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ECONOMIES OF SCALE AND EFFICIENCY MEASUREMENT IN THE SWISS NURSING HOMES INDUSTRY

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A B S T R A C T

This paper examines the cost structure in the nursing home industry, an issue of concern to Swiss policy makers because of the explosive growth of elderly care costs and the aging of the population. We consider a stochastic frontier cost model by estimating a translog cost function using a balanced panel data of 1680 observations from 336 nursing homes operating over 5 years (1998-2002) in Switzerland. This paper addresses two empirical issues, on the one hand to asses the presence of economies of scale in the Swiss nursing home sector, and on the other hand to compare the economic performance of the firms by estimating their cost efficiency scores. The empirical findings suggest that economies of scale are an important potential source of cost reduction in the Swiss nursing home industry. The performances of the individual units are often very close to the (estimated) Swiss best practice, but average inefficiency shows that cost in the nursing home industry can be reduced.

KEY WORDS: COST EFFICIENCY; ECONOMIES OF SCALE; NURSING HOMES; STOCHASTIC FRONTIER; PANEL DATA.

JEL CLASSIFICATION NUMBERS: C13, C21, D24, H70, I11, I18, L30

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1. INTRODUCTION

Health care costs are growing steadily in all industrialized countries as a result of some supply and demand factors such as the aging of population, the cost-increasing technology, the higher real income (inducing health care demand) and the rise in real health care prices. A low rate of economic growth in conjunction with the increase in public social and health care spending during the 1990s induced pressure for the Swiss Government to restrain the fiscal deficit, contain costs and achieve efficiency gains. Given that a considerable part of the Swiss public social and health care budget is spent in the nursing home industry, a special attention could be paid to the possibility of improving the efficiency of this sector. Moreover, the importance of the nursing home industry, with total expenditures approaching 1.5% of GDP, is expected to grow as the population grows older.

Switzerland (7.4 million inhabitants) is a federal State composed of 26 states called cantons. The decision-making autonomy of the cantons in the field of health and social care for the elderly creates a strong heterogeneity in the regulations in various cantons[1]. Last but not least the financial contribution from the State varies in dimension and form according to the 26 different legal platforms. Instead of having one single health system, Switzerland can be seen as an ensemble of 26 micro-systems connected to each other by the federal health insurance legislation. Moreover, the long-term care for the elderly is supplied by firms with different ownerships including private for-profit, private non-profit and public nursing homes.

The purpose of this study is to analyze the cost structure of the Swiss nursing homes in order to assess economies of scale and the level of cost efficiency by estimating a stochastic cost frontier model.

This paper is organized as follows: In section 2 the main characteristics of the Swiss nursing home industry are presented. Section 3 discusses the specification of the model, while the econometric approaches are described in section 4. The data set and the estimation results are presented in section 5. Section 6 takes a closer look at economies of scale and cost efficiency and conclusions are drawn in section 7.

[1] The Swiss nursing home sector produces both social and health care services. For this reason in this paper we consider the nursing home industry as belonging to both the social and health care sectors.

2. THE SWISS NURSING HOME INDUSTRY

The nursing home industry, with over 1300 homes located in the whole country, represents an important element of the Swiss social and health care sector and has at least three characteristics:

- A remarkable variety of institutional forms operating in this sector;
- A market characterized by excess demand and by a large contribution from the state in financial terms and in the definition of capacity on the supply side;
- A great regional (cantonal) disparity in the supply of care to the elderly.

In the nursing home sector in Switzerland there are various kinds of institutions with different origins and aims. Some nursing homes have been founded at the local level as non-medical centers, whereas other nursing homes have been established to serve a higher number of potential users (a district) and have been equipped to provide medical and health care services at the level of a small hospital. A peculiarity of the Swiss nursing home industry is that there are different institutional forms operating in this sector from 1998 to 2003, i.e. private for-profit nursing homes, non-profit private institutions and public institutions.

A significant regional difference can be noted in the composition of nursing homes population in each Canton as far as the institutional form is concerned. Some cantons (Aarghau, Bern, Geneve and Vaud) present a majority of private non profit institutions, while other cantons (Luzern, St. Gallen and Zurich) show a larger share of public nursing homes. As a general statement we can observe that the private for profit nursing homes are less frequent than non profit organizations (both public and private) and as a consequence, the Swiss nursing home industry is predominantly characterized by a non profit environment. The evidence of regional differences can be expressed by the large variation of the average cost per patient-day ranging from the minimum of CHF 93.4 in Canton Uri to the maximum of CHF 309.9 in canton Geneva, the median being canton Thurgau with CHF 166.6 of average cost per patient-day. Of course this variation can be attributed to many different factors, which must be taken into account when estimating the cost function. Among these factors we can mention the inter-cantonal differences in the costs of living, which are reflected in somewhat different average wage and price levels in the health sector, the type and number of nursing homes (both factors may influence the case mix of the residents), the range of services and the average level of comfort offered in the institutions (i.e. the quality of services), the dimension of the nursing homes in terms of bed capacity (consequently there is the risk of inefficiencies of scale in small and slightly urbanized cantons) and the existence of cost inefficiencies.

Finally, Swiss cantons still apply different subsidy models in the nursing home industry where the regulatory setting is different from one region to another. It is important to point out that in most cantons the State intervenes in public and private institutions by regulating the daily rates, setting quality standards, determining the minimum necessary infrastructure and staff requirements and, above all, by granting a financial contribution in form of subsidies. The degree of regulation covers a wide range of variation, from cantons where the State does not give any direct financial contribution to the other extreme case where the State covers both the investment costs and part of the operating costs.

