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ANALYSING THE EFFICIENCY OF PORTUGUESE PENSION FUNDS: A STOCHASTIC FRONTIER MODEL

Carlos Pestana Barros[a], Guglielmo Maria Caporale[b1] and António Luís Silvestre[c]

[a] Instituto Superior de Economia e Gestão (ISEG), Technical University of Lisbon, Department of Economics, Rua Miguel Lupi, 20, 1249-078 Lisbon, Portugal.
[b] School of Social Sciences, Brunel University, Uxbridge, Middlesex, UB8 3PH, United Kingdom
[c] Instituto Superior de Economia e Gestão (ISEG), Technical University of Lisbon, Department of Mathematics and CEMAPRE, Rua do Quelhas, 6, 1200-781 Lisbon, Portugal

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Abstract

This paper examines technical efficiency of Portuguese pension funds management companies, using a stochastic frontier model in order to obtain estimates of economies of scale and scope. The empirical findings reveal a significant effect of efficiency measures on pension funds efficiency. Their implications for managers and policy makers are discussed.

Keywords: Pension Funds, Efficiency, Stochastic Frontier Models

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[1] Corresponding author. Email: Guglielmo-Maria.Caporale@brunel.ac.uk

1. Introduction

The recent literature on incentives and informational asymmetries focusing on the effects of cost reduction by firms emphasises the endogeneity of costs (Laffont, 1999). In the case of pension funds, their performance depends strongly on the competition and regulation environment they face, which may result in consolidation and balance sheet restrictions. Active investment management helps to keep markets efficient and to ensure the flow of funds to the most successful enterprises, playing a major role in the allocation of resources within the economy (see Bauer, Koedijk and Otten, 2005). Pension fund management companies are particularly important in this respect in contemporary economies, given the increase in the size of the aged and retired population and the consequent problems in guaranteeing the financial sustainability of social security (Davis, 1995).

In this paper, we analyse the technical efficiency of Portuguese pension funds management companies from 1994 to 2003. Previous research on this topic includes the studies by Barrientos and Boussofiane (2005), who apply the DEA-CCR and DEA-BCC models to Chilean data; Barros and Garcia (2007), who analyse Portuguese data using a homogeneous stochastic frontier model, and Barros and Garcia (2006), who estimate four DEA models. The present paper contributes to this area of the literature by estimating for the Portuguese case a stochastic frontier model which enables us to identify significant economies of scale and of scope. The advantages of this approach are twofold. First, it allows for an error term combining different statistical distributions, which is an improvement on alternative specifications that rely on one specific distribution. Second, it allows for random parameters (i.e., parameters that describe characteristics not linked to observed characteristics, whereas the traditional frontier allows for variations related to observed characteristics). This procedure may be more effective in achieving results than the traditional procedure, which considers all the pension funds as homogeneous. Therefore the aim of the paper is to estimate a stochastic frontier model disentangling heterogeneous and homogeneous explanatory variables to identify those variables which can be managed in a homogeneous way and those that must be managed by clusters.

Our analysis is motivated by some interesting features of Portuguese pension funds management companies. Firstly, mergers and acquisitions are present in the market during the period under examination, which indicates a constant effort by these companies to increase their size. Secondly, regulation restricts their discretionary power, forcing them to adopt efficient procedures. Such institutions enjoy a special relationship of trust and responsibility with the principal (either a person or an organisation), and must resolve conflicts of interest in favour of the principal or beneficiary (Lakonishok et al., 1992). Regulation oversees the conflict of interests in pension funds, restricting discriminatory practices by the pension fund companies. The Portuguese pension funds management industry reacts to these constraints by attempting to increase the efficient use of inputs. One procedure adopted for improving competitiveness is benchmarking, based on research on an industry's best practices and on the idea that the widespread application of these practices can lead to improved performance throughout the industry.

This paper is organised as follows. Section 2 describes the institutional setting. Section 3 surveys the relevant literature on this topic, whilst Section 4 presents the theoretical framework. Section 5 discusses the data and the empirical findings. Section 6 considers the implications of this study for managers and policy makers, and Section 7 concludes.

2. The institutional context

Pension funds have been in existence in Portugal for about twenty years. Decree-Law No. 323/85, of August 6, 1985, was the first legislative document regulating this particular market, establishing the legal regime for pension funds management and empowering the Portuguese Insurance and Pension Funds Supervisory Authority to control and supervise such funds. In the twenty years since then, the registered growth has been quite significant: pension funds companies (collectively) currently constitute one of the country's largest institutional investors, channeling ever-increasing volumes of savings from households and companies into productive investment, and occupying a prominent position in the organisation and functioning of the national capital market.

