firms operating under the free-to-provide-services regime.

Table 4: Characteristics of sample firms per line of business
(average values for the period 1999-2007)

Company	Market share (%)				Distribution per product		
	Motor	Work	Fire	Non-life	Motor	Work	Fire
firm 01	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[50 − 60]	[20 − 30]	[10 − 20]
firm 02	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[50 − 60]	[20 − 30]	[10 − 20]
firm 03	[15 − 20]	[15 − 20]	[15 − 20]	[15 − 20]	[50 − 60]	[10 − 20]	[10 − 20]
firm 04	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[40 − 50]	[30 − 40]	[10 − 20]
firm 05	[10 − 15]	[10 − 15]	[10 − 15]	[10 − 15]	[40 − 50]	[10 − 20]	[10 − 20]
firm 06	[5 − 10]	[5 − 10]	[5 − 10]	[5 − 10]	[60 − 70]	[20 − 30]	[10 − 20]
firm 07	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[10 − 20]	[0 − 10]	[10 − 20]
firm 08	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[30 − 40]	[20 − 30]	[20 − 30]
firm 09	[5 − 10]	[5 − 10]	[5 − 10]	[5 − 10]	[50 − 60]	[10 − 20]	[10 − 20]
firm 10	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[40 − 50]	[20 − 30]	[10 − 20]
firm 11	[5 − 10]	[5 − 10]	[5 − 10]	[5 − 10]	[40 − 50]	[10 − 20]	[10 − 20]
firm 12	[10 − 15]	[10 − 15]	[5 − 10]	[5 − 10]	[50 − 60]	[20 − 30]	[10 − 20]
firm 13	[0 − 5]	[0 − 5]	[0 − 5]	[0 − 5]	[60 − 70]	[10 − 20]	[10 − 20]
Mean	6.4	6.6	5.9	6.1	48.4	21.2	15.0
St. deviation	5.2	4.5	4.8	4.7	12.1	6.7	2.9

Notes: market shares are measured by premium volume and do not take into account firms operating under the free-to-provide-services regime; the distribution per product is calculated according to the weight of the premium income of each product in the total non-life premia of each firm.

Table 5: Summary statistics for the model variables

Variable	Mean	Median	St. dev.	Minimum	Maximum
		Motor Vehicle Liability			
$\ln(y_{MOTOR})$	12.417	12.556	0.966	9.569	14.206
p	0.318	0.289	0.169	0.153	1.649
$CLAIMS\_RATIO$	0.128	0.111	0.075	0.047	0.638
		Employers' Liability			
$\ln(y_{WORK})$	10.448	10.567	0.837	8.535	11.831
p	0.931	0.899	0.303	0.409	2.568
$CLAIMS\_RATIO$	0.405	0.370	0.177	0.114	1.243
$COVERAGE$	46.629	38.570	28.191	15.444	206.276
		Fire and Other Damage to Property			
$\ln(y_{FIRE})$	11.992	12.122	0.835	10.054	13.677
p	0.148	0.145	0.031	0.077	0.266
$CLAIMS\_RATIO$	0.039	0.035	0.016	0.004	0.085
$COVERAGE$	119.785	107.802	36.212	65.362	250.174
		Firm			
$\ln(c)$	11.735	11.633	0.816	10.235	13.318
$\ln(w_{CLAIMS})$	-1.644	-1.635	0.280	-2.833	-0.604
$\ln(w_{ACQUISITION})$	-3.054	-3.031	0.290	-3.956	-1.997
$\ln(w_{ADMINISTRATION})$	-3.672	-3.661	0.398	-4.757	-2.800
$\ln(w_{CAPITAL})$	1.496	1.482	0.148	1.224	1.723
$\ln(AGE)$	3.017	2.773	0.944	0	4.605
$\ln(ASSETS)$	6.068	6.145	1.142	4.155	9.037
$SPECIALIZED$	0.615	1	0.489	0	1
$BANK$	0.615	1	0.489	0	1