3. COST MODEL FOR SWISS NURSING HOMES

The costs of operating a nursing home may be divided into two main categories which are: 1) building and equipment costs; 2) the costs of taking care of the residents. These costs may depend on the following factors:

- total number of resident-days of nursing home care (output);
- type and quality of care provided per resident-day;
- level of assistance required by the residents in normal daily activities such as eating, personal care or performing physiological functions;
- level of medical assistance required by the residents (case-mix);
- prices of labor and capital.
- capacity (size) of the nursing home (and the occupancy rate);
- variety of services provided by the nursing home;
- skill level and turnover frequency of the staff;
- institutional form;
- regulation environment (federal state);

A nursing home can, therefore, be represented as a firm transforming two major inputs (capital and labor) into patient-days of nursing home care. Moreover, the cost model specification should take into account a number of variables describing output characteristics as well as regional differences, which should capture the heterogeneous dimension of the output of a nursing home. Assuming that output level and input prices are exogenous[2], and that (for a given technology) firms adjust input levels in order to minimize costs[3], the firm's

[2]These assumptions are the subject of debate in the literature with contrasting opinions. For a well presented discussion see Breyer (1987).

[3] This assumption implies an input orientation for efficiency measurement

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total cost of operating a nursing home can be represented by the following long run cost function:[4]

$$TC = f(Y, P_K, P_L, H, R, D_{fo}, D_{qc}, D_s, D_{part}, D_{pu}, D_{np}) \qquad \textbf{(1)}$$

where TC represents the total cost and Y is the output, represented by the total number of patient-days of nursing home care. P_k and P_l are the prices of capital and labor, respectively. The price of labor is computed as the ratio between total labor expenses divided by the number of (full time equivalent) employees[5].

Unfortunately the data which would allow us to calculate the capital stock using the capital inventory method are not available. According to Wagstaffs (1989) and Filippini (2001) the capital stock is approximated by the number of beds owned and operated by a nursing home. The cost of capital is represented by all the expenses apart from labor cost, following the residual capital approach suggested by Friedlaender and Wang Chiang (1983). Hence the capital price is the ratio between capital expenses and capital stock. H is the average assistance time (expressed in hours per day) given to a home's patients including both normal daily activities (eating, personal care or performing physiological functions) and medical care. Following McKay (1988), this variable is introduced in the model to control for some differences in the output characteristics and can be interpreted as a proxy for the quality of supplied services as well as a level of assistance needed by the residents (case-mix). R is the average medical expenses per patient reimbursed by the health insurance system and is expressed in Swiss Francs. This variable can be considered as a proxy variable for case-mix since there is a negative correlation between the health condition of a resident and the medical expenses reimbursed by the health insurance system. In this way we control for nursing homes dealing with different case mix patterns.

To better explain total cost differences among Swiss nursing homes, we decided to introduce a set of dummy variables. This is because we want to keep the structure of the model as simple as possible without neglecting cost shifting factors specified by the dummies. We have introduced a dummy variable (D_{fo}) in the model to control for differences in cost between standard nursing homes and nursing homes organized in the form of sheltered

[4] The adopted specification in this study is more or less similar to that used by Crivelli et al. (2002). However, compared to that paper, we introduced some additional explanatory variables and we use a panel data set instead of cross-sectional data.

[5] Unfortunately the source of the salary data was at aggregate level and it was impossible to distinguish between the labor price of the different professional categories such as: doctors, nurses, and administrative staff.

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homes[6]. D_{qc} is equal to 1 whenever the ratio of the medical and nursing staff to the residents is bigger than 0.5 implying that for every two residents there is at least one member of the medical staff (either a nurse or a doctor). This variable should distinguish nursing homes operating with different levels of medical and nursing staff and can be viewed as a crude proxy for the quality of care given to residents. D_s is introduced to control for the heterogeneity in the supply of therapeutic and infrastructural services in the nursing homes. This dummy variable is equal to one if the number of services provided within a nursing home is bigger than 18 (3rd quartile value). The services considered cover different categories such as laundry, pharmacy, special therapies, recreational activities, spiritual care, and so on[7]. D_{par} is a dummy variable which takes value one when the ratio of total workers to the full time equivalent workers is bigger than 0.663 (median value). This variable reflects the working schedules organization and distinguishes the nursing homes with a considerable number of part-time workers. Finally we introduced the dummies D_{pu} and D_{np} to control for cost level in public nursing homes (D_{pu}) and private non profit nursing homes (D_{np}) in comparison to the private for profit institutions which are taken as the baseline.

The properties of the cost function (1) are that it is concave and linearly homogeneous in input prices and non-decreasing in input prices and output.[8] Estimation of the cost function (1) requires the specification of a functional form. The translog cost function offers an appropriate functional form for answering questions about economies of scale. Most important for our purposes, it does not impose a priori restrictions on the nature of technology, allowing the values for economies of scale to vary with output.