Pension funds can be managed either by specialist enterprises created for this exclusive purpose, operating under the name of pension funds management companies, or by insurance companies which are legally authorised to carry out life insurance activities in Portugal (Garcia, 2004). The great majority of pension plans, about 65 percent, are managed by specialist pension funds managers and the rest by insurance companies. Funds managed by funds management companies accounts for 96 percent of pension funds value (Report of the Insurance and Pension Funds Sector (2003) of the Portuguese Insurance and Pension Funds Supervisory Authority). The relevant legislation contains the regulations applying to pension funds companies. They manage pension funds charging fees that depend on the value of the pension funds under management. Therefore, they are profit organizations, like insurance companies, independently of their private or public nature. In the case of defined benefit plans, the sponsor undertakes the responsibility of paying the defined benefit, so the sponsor is committed to regular financing; in the case of defined contribution plans the pension funds management company does not provide any guarantees concerning the rate of investment return. In the event of bad performance and high fees and administrative costs, the accumulated value decreases, meaning that the members bear the investment risk. However, this is a very competitive industry. Therefore, some pension funds management companies agree with some sponsors to guarantee a minimum rate of return on funds under management, bearing the cost if the effective yield is below the promised rate, which affects the company's capital. Others do not guarantee this in the contractual rules, but agree on a market benchmark. If the performance is above that benchmark, the management company has additional commissions, without direct consequences in case of it being below it. There are even some situations where there is no rate of return guaranteed. However, if bad performance persists there is the risk that sponsors might move to other pension funds management companies.

These companies are subject to various regulations, especially investment rules, and are supervised by the Portuguese Insurance and Pension Funds Supervisory Authority. They should meet certain minimum prudential standards with respect to their activities and conditions of operation. The competent authority has the power and the means to obtain regularly the statement of investment-policy principles, the annual accounts and the annual reports, and all the documents necessary for the purpose of supervision. Additionally, they must provide proper information for members and beneficiaries of a pension scheme, specifically about the financial soundness of the company, the contractual rules, the benefits and the actual financing of accrued pension entitlements, the investment policy, and the management of risks and costs. Also, they are required to have a minimum capital of one million Euros. A prudent calculation of technical provisions is an essential condition to ensure that obligations to pay retirement benefits can be met. Therefore, these are calculated on the basis of recognised actuarial methods and certified by qualified actuaries and auditors.

Closed pension funds are prominent among the various types of pension funds on offer. A closed fund is one in which there is only one sponsor, or, should there be more than one, there is a corporate, associative, professional or social connection between the sponsors, the consent of all of the existing sponsors being required before new sponsors can be added. Unlike open funds, closed funds are occupational in nature. In an open fund, there is no requirement for any connection whatsoever between the different parties adhering to the fund; instead, acceptance into the fund is granted by the fund's managing institution.

Our analysis focuses on pension funds management companies, which are the most important ones in this industry in Portugal. In 1994, there were 15 specialist funds managers. This number decreased over the period to 13 in 2003. We consider only 12 pension funds management companies. This is a balanced sample that also covers the period 1994-2003 when mergers and acquisitions took place. Table 1 presents the characteristics of the pension funds management companies analysed in the paper.

INSERT TABLE 1

3. Literature Review

Although the existing literature is vast, only a small number of papers examine technical efficiency. Braberman et al. (1999) analyse Argentine pension funds management institutions using a Translog cost frontier model, applied to quarterly data from 1997Q2 to 1998Q1. A changing number of pension funds management institutions are used in the analysis. Operating costs are regressed on three independent variables: the number of members/participants; the positive transferences/turnover (participant switching from one management institution to another) corrected in accordance with the proportion of participant employees of the pension funds management institution; and the profitability of the fund. Two dummy variables were included to take into account the changes in regulations after November 1997. Regulation was found to increase total costs but not to affect significantly relative efficiency.

Barrientos and Boussofiane (2005) analyse Chilean pension funds management companies carrying out DEA-Data envelopment analysis, and adopting a two-stage procedure. In the first stage, the DEA efficiency scores are calculated, and, in the second stage, they are regressed on appropriate variables. Specifically, they used two outputs (total revenue and the number of contributors), and three inputs (marketing and sales costs, office personnel and executive pay, and administration and computing costs). In the second stage, they estimated a regression of the DEA scores on a constant, market share, sales, the ratio of contributors to affiliates and revenue. They concluded that there is no continuous trend towards an improvement in technical efficiency. An analysis of the determinants of efficiency shows that an increase in market share contributes positively to technical efficiency, whilst sales and marketing costs are detrimental.