Table 6: Demand model

	MOTOR			WORK			FIRE		
	ML-OLS	ML	NL	ML-OLS	ML	NL	ML-OLS	ML	NL
Regressors									
p	-2.219***	-4.337***	-2.941	-0.764***	-1.448***	-0.433**	-6.672***	-7.973***	-3.427***
	(0.367)	(0.895)	(4.023)	(0.210)	(0.278)	(0.206)	(0.957)	(0.844)	(0.777)
$CLAIMS\_RATIO$	1.728**	6.490***	4.405	0.117	0.204	0.126	0.346	1.868	0.626
	(0.693)	(2.080)	(6.122)	(0.226)	(0.382)	(0.187)	(2.036)	(1.855)	(0.914)
$\ln(ASSETS)$	1.058***	1.303***	0.871	0.963***	1.134***	0.091	0.659***	0.686***	0.167*
	(0.111)	(0.169)	(1.241)	(0.193)	(0.170)	(0.119)	(0.112)	(0.093)	(0.095)
AGE	0.008	0.007	0.030	0.166**	0.226***	0.322***	0.129***	0.131***	0.137***
	(0.072)	(0.088)	(0.077)	(0.082)	(0.077)	(0.013)	(0.044)	(0.038)	(0.034)
$COVERAGE$	—	—	—	0.006***	0.013***	0.003	0.001	0.002**	0.002***
				(0.002)	(0.003)	(0.002)	(0.001)	(0.001)	(0.000)
$GROUP\_SHARE$	—	—	0.323	—	—	0.833***	—	—	0.754***
			(0.907)			(0.145)			(0.098)
Instruments									
Exogeneity assumption	—	(a)	(a)	—	(a)	(b)	—	(b)	(b)
First-stage statistics									
Partial R^2									
p	—	0.398	0.398	—	0.573	0.153	—	0.563	0.563
$GROUP\_SHARE$	—	—	0.478	—	—	0.138	—	—	0.419
F statistic									
p	—	7.81***	7.81***	—	15.35***	1.93**	—	4.59***	4.59***
$GROUP\_SHARE$	—	—	15.84***	—	—	2.09**	—	—	2.65***
Kl. & Paap's test	—	10.10**	0.67	—	17.57***	10.40	—	42.52**	32.32
Struct. model statistics									
R^2	0.986	0.980	0.990	0.981	0.976	0.988	0.988	0.988	0.997
F statistic	1076.0***	609.7***	1192.7***	348.4***	288.9***	926.0***	1981.3***	2202.0***	5435.3***
J statistic	—	0.76	1.39	—	3.64	19.36	—	27.64	22.62
C statistic	—	12.09***	6.65**	—	13.74***	7.97**	—	5.74**	8.02**

Notes: all regressions include firm and year dummies. (a) summation assumption; (b) contemporaneous assumption.

Table 6a: Firm dummies with demand models

	MOTOR		WORK		FIRE	
	ML	NL	ML	NL	ML	NL
firm 01	-10.174*	-8.309	-22.460***	-20.505***	-14.574***	-9.940***
	(5.505)	(7.278)	(4.480)	(1.001)	(2.293)	(2.241)
firm 02	-9.749***	-7.664	-17.088***	-13.478***	-11.432***	-7.529***
	(3.562)	(6.995)	(2.756)	(0.834)	(1.448)	(1.467)
firm 03	-10.923***	-7.470	-11.949***	-3.975***	-7.293***	-2.767***
	(1.634)	(10.115)	(1.254)	(0.995)	(0.765)	(0.871)
firm 04	-8.536***	-6.132	-9.267***	-4.328***	-6.703***	-3.425***
	(1.274)	(7.085)	(0.899)	(0.686)	(0.534)	(0.648)
firm 05	-10.526***	-7.153	-11.231***	-3.353***	-7.059***	-2.502***
	(1.479)	(9.841)	(1.202)	(0.967)	(0.723)	(0.837)
firm 06	-9.287	-8.438	-25.690***	-26.904***	-16.058***	-13.102***
	(7.167)	(5.986)	(5.915)	(1.001)	(3.000)	(2.811)
firm 07	-9.374***	-6.479	-11.733***	-4.484***	-6.580***	-2.600***
	(1.290)	(8.449)	(0.954)	(0.987)	(0.572)	(0.734)
firm 08	-9.213***	-6.397	-10.264***	-4.504***	-6.773***	-2.838***
	(1.437)	(8.288)	(1.007)	(0.819)	(0.593)	(0.761)
firm 09	-10.315	-9.166	-29.085***	-29.967***	-17.614***	-13.717***
	(8.137)	(7.143)	(6.719)	(1.211)	(3.412)	(3.197)
firm 10	-8.568***	-5.914	-9.067***	-3.818***	-6.999***	-2.648***
	(1.251)	(7.776)	(0.869)	(0.728)	(0.511)	(0.751)
firm 11	-9.226***	-6.302	-10.066***	-3.466***	-6.672***	-2.523***
	(1.380)	(8.563)	(1.032)	(0.861)	(0.636)	(0.772)
firm 12	-8.868***	-6.160	-8.314***	-2.040***	-5.809***	-2.483***
	(1.093)	(7.843)	(0.934)	(0.769)	(0.554)	(0.607)
firm 13	-8.071***	-5.561	-8.029***	-1.337*	-6.161***	-2.305***
	(0.757)	(7.202)	(0.712)	(0.807)	(0.421)	(0.612)
*firm 01*Merger2002*	-0.062	-0.032	0.326**	0.225**	0.226**	0.199***
	(0.159)	(0.140)	(0.147)	(0.104)	(0.102)	(0.047)
*firm 03*Merger*	-0.295**	-0.191	-0.146	0.138	-0.053	0.120**
	(0.120)	(0.313)	(0.127)	(0.097)	(0.088)	(0.047)
*firm 05*Merger2001*	0.196	0.146	0.444***	0.247***	0.293**	0.182***
	(0.177)	(0.192)	(0.160)	(0.091)	(0.128)	(0.049)
*firm 05*Merger2005*	0.112	0.044	0.189**	-0.152*	0.119	0.083
	(0.094)	(0.207)	(0.090)	(0.092)	(0.113)	(0.057)
*firm 11*Merger*	0.089	0.039	0.050	0.035	0.057	0.155***
	(0.083)	(0.155)	(0.099)	(0.137)	(0.072)	(0.044)