Since linear homogeneity is imposed in factor prices, the price of capital will act as a numeraire and the complete cost model frontier function results:

$$
\begin{aligned}
\ln(TC/P_K) = {} & a_0 + a_y \ln y + a_L \ln P_L/P_K + a_H \ln H + a_R \ln R \\
& + a_{yy}\frac{1}{2}\ln^2 y + a_{LL}\frac{1}{2}\ln^2 P_L/P_K + a_{HH}\frac{1}{2}\ln^2 H + a_{RR}\frac{1}{2}\ln^2 R \\
& + a_{yL}\ln y \ln P_L/P_K + a_{yH}\ln y \ln H + a_{yR}\ln y \ln R \\
& + a_{LH}\ln P_L/P_K \ln H + a_{LR}\ln P_L/P_K \ln R + a_{HR}\ln H \ln R \\
& + a_{fo}D_{fo} + a_{qc}D_{qc} + a_s D_s + a_{par}D_{par} + a_{pu}D_{pu} + a_{np}D_{np}
\end{aligned}
\qquad \textbf{(2)}
$$

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[6] The sheltered homes offer less restricted life conditions to residents with a high degree of independence.

[7] This dummy variable could also reflect in some sense the nursing home's quality from a non medical point of view, as various in-house activities make the stay more interesting and the services are provided more or less according to the needs and wishes of the residents.

[8] See Cornes (1992), p.106.

4. METHODOLOGY

Cost frontier analysis can be used to estimate indicators of cost-efficiency and scale economies. The use of cost frontier models to evaluate efficiency in the health-care sector has been criticized by Newhouse (1994) and Skinner (1994). The main arguments against these models are related to the unobserved heterogeneity due to differences in case-mix and quality and the errors committed by aggregation of outputs as well as non-testable assumptions on the distribution of efficiency. Folland and Hofler (2001) provide a discussion on the reliability of hospital efficiency estimates obtained from stochastic cost frontier models. These authors show that the individual efficiency estimates are rather sensitive to the adopted model specification and functional form. However, the results are robust when the comparisons are performed between hospital group mean inefficiencies. This finding is consistent with the results reported by Hadley and Zuckerman (1994) suggesting that the stochastic frontier analysis is of practical use when applied for comparing group means of hospital efficiency. Farsi, Filippini and Kuenzle (2003) reached a similar conclusion in their study of the Swiss nursing homes. Although nursing homes have generally a more uniform case-mix than hospitals, the above arguments apply more or less to these providers as well.

There are several cost frontier methods to estimate the cost efficiency of individual firms. Two main categories are non-parametric methods originated from operations research, and parametric (econometric) approaches namely stochastic cost frontier models.[9] In non-parametric approaches like Data Envelopment Analysis (DEA), the cost frontier is considered as a deterministic function of the observed variables but no specific functional form is imposed. Moreover, non-parametric approaches are generally easier to estimate.[10] Parametric methods on the other hand, allow for a random unobserved heterogeneity among different firms but need to specify a functional form for the cost function. The main advantage of such methods over non-parametric approaches is the separation of the inefficiency effect from the statistical noise due to data errors, omitted variables and other random cost differences due to unobserved heterogeneity. The non-parametric methods' assumption of a unique deterministic cost frontier for all firms is unrealistic. Another advantage of parametric methods is that these methods allow statistical inference on the significance of the variables included in the model, using standard statistical tests. In non-parametric methods on the other hand, statistical inference requires elaborate and sensitive re-sampling methods like bootstrap techniques.[11]

9 See Kumbhakar and Lovell (2000) for an extensive survey of parametric methods and Coelli et al. (1998), chapter 6, and Simar (1992) for an overview of non-parametric approaches.

10 See Coelli et al. (2003) for more details.

11 These methods are available for rather special cases and have not yet been established as standard tests. See Simar and Wilson (2000) for an overview of statistical inference methods in non-parametric models.

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Starting from the paper of Aigner, Lovell and Schmidt (1977), the stochastic frontier approach has been intensively used in the literature. Kumbhakar and Lovell (2000) provide an intensive survey of various models proposed in the literature. A frontier cost function defines minimum costs given output level, input factor prices and the existing production technology. Generally, a cost frontier model can be presented as: $TC = f(\mathbf{Y}, \mathbf{P}) + e$, where TC is the total cost; **Y** is its output vector; and **P** is the vector of input factor prices. Theoretically the perfectly efficient firms are located on the cost frontier f (**Y**, **P**). However, the observed costs of other firms can be higher than their corresponding frontier costs. The difference (e) represents the firm's excess cost, which is partly due to suboptimal allocation of resources and/or technical inefficiency in production. Part of this excess cost may also be related to differences in external factors that are not related to the firms' inefficiency. For instance nursing homes that have sicker or more dependent patients incur higher costs.

Assuming that our cost frontier already accounts for the observed differences among production units, the firm i's excess cost (e_i) can be decomposed into two parts: The first part is due to the unobserved differences between firms (m_i) and the second component is related to the firm's inefficiency (u_i). In other words, after controlling for unobserved stochastic differences (m_i) the excess costs represent the inefficiency. Both terms can vary across individual observations or nursing homes. In the original frontier model (Aigner et al., 1977), a half-normal distribution is assumed for the inefficiency term, while the heterogeneity term is assumed to follow a normal distribution. This model has been originally developed for cross sectional data but can be applied to panel data by pooling together the observations in different periods. This model, which is referred to as the pooled model can be written as:

$$C_{it} = f\left(y_{it}, w_{it}, k_{it}\right) + m_{it} + u_{it} \qquad \textbf{(3)}$$

where:

- C_{it} is observed total cost for i unit at time t;
- y_{it} is a vector of output produced by unit i at time t;
- w_{it} is a vector of input price used by firm i at time t;
- k_{it} is a vector of firm characteristics or environmental factors or regulation variables affecting unit i at time t;
- f (·) is a functional form that is used to specify the cost frontier;

m_{it}, is a one-sided non negative disturbance with a half-normal distribution, reflecting the effect of inefficiency (including allocative and technical inefficiency), and u_{it} is a symmetric normal disturbance capturing the effect of statistical noise.