Barros and Garcia (2006) analyse the same sample with four DEA models, concluding that traditional DEA models are unable to discriminate adequately between Portuguese pension funds. Finally, Barros and Garcia (2007) analyse the efficiency of a sample of Portuguese pension funds with a homogeneous stochastic frontier model. Therefore, the present paper, based on a stochastic frontier model, represents an original contribution to this area of literature. As explained above, the advantages are the disentangling of homogenous and heterogeneous variables in the frontier model.

4. Theoretical Framework

Our framework is based on two strands of the literature: models of industry efficiency and stochastic frontier models.

4.1. Models of Industry Efficiency.

Two competing models of industry efficiency exist in the literature. The strategic-group theory (Caves and Porter, 1977) explains differences in efficiency scores as being due to differences in the structural characteristics of units within an industry, which in turn lead to differences in performance. In the case of retailers, units with similar asset configurations pursue similar strategies with similar results in terms of performance (Porter, 1979). As there are different strategic options to be found in the different sectors of an industry, because of mobility impediments, not all options are available to each retailer, causing a spread in the efficiency scores of the industry. By contrast, the resource-based theory (Barney, 1991; Rumelt, 1991; Wernerfelt, 1984) accounts for different efficiency scores in terms of heterogeneity of resources and capabilities on which retailers base their strategies. These may not be perfectly mobile across the industry, resulting in a competitive advantage for the best-performing retailers.

Purchasable assets cannot be considered to represent sources of sustainable profits. Indeed, critical resources are not available in the market. Rather, they are built up and accumulated on the retailer's premises, their non-imitability and non-substitutability being dependent on the specific traits of their accumulation process. The difference in resources thus results in barriers to imitation (Rumelt, 1991) and in the retailer managers' inability to alter their accumulated stock of resources over time. In this context, unique assets are seen as exhibiting inherently different levels of efficiency; sustainable profits are ultimately a return on the unique assets owned and controlled by the retailers (Teece et al., 1997).

4.2 Stochastic Frontier Models.

In this paper, we adopt the stochastic cost frontier approach. This approach, first proposed by Farrell (1957), came into prominence in the late 1970s as a result of the work of Aigner, Lovell and Schmidt (1977), Battese and Corra (1977) and Meeusen and Van den Broeck (1977).

The frontier is estimated econometrically, and the difference between the inefficient units and the frontier is measured by the residuals. This is an intuitive approach based on traditional econometrics. By assuming that the residuals have two components (noise and inefficiency), one obtains the stochastic frontier model. Therefore, the main issue is the decomposition of the error terms. Let us present the model more formally. The general frontier cost function proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) is the following:

$$C_{it} = C(\mathbf{x}_{it}).e^{v_{it}+u_{it}} \; ; \; \mathrm{i}=1,2,\ldots \mathrm{N}, \mathrm{t}=1,2,\ldots T \qquad (1)$$

where C_{it} and $\mathbf{x}_{\mathrm{it}}$ represent a scalar cost and a vector of variables including the input prices and the output descriptors present in the cost function of the decision-unit *i* under analysis in the *t*-th period, respectively. The error term $\varepsilon_{it} = v_{it} + u_{it}$ has two components: u_{it}, representing technical inefficiencies and assumed to be positive and normally distributed with zero mean and variance σ_u^2, and v_{it}, namely the traditional error term of econometric models, assumed to be independently and identically distributed, representing the effect of random shocks (noise) and being independent of u_{it}. The positive disturbance u_{it} has a half-normal independent distribution truncated at zero, indicating that each fund management company's cost must lie on or above its cost frontier. This implies that any deviation from the frontier is caused by management factors controlled by the pension fund management company.

Denoting by σ_v^2 and σ_u^2 the variance of the traditional error term v and the inefficiency term u, respectively, the total variance of the error term is given by $\sigma^2 = \sigma_v^2 + \sigma_u^2$. The contributions of the error and inefficiency terms to the total variance are $\sigma_v^2 = \sigma^2 /(1+\lambda^2)$ and $\sigma_u^2 = \sigma^2 \lambda^2 /(1+\lambda^2)$, respectively, where λ provides an indication of the relative contribution of u and v to $\varepsilon = u + v$ and is defined as the ratio of the standard deviations of u and v, $\lambda = \frac{\sigma_u}{\sigma_v}$.