Notes: the estimated standard errors are presented below the corresponding estimates; ***, ** and * denote test statistics which are significant at 1%, 5% or 10%, respectively.

Table 7: Demand elasticities (median values for the period 1999-2007)

	Own elasticities			Cross elasticities					
	MOTOR	WORK	FIRE	MOTOR		WORK		FIRE	
				Same nest	Others	Same nest	Others	Same nest	Others
ML									
firm 01	-0.999	-1.206	-0.997		0.046***		0.066***		0.030***
firm 02	-0.936	-1.246	-1.280**		0.050***		0.039***		0.027***
firm 03	-1.052	-1.210	-0.978		0.255***		0.245***		0.226***
firm 04	-1.141	-1.366	-1.465***		0.034***		0.067***		0.036***
firm 05	-0.997	-1.001	-1.053		0.147***		0.155***		0.146***
firm 06	-1.189	-1.131	-1.183*		0.101***		0.099***		0.060***
firm 07	-1.607**	-0.824	-0.967		0.016***		0.009***		0.046***
firm 08	-1.252	-1.862**	-0.809		0.024***		0.060***		0.051***
firm 09	-1.187	-1.478	-1.048		0.107***		0.096***		0.079***
firm 10	-1.470*	-0.923	-1.109		0.028***		0.051***		0.020***
firm 11	-1.089	-1.331	-1.148*		0.114***		0.116***		0.099***
firm 12	-1.158	-1.080	-1.036		0.134***		0.138***		0.081***
firm 13	-1.258	-1.065	-1.423***		0.029***		0.020***		0.015***
NL									
firm 01	-0.987	-2.160	-1.716***	0.055	0.031***	0.178**	0.019***	0.082***	0.014***
firm 02	-0.908	-2.066	-2.073***	0.089	0.034***	0.222**	0.012**	0.207***	0.012***
firm 03	-0.996	-1.962	-1.540*	0.320**	0.177***	0.712***	0.078***	0.593***	0.103***
firm 04	-1.112	-2.222	-2.341***	0.064	0.024**	0.337**	0.018**	0.273***	0.016***
firm 05	-0.962	-1.661	-1.720**	0.181	0.101***	0.365**	0.036**	0.368***	0.065***
firm 06	-1.108	-1.644	-1.672**	0.189	0.070**	0.523**	0.029***	0.488***	0.027***
firm 07	-1.605	-1.462	-1.657*	0.019	0.011**	0.023*	0.003**	0.118***	0.020***
firm 08	-1.248	-3.253	-1.395*	0.031	0.017**	0.165**	0.016**	0.120***	0.019***
firm 09	-1.167	-2.583	-1.803***	0.130	0.073***	0.227**	0.025**	0.182***	0.031***
firm 10	-1.465	-1.612	-1.914**	0.034	0.019***	0.117**	0.012**	0.052***	0.007***
firm 11	-1.071	-2.336	-1.890***	0.140	0.078***	0.343**	0.033***	0.225***	0.038***
firm 12	-1.043	-1.429	-1.320	0.240	0.090***	0.744**	0.042***	0.633***	0.036***
firm 13	-1.232	-1.853	-2.378***	0.056	0.020**	0.118**	0.007**	0.118***	0.007***