An important variation of the pooled model is Pitt and Lee (1981)'s model in which the inefficiency term m_{it} is assumed to be constant over time, that is: $m_{it} = m_i$ for all t. There is also another version of this model (proposed by Schmidt and Sickles (1984)), that relaxes the distribution assumptions on both m_i and v_{it}, and estimates the model using Generalized Least Squares (GLS) method. Both models are versions of random-effects model. The advantage of these models is that they use the panel aspect of the data to estimate the parameters, thus should be more efficient.[12] In cases where the individual firm effects (m_i) are correlated with the explanatory variables, the estimated parameters may be biased. Schmidt and Sickles (1984) proposed a fixed-effects approach to avoid such biases. In this model the inefficiency term (m_i) is not random and is estimated as an intercept for each company. It should be noted that both in the GLS and the fixed-effect method the individual effect (m_i) can be negative. Therefore the inefficiency of company i is estimated as the difference of (m_i) with its minimum value over all companies ($m_{\min}$).

There is however, an important practical problem with the fixed-effect model in that it requires the estimation of a large number of unknown parameters, which limits its application to reasonably long panels with sufficient within-firm variation. Generally, in short panels the fixed effects are subject to considerable estimation biases, which directly reflect in the inefficiency scores.[13] Given that our data is a rather short panel of 5 years, the fixed effects model is a feasible approach but our preliminary analysis shows that in the main variables, the between variations are dominant and the within variations are comparatively insignificant.[14]

Another important issue is that in both fixed and random effects models discussed above, the inefficiencies are assumed to be constant over time. This is an unrealistic assumption in most practical cases, where the driving forces of cost-inefficiency are not generally persistent. In fact firms constantly face new problems[15] and revise their strategies. Moreover, there exist incentive mechanisms (either through regulation and monitoring or through profit and career incentives) that induce managers to correct their past suboptimal decisions. Greene (2004, 2002) proposes a new approach that integrates the random and fixed effects approaches into the original Aigner et al. (1977)'s model. These models are labelled as

[12] Efficient in statistical terms means more accurate.

13 See Greene (2004, 2002) for more details. This author considers a panel of 5 years as a short panel.

14 In contrast with "between" variations that are related to the differences across companies, "within" variations correspond to the changes in a given company over time. Roughly speaking, a long panel data with low within variation is equivalent, for econometric purposes, to a short panel data.

15 These problems may emerge from the implementation of new techniques, or from dealing with new regulation systems, or other external constraints.

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"true" random effects and "true" fixed effects models.[16] In addition to the two stochastic terms included in Aigner et al.'s model, these models include a third firm-specific stochastic term that captures the unobserved, time-invariant heterogeneity across production units. These models have an important advantage over all other models in that they not only allow for time-variant inefficiency while controlling for firm-level unobserved heterogeneity through fixed or random effects. The main difficulty of these models is that they are numerically cumbersome. In particular, our experience suggests that in cases where the within variation in the data is low and the number of time periods in the sample is limited, these methods are numerically unstable.

As will be discussed in the data section, the regression sample is a balanced panel of 5 years with a low within variation of the regressors making it a panel that does not suit the use of fixed effect models. Our choice of panel models is thus limited to the random-effects models. The "true" random effect model proposed by Greene (2004, 2002) requires a numerically cumbersome estimation method based on integration by Monte Carlo simulations[17]. The data constraints (short panel) suggested us to compare the original pooled frontier model in line with Aigner et al. (1977) with three different random-effect models: the Pitt and Lee (1984) model, the Schmidt and Sickles (1984) model and the "true" random-effect model proposed by Greene (2004, 2002). In this paper we refer to these four models as the POOL-AIGN, RE-PTT/LEE, RE-SHM/SKL, and TRE-GRN models respectively. All the models are estimated using the Maximum Likelihood Estimation (MLE) method with the exception for the RE-PTT/LEE model that is estimated using the Generalized Least Square (GLS) method.

5. THE DATA AND ESTIMATION RESULTS

The data used for this study have been provided by the Swiss Federal Statistical Office. The original sample consisted of 3474 observations from 1070 nursing homes operating through years 1998-2002. By nursing homes, we mean the facilities that provide full-time nursing care as well as basic medical care to the elderly people.[18]

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16 See Farsi, Filippini and and Greene (2005) for a detailed presentation of the econometric models and Farsi, Filippini and Kuenzle (2003) for an application in Switzerland's nursing homes.

17 Note that this econometric approach may lead to numerical instability in the convergence process of the iterative algorithm. We experienced this problem in some specification not reported in this paper.

18 We followed the definition of the Federal Statistical Office including only those observation with the majority of long care bed. The facilities that do not provide any medical care, identified by zero reimbursement from health insurance systems, are not included in this sample.