Because estimation procedures of equation (1) yields only the residual, ε, but not the inefficiency term *u,* the latter must be calculated indirectly (Greene, 2003). In the case of panel data, as in this paper, Battese and Coelli (1988) used the conditional expectation of u_{it}, conditioned on the realised value of the error term, $\varepsilon_{it} = (v_{it} + u_{it})$, as an estimator of u_{it}. In other words, $E\lfloor u_{it} / \varepsilon_{it} \rfloor$ is the mean productive inefficiency for the *i* th pension fund management company at any time *t*.

However, inefficiency can also be due to heterogeneity of the firms. To take this into account, we consider the following random effects model:

$$c_{it} = (\beta_0 + w_i) + \boldsymbol{\beta}'\mathbf{x}_{it} + v_{it} + u_{it} \qquad (2)$$

where the variables are in logs and w_i is a time invariant, firm-specific random term that captures company heterogeneity. To estimate the model, the identification condition requires the random components of the coefficients to be uncorrelated with the explanatory variables. A second issue concerns the stochastic specification of the inefficiency term *u*. For the latter, we assume a Half-Normal distribution. For the estimation of the parameters, we construct the likelihood function using the approach proposed by Greene (2005).

Under the previous assumptions, the conditional density of c_{it} given w_i is

:

$$f(c_{it} \mid w_i) = \frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right) \quad , \ \varepsilon_{it} = c_{it} - (\beta_0 + w_i) - \boldsymbol{\beta}'\mathbf{x}_{it} \qquad (3)$$

where ϕ is the standard normal density function, and Φ the respective cumulative distribution function. The parameters λ and σ^2 were defined before.

Conditional on w_i, the *T* observations for company *i* are independent, and therefore the joint density for the *T* observations is

$$f(c_{i1},\ldots,c_{iT} \mid w_i) = \prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right) \qquad (4)$$

The unconditional joint density is obtained by integrating the heterogeneity out of the density,

$$L_i = f(c_{i1},\ldots,c_{iT}) = \int_{w_i}\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right)g(w_i)dw_i \qquad (5)$$

The log likelihood, $\sum_i \log L_i$, is then maximised with respect to the parameters β_0, $\boldsymbol{\beta}$, σ, λ and any parameters appearing in the distribution of w_i. The integral in (5) will be intractable. However, if one rewrites equation (5) in the equivalent form:

$$L_i = f(c_{i1},...,c_{iT}) = E_{w_{ii}}\left[\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it}}{\sigma}\right)\right] \qquad (6)$$

one can compute the log likelihood by simulation. Averaging the function given by (6) over sufficient draws from the distribution of w_i will produce a sufficiently accurate estimate of the integral in (5) to allow estimation of the parameters (see Gourieroux and Monfort, 1996 and Train, 2003). The simulated log likelihood is

$$\log L_s(\beta_0, \mathbf{\beta}, \lambda, \sigma, \theta) = \sum_{i=1}^{N}\log\frac{1}{R}\sum_{r=1}^{R}\left[\prod_{t=1}^{T}\frac{2}{\sigma}\phi\left(\frac{\varepsilon_{it} \mid w_{ir}}{\sigma}\right)\Phi\left(\frac{\lambda\varepsilon_{it} \mid w_{ir}}{\sigma}\right)\right] \qquad (7)$$

where θ includes the parameters of the distribution of w_i and w_{ir} is the *r*th draw for observation *i* (see Kumbhakar and Lovell, 2000).

5. Data and results

5.1 Data

To estimate the cost frontier, we used a balanced panel on Portuguese pension funds management companies for the years from 1994 to 2003 (12 companies × 10 years = 120 observations). Frontier models require the identification of inputs (resources) and outputs (transformation of resources). Several criteria can be used. One empirical criterion is data availability. Literature surveys can also be taken into account. The last criterion for measurement selection is the professional opinions of managers in the industry. In this paper, adopt all three criteria.

Using the available data, we estimate a stochastic Translog cost function (see Varian, 1987). We have transformed the variables according to the description column in Table 2. We adopt the traditional log-log specification to allow for the possible non-linearity of the frontier.

INSERT TABLE 2

The rationale for using capital-management services and capital-premises is the following. Pension fund management companies use commissions and premises to develop their activity. Therefore, in order to capture the specificity of this activity, we need to disentangle these two types of capital.