Notes: ***, ** and * denote elasticities which are significantly different from -1 (own elasticities) or 0 (cross elasticities) at 1%, 5% and 10%; test statistics based on the bias-corrected bootstrap method

Table 8: Cost model

Variable / Parameter	I	II	III	IV
Frontier				
$\ln(y_{MOTOR})$	0.373***	0.380***	0.357***	0.441***
	(0.047)	(0.043)	(0.045)	(0.032)
$\ln(y_{WORK})$	0.127**	0.110*	0.093*	0.166***
	(0.053)	(0.057)	(0.050)	(0.038)
$\ln(y_{FIRE})$	0.343***	0.369***	0.433***	0.298***
	(0.054)	(0.063)	(0.073)	(0.036)
$\ln(y_{MOTOR})^2$	0.127***	0.127***	0.126***	0.128***
	(0.004)	(0.004)	(0.004)	(0.003)
$\ln(y_{WORK})^2$	0.040***	0.025***	0.030***	0.046***
	(0.005)	(0.006)	(0.007)	(0.003)
$\ln(y_{FIRE})^2$	0.127***	0.121***	0.118***	0.131***
	(0.005)	(0.005)	(0.006)	(0.004)
$\ln(y_{MOTOR}) * \ln(y_{WORK})$	-0.038***	-0.030***	-0.031***	-0.047***
	(0.007)	(0.007)	(0.007)	(0.005)
$\ln(y_{MOTOR}) * \ln(y_{FIRE})$	-0.215***	-0.223***	-0.217***	-0.215***
	(0.005)	(0.006)	(0.007)	(0.004)
$\ln(y_{WORK}) * \ln(y_{FIRE})$	-0.034***	-0.014	-0.021**	-0.037***
	(0.006)	(0.009)	(0.010)	(0.004)
$\ln(w_{CLAIMS})$	0.750***	0.739***	0.745***	0.737***
	(0.007)	(0.008)	(0.008)	(0.005)
$\ln(w_{ACQUISITION})$	0.140***	0.140***	0.137***	0.161***
	(0.005)	(0.006)	(0.005)	(0.004)
$\ln(w_{ADMINIST.})$	0.099***	0.102***	0.103***	0.100***
	(0.003)	(0.004)	(0.004)	(0.003)
$\ln(w_{CAPITAL})$	-0.018**	-0.015**	-0.011*	-0.014**
	(0.007)	(0.006)	(0.007)	(0.006)
$CONSTANT$	2.648***	2.513***	2.377***	2.313***
	(0.201)	(0.261)	(0.302)	(0.139)
$\frac{\sigma_v^2}{\sigma_v^2+\sigma_u^2}$	—	0.739***	0.816***	0.849***
		(0.151)	(0.116)	(0.031)
Inefficiency model				
$t-T$	—	—	0.102	—
			(0.067)	
$CONSTANT$	—	—	—	-0.094
				(0.344)
$TREND$	—	—		-0.009
				(0.010)
$TREND * MERGER$	—	—	—	-0.022
				(0.099)
$\ln(AGE)$	—	—	—	0.006
				(0.005)
$\ln(ASSETS)$	—	—	—	-0.007
				(0.007)
$SPECIALIZED$	—	—	—	0.139
				(0.342)
Log-likelihood	387.5	389.6	390.6	412.4
H_0: model I - Coelli's (1995) test	—	4.3**	6.4**	49.8***
H_0: model II - Wald test	—	—	2.4	10.0

Notes: standard errors are presented below the corresponding parameter estimates; ***, ** and * denote parameters or test statistics which are significant at 1%, 5% or 10%, respectively.

Table 9: Predicted marginal and average costs and returns to scale
(median values for the period 1999-2007)