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The data set was sufficiently detailed to ensure a good specification of the cost model. However, we could not find a reliable measure of quality, and the financial section reported rather aggregated information on costs. The sample has been cleaned by dropping all the observations that appeared to be erroneous (extreme outliers from a statistical point of view) and discarding some more observations, which showed evidently unrealistic values[19]. We also excluded the observations with missing values for any one of the variables included in the model. This study is based on the resulting estimation sample, which is a balanced panel data[20] consisting of 1680 observation and composed by 336 nursing homes.

All the financial data have been deflated according to the Swiss consumer price index based on May 2000 prices. In table 1 we present the main descriptive statistics for the continuous variables included in the regression.

Table 1: Descriptive statistics for cost model variables

Variable (Label)	unit	Mean	St. Dev.	1^{st} qu.le	Median	3^{rd} qu.le
Total cost (TC)	CHF	4605298	3713400	2081900	3595000	6130100
Output (Y)	Patient-days	22864	16276	11786	18655	28706
Labor price (P_L)	CHF /worker	69869	13433	62232	69375	77204
Capital price (P_K)	CHF / bed	21413	10638	13801	18456	25600
Care giving (H)	care hours / resident	2.762	1.123	1.912	2.605	3.588
Reimbursement (R)	CHF / resident	20591	12115	12198	17989	26074
Average Cost (CHF/resident-day)		201.2	67.4	153.7	189.2	236.2
Number of nursing home beds		65.4	47.1	34	53	82

The results of the estimates for the total cost frontier function (3) under different econometric specifications are presented in Table 2.

All first and second order parameters are statistically significant in all the specifications. Since total costs and all the regressors are in logarithms and have been normalized, the first order coefficients can be interpreted as cost elasticities evaluated at the sample median. All these coefficients have the expected signs and are highly significant.

19 In particular we excluded nursing homes with a number of bed inferior to 10 and those with a bed occupancy rate (total days in a year / 365*bed number) lower than 10%.

20 A balanced panel is a data set consisting of repeated observations over time for the same units (here, nursing homes) with identical number of observations for all units. The panel is unbalanced if the observation period varies across the units.

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Table 2 Estimation results (standard errors are in brackets)

	POOL-AIGN		RE-PTT/LEE		RE-SHM/SKL		TRE-GRN	
α_y	0.974*	(0.006)	0,915*	(0,007)	0.888*	(0.010)	0.873*	(0.012)
α_L	0.637*	(0.009)	0,602*	(0,009)	0.596*	(0.009)	0.585*	(0.007)
α_H	0.102*	(0.009)	0,045*	(0,011)	0.055*	(0.009)	0.045*	(0.010)
α_R	0.065*	(0.007)	0,030*	(0,008)	0.036*	(0.007)	0.024	(0.007)
α_{yy}	0.036	(0.011)	0,303*	(0,007)	0.356*	(0.015)	0.355*	(0.010)
α_{LL}	0.067	(0.025)	0,048	(0,016)	0.048	(0.019)	0.027	(0.013)
α_{HH}	0.111	(0.036)	0,106*	(0,025)	0.081	(0.026)	0.077*	(0.023)
α_{RR}	0.047	(0.017)	0,056*	(0,014)	0.053*	(0.012)	0.032	(0.012)
α_{yL}	0.036	(0.012)	0,035	(0,011)	0.030	(0.012)	0.013	(0.009)
α_{yH}	0.011	(0.013)	-0,040*	(0,010)	-0.018	(0.011)	-0.024	(0.009)
α_{yR}	0.048*	(0.010)	0,051*	(0,008)	0.058*	(0.009)	0.031*	(0.007)
α_{LH}	0.106*	(0.019)	0,036*	(0,014)	0.047	(0.015)	0.052*	(0.011)
α_{LR}	0.015	(0.017)	0,013	(0,011)	0.012	(0.013)	-0.0001	(0.009)
α_{HR}	-0.131*	(0.020)	-0,111*	(0,012)	-0.107*	(0.013)	-0.091*	(0.011)
α_{fo}	-0.059*	(0.013)	-0,106*	(0,011)	-0.084*	(0.014)	-0.091*	(0.010)
α_{qc}	0.169*	(0.008)	0,056*	(0,009)	0.067*	(0.006)	0.058*	(0.007)
α_s	0.014	(0.008)	0,009	(0,010)	0.014	(0.007)	0.014	(0.008)
α_{par}	0.021	(0.007)	0,048*	(0,007)	0.045*	(0.005)	0.044*	(0.006)
α_{pu}	0.040	(0.012)	0,135*	(0,021)	0.100*	(0.018)	0.071	(0.027)
α_{np}	0.019	(0.010)	0,073*	(0,013)	0.062*	(0.015)	0.030	(0.018)
$\alpha_{0?}$	14.836*	(0.014)	14,496*	(0,018)	14.841*	(0.159)	14.783*	(0.020)
σ_α	-	-	-	-	-	-	0.197*	(0.008)
σ	0.188*	(0.0009)	0,383*	(0,033)	-	-	0.1003*	(0.003)
$\lambda=\sigma_\mu/\sigma_v$	1.476*	(0.073)	4,975*	(0,982)	-	-	1.816*	(0.1731)

* means significant at less than 0.1%. Shaded fields indicate that the estimate is no significant at 5% confidence level.

The sample includes 1680 observations (336 Nursing Homes for 5 years).