5.2 Results

We estimate a stochastic Translog cost function with three input prices (one price of labor and two prices of capital), and four outputs (profits, number of participants, number of closed funds and the existence or not of open funds under management). Linear homogeneity in input prices is imposed by dividing monetary values by the price of the input price of capital-premises. The model is as follows: c_{it} represents the cost of unit *i* for period *t*, which is divided by the price of capital-premises ($PK2_{it}$) giving the term $c_{it}/PK2_{it}$; PL_{it} is the price of labour, defined as the ratio of total wages to the number of workers, divided by the price of capital-premises ($PK2_{it}$), which gives $PL_{it}/PK2_{it}$; $PK1_{it}$ is the price of capital-management services, measured by dividing the commissions value by the value of the pension funds under management, then divided by the price of capital-premises ($PK2_{it}$) to obtain $PK1_{it}/PK2_{it}$. Profit is the value of the unit profits. Participants is the number of the participants in the fund. Closed and open stand for the number of closed and open funds respectively. M&A is a dummy variable that is one for pension fund management companies which were involved in mergers and acquisitions in the period and zero otherwise. Share is the market share of the unit analysed, measured by the Herfindahl index.

This cost frontier model is specified as an Error Components Model, following Coelli, Rao and Battese (1998), in order to account for causes of efficiency controlled by the management (labor, capital, profit, participants, closed funds and open funds).

The regularity conditions require that the cost function be linearly homogeneous, non-decreasing and concave in input prices (Cornes, 1992). Dividing money values by the price of the input imposes linear homogeneity in input prices. Considering *m* input prices, P_k (price of labour and price of capital-management services), *n* outputs, Y_j , (profits, number of participants, number of closed funds and number of open funds), a quadratic trend, a dummy variables (M&A) and a Market Share index (Share), the model specification is the following:

$$\ln\left(\frac{Cost_{it}}{PK2_{it}}\right) = \tau_0 + \tau_1 t + \frac{1}{2}\tau_2 t^2 + \sum_{k=1}^{m} \alpha_k \ln\left(\frac{P_{kit}}{PK2_{it}}\right) + \sum_{j=1}^{n} \beta_j \ln Y_{jit} +$$
$$\frac{1}{2}\left[\sum_{k=1}^{m}\sum_{r=1}^{m} \pi_{kr} \ln P_{kit} \ln P_{rit} + \sum_{j=1}^{n}\sum_{s=1}^{n} \delta_{js} \ln Y_{jit} \ln Y_{snt}\right] + \sum_{k=1}^{m}\sum_{j=1}^{n} \theta_{kj} \ln Y_{kit} \ln P_{jit} +$$
$$+ \eta\, M\&A_{it} + \kappa\, Share_{it} + (V_{it} + U_{it}) \qquad (8)$$

Table 2 contains descriptive statistics for all the variables. Table 3 presents the results obtained for the stochastic frontier, under the assumption of a Half-Normal distribution. For comparative purposes a non-stochastic frontier model and a traditional cost function are estimated. A GAUSS program was used for the estimation.

INSERT TABLE 3

The estimated cost function appears to fit the data well, as both the R-squared value and the overall F-statistic from the initial ordinary least-squares estimation used to obtain the starting values for the maximum-likelihood estimation are high. Having estimated two competing models, the homogeneous Translog frontier model and the heterogeneous Translog frontier model, we carry out a Likelihood Ratio test to select the most adequate functional form. In the present case the test statistic has a χ^2 distribution with 2 degrees of freedom, its value is 12.510, with a critical value for p=0.05 equal to 5.991. Therefore, it can be concluded that the heterogeneous frontier model describes the data better than the Translog model.

We also compute a Lagrange Multiplier test as a general specification test of adding variables to model. It has also a χ^2 distribution with degrees of freedom equal to the number of restrictions imposed on the restricted model. In our case, the test statistic is equal to 10.123, and therefore the heterogeneous frontier model with the added variables is supported by the test at the 5% level. Finally, the σ^2 and λ parameters of the frontier model are both statistical significant, which means that a traditional cost function is unable to capture adequately all dimensions of the data set.

The estimated coefficients also have the expected signs, with cost exhibiting a negative trend, indicating technological progress during the period examined. Moreover, cost increases with the price of labour, the price of capital, profit, M&A and share, closed and open funds. However, the closed and open funds parameters are random parameters, and hence they vary along the sample. Their mean values suggest that the number of closed and open funds are heterogeneous in our sample, and therefore policies to control costs should take into account this heterogeneity. A common policy based on the average values of the homogeneous variables will not be appropriate for all clusters identified in the heterogeneous variables. Different policies for the different segments of the pension fund management companies are needed. The model does not identify how many clusters exist in the sample, but only their heterogeneous nature. However, other techniques can be applied to identify the clusters. The scale parameters of the heterogeneous variables are small, but statistically significant, confirming the presence of heterogeneity.