	Marginal costs				Average	Returns
	MOTOR	WORK	FIRE	Firm	costs	to scale
firm 01	0.258	0.287	0.249	0.266	0.600	2.258
	(0.007)	(0.020)	(0.009)	(0.008)	(0.016)	(0.059)
firm 02	0.276	0.330	0.212	0.290	0.566	1.950
	(0.016)	(0.036)	(0.031)	(0.020)	(0.062)	(0.130)
firm 03	0.272	0.390	0.280	0.301	0.647	2.150
	(0.015)	(0.066)	(0.016)	(0.019)	(0.033)	(0.137)
firm 04	0.298	0.278	0.291	0.286	0.791	2.767
	(0.007)	(0.027)	(0.011)	(0.009)	(0.015)	(0.091)
firm 05	0.260	0.351	0.263	0.283	0.659	2.332
	(0.021)	(0.048)	(0.021)	(0.022)	(0.035)	(0.105)
firm 06	0.274	0.339	0.259	0.287	0.572	1.993
	(0.026)	(0.034)	(0.030)	(0.025)	(0.075)	(0.104)
firm 07	0.131	0.307	0.156	0.158	0.383	2.423
	(0.064)	(0.262)	(0.062)	(0.084)	(0.236)	(0.390)
firm 08	0.222	0.338	0.236	0.264	0.815	3.094
	(0.014)	(0.067)	(0.012)	(0.025)	(0.074)	(0.289)
firm 09	0.251	0.364	0.254	0.276	0.593	2.149
	(0.018)	(0.060)	(0.019)	(0.020)	(0.037)	(0.098)
firm 10	0.315	0.247	0.319	0.282	0.865	3.063
	(0.035)	(0.035)	(0.034)	(0.025)	(0.057)	(0.178)
firm 11	0.282	0.386	0.283	0.303	0.670	2.208
	(0.025)	(0.049)	(0.025)	(0.025)	(0.061)	(0.101)
firm 12	0.283	0.338	0.275	0.295	0.650	2.204
	(0.010)	(0.037)	(0.012)	(0.012)	(0.028)	(0.068)
firm 13	0.300	0.343	0.231	0.301	0.541	1.796
	(0.046)	(0.051)	(0.060)	(0.043)	(0.169)	(0.185)

Note: standard errors based on 499 bootstrap samples are presented below the corresponding estimates.

Table 10: Pricing model

	MOTOR		WORK		FIRE	
	ML	NL	ML	NL	ML	NL
Parameters						
γ_1	1.068	0.973	0.559*	0.502*	0.732***	0.519***
	(1.102)	(0.899)	(0.341)	(0.324)	(0.155)	(0.097)
δ	-0.251	-0.238	-0.031**	-0.029*	-0.145***	-0.111***
	(0.179)	(0.166)	(0.016)	(0.015)	(0.028)	(0.029)
Instruments						
Exogeneity assumption	(b)	(b)	(b)	(b)	(b)	(b)
First-stage statistics						
Partial R^2						
Regressor #1 of eq. (8)	0.915	0.884	0.412	0.090	0.775	0.771
Regressor #2 of eq. (8)	0.927	0.891	0.839	0.795	0.952	0.877
F statistic						
Regressor #1 of eq. (8)	109.5***	62.6***	2.8***	1.0	10.8***	15.1***
Regressor #2 of eq. (8)	140.0***	64.8***	45.3***	25.8***	109.4***	35.6***
Kl. & Paap's test	73.99**	60.42***	31.08**	15.50	50.40***	41.99**
Struct. model statistics						
R^2	0.356	0.356	0.226	0.204	0.460	0.425
F statistic	346.3***	337.1***	70.3***	67.2***	803.0***	517.7***
J statistic	9.91	9.88	14.42	16.61	29.99	28.96
C statistic	1.46	1.41	4.43	2.66	3.79	5.31*
t ratios (1999)						
H_0: Nash equilibrium	1.066	1.082	1.640*	1.550*	4.717***	5.362***
H_0: Joint profit maximization	0.068	-0.030	-1.293*	-1.533*	-1.723**	-4.961***
t ratios (2007)						
H_0: Nash equilibrium	-1.194	-1.046	0.893	0.770	-1.296	-1.256
H_0: Joint profit maximization	-2.468***	-2.381***	-2.003**	-2.067**	-4.330***	-4.672***

Notes: (b) contemporaneous exogeneity assumption. All models were estimated by GMM.

Table 11: Predicted cost efficiencies

	Score	St. error	95% confidence interval	
firm 01	0.998	0.003	0.992	1.000
firm 02	0.995	0.005	0.984	1.000
firm 03	0.992	0.006	0.976	1.000
firm 04	0.990	0.005	0.981	1.000
firm 05	0.992	0.006	0.980	1.000
firm 06	0.995	0.005	0.986	1.000
firm 07	0.967	0.027	0.891	1.000
firm 08	0.998	0.004	0.982	1.000
firm 09	0.990	0.006	0.977	1.000
firm 10	0.982	0.009	0.964	1.000
firm 11	0.989	0.005	0.979	1.000
firm 12	0.997	0.004	0.988	1.000
firm 13	0.988	0.008	0.971	1.000
Average	0.990	0.005	0.982	1.000

Notes: standard errors based on 499 bootstrap samples; confidence intervals based on the bootstrap bias-corrected method.