The output elasticity is positive and implies that an increase in supply will raise the total cost. The increase (percentage) in total cost, as a response of a 10% increase in the number of patient-days of nursing home care, depend on the model specification and corresponds to 9.74% for the POOL-AIGN model and is smaller and very similar (9.15%, 8.88% and 8.73%) for the other models. These results, showing some variability in the parameter estimates, are fairly similar across different econometric specifications[21].

The labor and capital cost shares are positive, implying that the cost function is monotonically increasing in input prices. The cost elasticities with respect to the output characteristics (*H* and *R*) are, as expected, positive. This result suggests that an increase in the average assistance time and in the reimbursement per patient (ceteris paribus) will both lead to a rise in total cost.

The dummy variable D_{fo} that distinguishes sheltered nursing homes is negative and statistically significant. This result is not surprising because generally people living in these apartments require a lower degree of assistance than those living in ordinary nursing home and, consequently, incur lower costs. The dummy D_{qc}, introduced to explain the quality of provided care, is positive and suggests that a higher ratio of medical staff per patient raises costs. The dummy variable D_s, which distinguishes nursing homes providing a relatively wide range of services, is positive as expected. A possible explanation is that providing a complex mix of services shifts up costs but this last parameter is significantly different from 0, from a statistical point of view, only in the RE-SHM/SKL model. The variable D_{par} has a positive coefficient that suggests higher costs for the nursing home, which operates with a high number of workers for the same equivalent working time. Finally, the two dummies characterizing the institutional form (D_{pu} and D_{np}) are both positive but only D_{pu} is always significantly different from zero. The interpretation of this result is that running a non profit nursing home (either public or private) leads to higher cost in comparison to a for profit institution with the same characteristics.

This result, which is in line with economic theory, should be verified by further investigation namely with a more accurate control for quality and case mix characteristics.

6. ECONOMIES OF SCALE AND COST EFFICIENCY

In this section we take a closer look at the estimation results as far as economies of scale and cost efficiency are concerned. We are interested in understanding the general features of the technology used in the nursing home industry and in particular the presence of economies of scale. Moreover, we used the cost frontier model to assess the economic

[21] In the estimation process we evaluate also different version of the economic model presented above. The estimates of the parameters for all the regressions were quite stable across the 4 econometric specifications.

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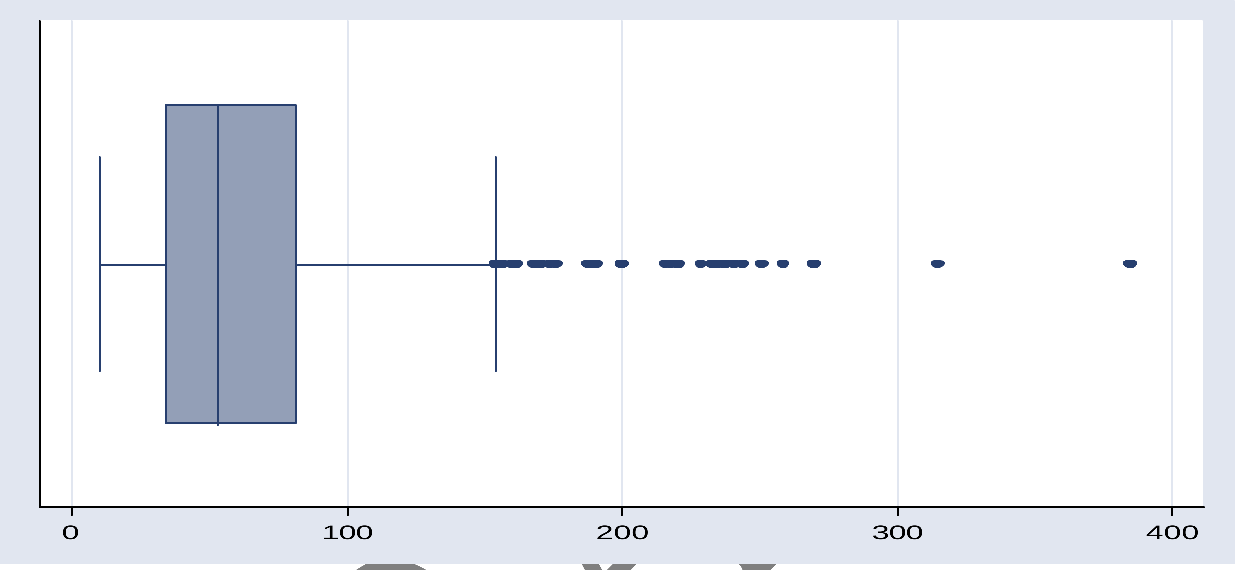
performance of each single nursing home and to evaluate and explain the source of these individual cost efficiencies.

The bed distribution of the nursing homes included in our sample is presented in figure 1. This distribution is characterized by a strong concentration around the median value, which is 53. The high concentration around the median value suggests that the median nursing home can be considered as the representative nursing home[22].

Figure 1: Box-plot of the actual size (number of bed) distribution



The concept of economies of scale indicates the degree to which a company operates at the optimal scale. Frisch (1965) defines the optimal scale as the level of operation where the scale elasticity is equal to one. Economies of scale (*ES*) are defined as the inverse of scale elasticity, which is the proportional increase in total costs resulting from a proportional increase in the output (*Y*), holding all input prices and other explanatory variables fixed:

$$ES = \frac{1}{\dfrac{\partial \ln TC}{\partial \ln Y}} \qquad \textbf{(4)}$$

There are economies of scale if *ES* is greater than 1 and, conversely, there are diseconomies of scale if *ES* is lower than 1. In the case of *ES* = 1 there are no economies or diseconomies of scale. In other words economies (diseconomies) of scale exist if the average cost of a nursing home decreases (increases) as output increases.