5.3 Efficiency Scores

Table 4 presents the results of the time-invariant efficiency scores computed from the residuals. Technical efficiency is achieved, in a broad economic sense, by the unit which allocates resources without waste, and thus refers to a situation on the frontier. Units with a score equal to one are on the frontier, while those with a score lower than one are above the cost frontier of best practices. The value of waste is measured by the difference between one and the score. For example, the waste of the worst performing pension funds management company, the Banif Açor Pensões, is (1-0.753) = 0.247. This represents relative waste that should be eliminated in order for this institution to improve its performance.

INSERT TABLE 4

The mean score is 87.8%, which suggests that pension funds management companies could reduce their output cost by 12.2% without decreasing their inputs, which, in this case, are the prices of labour, of capital premises and of capital management services. The maximum fund score of 1 is achieved by SGF, while the minimum efficiency score of 75.3% is achieved by Banif Açor Pensões. The median is 88.4%, and the standard deviation 8.4%. These efficiency scores are high in comparison with those found in other activities, such as insurance (see Barros and Borges, 2005). High efficiency scores are typical of organisation operating in more competitive markets.

5.4 Economies of Scale

Long-run scale economies (SCE) are calculated as one minus the cost elasticity along an output ray (Brown, Caves and Christensen, 1979), using the following formula:

$$SCE = 1 - \sum_{k=1}^{M} \frac{\partial \ln C}{\partial \ln Y_k} \qquad (9)$$

where M is the number of outputs, and $\partial \ln C / \partial \ln Y_k$ is the marginal cost of production k ($k=1,2,\ldots,M$), which is given by the partial derivative of $\log C_{it}$ with respect to $\log Y_{kt}$, where $\log C_{it}$ is given in equation (8) and $\log Y_{kt}$ is the logarithm of output Y_{kt} (k=1,2,3,4). In the present case, the outputs are profits, participants, closed, and open funds. SCE stands for the change of total cost as all inputs are changed and the input prices remain constant. It is positive for scale economies and negative for scale diseconomies. When SCE is multiplied by 100, it can be interpreted as the percentage difference between cost and total revenue, which would arise from pricing all outputs at marginal cost (Brown, Caves and Christensen, 1979). Here the estimated average value for SCE is 1.528 with a standard deviation equal to 0.012. This indicates increasing economies of scale in pension fund management companies, with costs increasing with output. This result confirms prior research using different procedures (see Barros and Garcia, 2006).

5.5 Economies of Scope

The estimated cost function can be used to test hypotheses about economies of scope in production. Following Denny, Fuss and Waverman (1981) and focusing on the case of the cost interaction between closed funds and open funds, the joint parameter is defined as the partial derivative of $\log C_{it}$ with respect to the term of interaction, *ln(open)**ln(closed)*, which measures the increase in marginal costs when open and closed funds increase. If this derivative (joint parameter) is positive, i.e.

$$\frac{\partial \ln C_{it}}{\partial(\ln open * \ln closed)} > 0 \quad (10)$$

this indicates that costs increase because of the interactions arising from joint production.

If instead $\frac{\partial \ln C_{it}}{\partial(\ln open * \ln closed)} < 0$, then costs are a negative function of joint production.

The estimated parameter is equal to -0.231, and therefore costs are found to decrease with joint production. A rational for this result is that these are two complementary technologies, which decreases costs.

6. Discussion

How do we interpret the above results? First, we can conclude that random frontier models describe Portuguese pension fund management companies more accurately than homogenous frontier models. This is the main finding of the present paper. The implication of this result is that a common government policy for pension funds will not fit equally well all pension funds management companies, since heterogeneity exists between both close and open funds. Therefore any economic policy targeting them has to be tailored by clusters. Heterogeneity of pension fund management companies is not surprising.. There are small and large and medium companies. These visible characteristics translate into different performances and different clusters in the market. By contrast, Portuguese pension fund management companies appear to be relatively homogenous in terms of the price of labour and the price of capital premises. With regard to labour, this means that competition over resources drives the market and translates into homogenous dynamics in the labour market. As for capital premises, it indicates that a certain level of investment in buildings is a pre-requisite in this market, which translates into homogenous behaviour.

Second, the trend is negative, which indicates that cost decreases over time (and decreases at a increasing rate). This is to be expected for the pension fund industry, which is driven by technology improvements based on intense competition in the market.