[22] A translog function requires the approximation of the underlying cost function to be made at a local point. We choose to normalize all the variables at the median point which can be considered representative for the whole population.

Table 3 presents in more details the results in term of economies of scale for the different specifications. The value of ES for the small (32 beds) and medium (51 beds) sized nursing is greater than 1 for all specifications and this means that economies of scale still exist at the sample median point of approximation. In other words, half of the units observed in the sample could reduce total costs simply by increasing the scale of production.

Table 3: Economies of scale

Economies of Scale	**Y = 1st Quartile (Size = 32 beds)**	**Y = median (Size = 51 beds)**	**Y = 3rd Quartile (Size = 79 beds)**	**Optimal size[23] (*ES* = 1)**
POOL-AIGN	1.074	1.03	0.991	115 beds
RE-PTT/LEE	1.308	1.093	0.948	68 beds
RE-SHM/SKL	1.431	1.125	0.937	68 beds
TRE-GRN	1.417	1.144	0.97	74 beds

Note: Bed number is computed as the output (Y) divided by total capacity (bed *365 days).

The optimal size (ES=1) for a nursing home corresponds to the minimum of the estimated average cost frontier which depends on the days of care offered (Y) but also on other regressors. The number of beds corresponding to the optimal size varies according to the different econometric specifications (table 3) but we can safely consider the bed interval 65-85 as a reliable indication for the optimal size of a representative nursing home. The estimation results show that in the Swiss nursing home industry most of the firms are operating at a sub-optimal size. This widespread scale inefficiency could be justified with two arguments: quality and access. The quality argument relies on the fact that often a nursing home priority is to maintain a comfortable and friendly living environment, which is more easily achieved in a small institution. The access argument is based on the importance of providing a social service to elderly people also in rural and border area. In the Swiss case, another explanation for the small dimensions of many nursing homes could be fiscal federalism. In the past municipalities were responsible for providing care of their elderly populations and, of course, this situation produced a huge numbers of small nursing homes throughout the country. It should be noted that because of capacity constraints, an existing small nursing home cannot simply increase its

[23] The optimal size figures correspond to the minimum of the average cost frontier. The cost minimizing size is given by an extension of output (Y) keeping all the other variables of the model constant to their median value.

output to exploit the scale economies. We contend that such nursing homes could however exploit certain economies of scale through cooperation with neighboring nursing homes in different areas such as sharing their staff, joint purchase of drugs and materials, laundry and other services.

The results reported in table 3 are confirmed by the results obtained in previous studies using data on Swiss nursing homes. Table 4 illustrates the results obtained in these studies. The study by Filippini (2001) and Farsi and Filippini (2004) estimate a cost function using panel data for a sample of nursing homes operating in Canton Ticino. Crivelli et al. (2002) estimate a cost frontier model using a cross-section for a sample of Swiss nursing homes. The values of economies of scale reported in the studies by Farsi and Filippini (2004) and Filippini (2001) are higher than those reported in this study and in the study by Crivelli et al. (2002). This difference may be due to the different data set and to the different econometric approaches used. For instance, Farsi and Filippini (2004) were able to use a rich panel data set composed of 36 nursing homes operating in Ticino over the 9-year period from 1993 to 2001.

Table 4: Previous results regarding scale economies in Swiss nursing homes

	Crivelli, Filippini, Lunati (2002)	Farsi, Filippini (2004)	Filippini (2001)
Ecomomies of scale evaluated at	Frontier All Switzerland Cross section (1998) MLE (Aigner)	Frontier Ticino PANEL (1993-01) REM (Pitt-Lee)	SUR Ticino (1993-95)
1st quartile	1.102 (30 beds)	1.134 (47 beds)	1.19 (41 beds)
Median	1.031 (58 beds)	1.124 (61 beds)	1.18 (57 beds)
3rd quartile	1.006 (74 beds)	1.116 (80 beds)	1.15 (80 beds)
optimal size at Median	79 beds	120 beds	120 beds

The estimation results (Table 2) can be used to recover estimates of cost inefficiency for each nursing home along the lines suggested by Kumbhakar and Lovell (2000). Thus, the inefficiency indicator can be measured as the excess of actual costs compared to the efficient level of cost indicated by the cost frontier. The inefficiency indicator can be calculated using simple expressions according to the different econometric specification.[24]

Table 5 shows some summary statistics of inefficiency score, calculated for the nursing homes of our sample. The cost inefficiency figures range from 0 – indicating full efficiency – to infinitive. The value of inefficiency can be read as a percentage of cost beyond the frontier value obtained by a fully efficient unit. For instance, a score of 0.24 indicates that the actual cost of a nursing home is 24% higher than the (estimated best practice) efficient level. The inefficiency scores are really sensitive to the different model specifications. This huge variation could be interpreted as inefficiency differences among Swiss nursing homes only if we are sure that the comparison is made between homogeneous units. In real world there is a lot of heterogeneity but the model can capture only part of it. In other word we are measuring inefficiency mixed with something else that can be only partially filtered by using proper model specification and econometric technique.

The worst method to measure inefficiency is Fixed Effect Model. As discussed before in the methodological session, this model cannot include any time invariant regressor and cannot distinguish between inefficiency and heterogeneity[25]. On the contrary, the TRE-GRN model, as discussed before, compute a quite precise inefficiency measure since it separate the efficiency component from the heterogeneity one. Nonetheless this model assumes a time-variant inefficiency term and a separate stochastic term for firm-specific unobserved heterogeneity. This means that the model cannot detect the presence of time-invariant inefficiency, which is captured by the firm-specific term, leading to a (possible) downward bias in efficiency measurement.

According to the four (five with Fixed Effect) specifications we get (as expected) different results that are difficult to summarize in few words. It is important to spend some general comments and give some guidelines to interpret the figures in table 5.

In the RE-PTT/LEE model all the firm-specific heterogeneity is captured by the half-normal stochastic term and is considered as inefficiency. This term may include other cost differences that are not related to the nursing home's performance, but simply differences in case-mix etc. across nursing homes. Given that this term is time-invariant, it can capture a considerable fraction of between variations, whereas in the POOL-AIGN model such variations are shared between both stochastic terms. Therefore, this latter model is expected to give a more precise and reliable estimates of inefficiency. The RE-SHM/SKL efficiency scores are recovered from the regression residuals, considering the time-average of each nursing home like an estimates of the inefficiency component (supposed to be constant over

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[24] See Farsi et al. (2005) for a clear presentation of the different formulae to recover an estimate of value of ? ? from the regression parameters. The efficiency score is then obtained as the exponential of ? ?, that is exp(? ?).

25 The Fixed Effect Model inefficiency statistics had been calculated and are presented to provide a upper boundary to inefficiency scores and a benchmark for other models.

time). The idea behind this is that the random component, hidden in the residual, should cancel out by averaging over a (reasonably) long time period. The panel at our disposal is too short to clean the inefficiency from other factors and this is likely to bias (upward) the inefficiency scores.

Table 5 Efficiency scores statistics

	MODELS				
Ineffciency	**Fixed Effect**	POOL AIGN	RE PTT/LEE	RE-GLS SHM/SKL	TRE GRN
Mean	2.827	0.130	0.441	0.807	0.070
Median	2.701	0.117	0.427	0.821	0.060
Maximun	6.249	0.674	0.945	1.512	0.708
90 percentile	4.497	0.209	0.699	1.180	0.115
Minimum	0	0.019	0.104	0	0.011

For the reasons stated before, we comment on the TRE-GRN results only, leaving the comparison with other specification to the reader. The median inefficiency score is 0.06 and this means that about 50% of the nursing homes in the sample are operating with a total cost that is only 5-6% higher than the minimum possible cost. This result shows that the majority of Swiss nursing homes are operating relatively close to the fully efficient cost frontier especially if we considered that the inefficiency value of the 90th percentile is 0.11 indicating that almost 90% of the nursing homes have an inefficiency of 11% or less.

In summary, we contend that these results can be used to estimate the order of magnitude of inefficiency in the whole sector of nursing homes. At an individual level, such studies can only be used as a first step in a more detailed or case-by-case analysis of inefficiencies. The link between performances and factors that may influence them is important from an economic as well as a methodological point of view, but this is a piece of work that is left for future research.

7. CONCLUSIONS

The purpose of this study was to analyze the cost structure of a sample of Swiss nursing homes in order to assess economies of scale and cost inefficiency. Policy-makers are particularly interested in cost information in order to determine the optimal size of a nursing home. Moreover, this paper measures cost efficiency under different econometric specifications. Four different stochastic frontier cost models have been considered. A translog cost function was estimated using an unbalanced panel of 336 nursing homes operating in Switzerland from 1998 to 2002. The main conclusions of this study with respect to the adopted methodology and the empirical implications can be shortly summarized.

First, we would like to stress that with the available short panel, the unobserved heterogeneity at the firm level cannot be sufficiently considered and the empirical results especially concerning the individual efficiency estimates should be considered with caution. Secondly, we note that the two purposes of our estimations require somewhat different conditions in the model. An accurate estimation of scale economies requires an unbiased estimation of the cost frontier slopes (Fixed Effect Model), whereas this condition is not necessary for a reasonable estimation of cost efficiency. As we have seen earlier the pooled model (POOL-AIGN) ignores the panel structure of the data, thus may result in biased estimates of the slopes, whereas, the panel models (RE-PTT/LEEE, RE-SHM/SKL, TRE-GRN) controls to some extent, for the unobserved heterogeneity, thus should have a lower bias in the slope estimates. Therefore, the estimated scale economies from the panel model are more reliable, or at least they can indicate the direction of such biases.

These points should be kept in mind in the interpretation and application of the results presented in this paper for policy purposes.

Empirical evidence indicates that economies of scale are exhausted up to a capacity of beds ranging from 75 to 85 beds. This result suggests that the effects of size on costs should be taken into account in building new nursing homes. This result also points to the economic advantages of joint activities between small nursing homes, and eventually consolidation of small facilities through mergers and acquisitions.

The outcome of this analysis, according to the most favorable results, shows that over 75% of the nursing homes included in our sample operate close (not more than 10%) to the national (relative) standard for efficiency. The average inefficiency is 7% of cost excess above the (estimated) Swiss best-practice.

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