Third, the estimated λ inefficiency parameter indicates that on average 60% of the costs are imputable to inefficiency according to the homogenous frontier. However, the corresponding value for the heterogeneous frontier is 15%, which means that inefficiency characterises the homogenous frontier models. Moreover, σ is smaller in the stochastic frontier model, i.e. average homogenous inefficiency includes heterogeneity and therefore a heterogeneous frontier best describes the errors in this context.

Finally, unique assets appear to be characterised by inherently different levels of efficiency: sustainable profits are ultimately a return on the unique assets owned and controlled by the pension fund management companies (Teece et al., 1997). Strategic-groups theory (Caves and Porter, 1977), which justifies different efficiency scores on the grounds of differences in the structural characteristics of units within an industry, can also partly explain efficiency differences observed in the Portuguese pension fund management companies.

Our study is comparable to Greene (2004, 2005), but only to some extent, as we estimate two frontier models, and clearly separate homogenous and heterogeneous variables, whereas Greene (2004. 2005) focuses on the statistical characteristics of the model. However, our findings confirm that homogenous frontiers tend to include heterogeneity in their error terms, resulting in higher errors parameters.

7. Conclusions

In this paper we have estimated a stochastic frontier cost model to investigate the existence of economies of scale and scope in a sample of 12 Portuguese pension funds companies over the period 1994 to 2003. Two competing models were considered: the homogeneous and the heterogeneous Translog frontier model respectively. Model selection criteria favour the latter specification. The scale parameters of the heterogeneous variables are small but statistically significant, supporting heterogeneity. But the chosen model does not identify how many clusters exist in the sample under examination - it only identifies their heterogeneity.

As far as economies of scale are concerned, we find that they are increasing in pension funds companies - costs increase with output but at a low rate. Finally, joint estimation of two outputs (of both open funds and closed funds) shows that complementary technologies are used, which decreases costs. Future research should investigate further the robustness of these results.

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Table 1: Pension funds management companies in 2003 – Key indicators

Companies	Number of funds	Ratio: Participants/ Beneficiaries (%)	Ratio: Value of pension funds (thousands of Euros)/ Number of workers	ROE (return on equity) (%)
Banif Açor Pensões - SGFP, S. A.	8	65	62683.53	5.39
BBVA Fundos - SGFP, S. A.	6	74	54120.46	17.06
BPI Pensões - SGFP, S. A.	28	14	116611.1	41.93
CGD Pensões - SGFP, S. A.	10	21	265500.8	10.73
ESAF - SGFP, S. A.	12	26	44123.52	39.86
Futuro - SGFP, S. A.	17	55	30422.34	7.23
Pensõesgere - SGFP, S. A.	43	21	141871.5	41.24
Previsão - SGFP, S. A.	3	12	69438.55	3.16
Santander Pensões - SGFP, S. A.	4	10	434819.7	16.64
SGF - SGFP, S. A.	13	56	5478.498	0.09
SGFP do Banco de Portugal, S. A.	1	79	26874.33	1.35
Unipensão - SGFP, S. A.	8	21	14157.21	1.44

Source: *Relatório do Sector Segurador e Fundos de Pensões* (Report of the Insurance and Pension Funds Sector), 2003, ISP

Table 2: Descriptive Statistics of the Data

Variable	Description	Minimum	Maximum	Mean	Standard deviation
Ln Cost	Logarithm of operational cost in Euro at constant price 1999=100	0.577	3.317	2.252	0.672
Ln PL	Logarithm of price of workers, measured by dividing total wages by the number of workers	-0.330	2.015	1.232	0.515
Ln PK1 - management services	Logarithm of price of capital-management services, measured by dividing the commissions value by the value of the pension funds under management	-2.164	1.039	-1.346	0.341
Ln PK2 - premises	Logarithm of price capital-premises, measured by dividing the expenditure on equipment and premises by the value of the pension funds under management	-3.152	2.052	-1.161	0.737
Ln Profit	Logarithm of the profit in Euro at constant price 1999=100	0.155	3.709	2.251	0.745
Ln participants	Logarithm of the number of participants	3.001	5.024	4.029	0.529
Ln closed	Logarithm of number of closed funds	1.811	5.879	4.572	0.875
Ln Open	Logarithm of number of open funds	1.215	4.321	3.153	0.714
M&A	Dummy variable which is one for companies involved in Mergers and Acquisitions during the period	0	1	0.45	—
Share	Market share of the companies measured by the Herfindahl index	0.018	0.279	0.083	0.082

Table 3: Stochastic Translog panel cost frontier (dependent variable: Log Cost)

Variables	Random Frontier model	Non Random Frontier Model
Non-random parameters	Coefficients (t-ratio)	Coefficients (t-ratio)
Constant (τ_0)	-0.2638 (-4.790)*	-1.0689 (-0.385)
Trend (τ_1)	-0.069 (-3.128)*	-0.0808 (-8.334)*
Trend2 (τ_2)	0.127 (2.917)*	0.231 (2.832)**
Ln PL(α_1)	0.8114 (3.987)*	0.7685 (3.792)*
Ln PK1 (α_2)	0.1025 (5.231)*	0.138 (0.218)
Ln Profits(β_1)	0.1861 (4.125)*	0.1935 (1.312)
Ln Participants(β_2)	—	0.9405 (0.813)
Ln Closed(β_3)	—	0.252 (2.596)*
Ln Open (β_4)	—	0.159 (2.316)*
1/2LnPL^2 (π_{11})	-0.531 (3.321)	-0.453 (3.129)
1/2LnPK1^2 (π_{22})	-0.163 (2.452)	-0.218 (2.189)
1/2LnProfits^2 (δ_{11})	0.283 (3.219)	0.251 (4.219)
1/2LnParticipants^2 (δ_{22})	0.255 (3.452)*	0.145 (3.219)*
1/2LnClosed^2 (δ_{33})	0.523 (3.453)	0.452 (3.218)
1/2LnOpen^2 (δ_{44})	0.321 (3.652)	0.218 (3.219)
LnPL*lnPK1 (π_{12})	-0.247 (1.652)	-0.217 (1.238)
LnPL*lnProfits (θ_{11})	-0.045 (1.145)	-0.021 (1.037)
LnPL*lnParticipants (θ_{12})	-0.317 (0.152)	-0.231 (0.034)
LnPL*ln closed (θ_{13})	0.252 (1.452)	0.219 (1.023)
LnPK1*LnProfits (θ_{21})	0.237 (1.568)	0.128 (1.239)
LnPK1*LnParticipants (θ_{22})	0.389 (1.316)	0.432 (1.045)
LnPK1*LnClosed (θ_{23})	-0.568 (3.519)	-0.432 (3.983)
LnPK1*LnOpen (θ_{24})	-0.368 (-2.813)	-0.339 (-2.743)
LnProfits*LnParticipants (δ_{12})	0.358 (4.156)	0.330 (4.563)
LnProfits*Ln Closed (δ_{13})	0.345 (3.673)	0.358 (3.563)

LnProfits*Ln Open (δ_{14})	0.521 (3.378)*	0.435 (2.983)*
Ln Participants* LnClosed (δ_{23})	0.238 (2.973)*	0.130 (3.153)*
Ln Participants* Ln Open (δ_{24})	0.239 (3.892)*	0.398 (3.218)*
Ln Closed * Ln Open (δ_{34})	-0.231 (-2.894)*	-0.023 (-1.023)
M&A (η)	0.512 (2.316)*	0.385 (2.173)*
Share (κ)	0.517 (3.631)*	0.396 (2.318)*
Mean for Random Parameters		
Ln Closed	0.5071 (5.331)*	—
Ln Open	-0.0742 (-7.998)*	—
Scale Parameters for Dists. Of Random Parameter		
Ln Closed	0.3183 (3.698)*	—
Ln Open	0.0858 (4.703)*	—
$\sigma = [\sigma_V^2 + \sigma_U^2]^{1/2}$	0.0438 (4.111)*	0.163 (2.741)*
$\lambda = \sigma_U / \sigma_V$	0.151 (4.625)*	0.206 (2.255)*
Log likelihood	-294.343	-288.088
LR	8.321	6.393
Chi Square (prob.)	142.683 (0.000)	—
R-adjusted	0.932	0.921
F test:7,120 (prob.)	210.321	192.31
Observations	120	120

t Statistics in parentheses are below the parameters, those followed by * are significant at 1% level.

Table 4: Efficiency Scores

Pension funds management companies	Efficiency Scores
SGF	1.000
Santander	0.982
Futuro	0.953
BBV Fundos	0.942
Pensõesgere	0.910
CGD Pensões	0.895
Unipensão	0.873
Banco de Portugal	0.870
ESAF	0.800
BpiPensões	0.785
Previsão	0.774
BanifAçor	0.753
Mean	0.878
Median	0.884
Std. Dev	0.084