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Abstract

In Switzerland, nursing home services are mainly provided by regulated public and private nonprofit organizations. Some of them are created by local governments as foundations. This provides a unique setting to analyze the impact of the institutional form on the performance of nursing homes. We propose a model where the institutional form is represented as a legal constraint which affects managers in the decison-making process. Considering a sample of 44 Swiss Italian nursing homes over a 7-years period (1999-2005), we then disentangle persistent inefficiency due to differences in the institutional form from unobserved heterogeneity. The applied estimation strategy provides more accurate estimates of the impact of the institutional form on nursing homes efficiency, as compared to previous studies. Our results suggest that governmental nursing homes are more costly than private and public foundations. These results are consistent across different model specifications.

Keywords: constant inefficiency, unobserved heterogeneity, nursing homes, nonprofit, institutional form.

JEL classification: C23, I18, L20.

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1 Introduction

The influence of different organizational structures on nursing homes (NHs) efficiency is a relevant issue in most health care systems. The organizational structure affects the behavior of managers and, consequently, the governance of NHs. As population ages and pressure on healthcare costs increases, some organizational structures may be more successful in saving costs as compared to other structures.

In Switzerland, NHs services are mostly provided by regulated public and private nonprofit firms. For-profit institutions serve about 5% of the elderly population and generally provide luxury residential services. Around 46% of regulated NHs are privately owned foundations, whereas 44% are governmental organizations. The latter do not have a separate juridical status and are directly integrated in the local public administration. The remaining 10% of NHs is represented by publicly-owned firms that have been created by local governments as foundations, and are therefore called municipality-owned foundations. The provision of nursing care services is organized at local level, and NHs operate as local monopolies and face an excess of demand due to subsidized prices.

We distinguish between nonprofit NHs subject to private-law working contracts and NHs under public-law working contracts. Hereafter, we refer to those two forms of institutions as *private-law* NHs and *public-law* NHs, respectively. Public-law NHs correspond to governmental NHs, while private-law NHs include privately-owned foundations as well as municipality-owned foundations. In public-law NHs, the governing body is represented by local politicians (city council), while the executive arm is left to the municipality, which delegates it to a manager. In private-law NHs, the governing body is represented by the foundation council. The decision-making process may then vary across institutional forms. Worthington and Dollery (2000) speak of local government managers being "constrained by a host of non-discretionary factors in arriving at efficient outcomes" (p.14). Hart, Schleifer and Vishny (1997) see public managers as being constrained by some government agreement to implement any cost innovation decision while managers of private-law firms can freely implement these decisions. In addition, private-law firms are expected to face lower probability to be bailed out by public authorities or tougher punishment for poor managerial effort. Differences in the institutional form may then lead to differences in the efficiency of NHs. However, behavioral differences between institutional forms may be mitigated in highly regulated systems such as the Swiss nursing home sector.

The issue of the most efficient organizational form in the provision of nursing care has not received a conclusive answer by the economic literature so far. The literature has mainly focused on the effect of the ownership by comparing for-profit privately-owned and publicly-owned organizations (e.g. Chou, 2002; Crivelli et al., 2002; Santerre and Vernon, 2005; Grabowski et al., 2009). However, in the Swiss nursing home sector the majority of NHs are not-for-profit organizations (both public and private).

Within the nonprofit sector, there is no accepted theory of organizational behavior, although Kapur and Weisbrod (2000) have since long recognized that governmental and private nonprofit firms do differ in their objective functions. From an empirical point of view, little work has been done on the impact of the institutional form on productive efficiency. To our knowledge, only few studies (e.g. Vitaliano and Torren, 1994; Farsi and Filippini, 2004; Holmes, 1996; Farsi et al., 2008) analyze the impact of the institutional form on the performance of not-for-profit NHs. Two studies use Swiss data. Farsi and Filippini (2004) estimate a random effect model with time-invariant inefficiency as proposed by Schmidt and Sicklers (1984) using data on Swiss Italian NHs. The authors show that foundations are slightly more efficient than governmental NHs. The study has two main drawbacks. First, given the length of the panel, the assumption of time-invariant inefficiency may not be appropriate. Second, since the individual effects are interpreted as inefficiency, they are likely to include any unobserved factor which remains constant over time. Therefore, in the presence of unobserved heterogeneity, the results can be biased. To tackle these aspects, Farsi et al. (2008) estimate a true random effect model (TRE) on a panel of Swiss NHs and do not find significant differences between institutional forms. The new approach allows for time-varying inefficiency and controls for the unobserved heterogeneity. However, another weakness arises if part of the inefficiency remains constant over time. In fact, an important drawback of this approach is that constant inefficiency is captured by the individual effects rather than being included in the traditional inefficiency term. This may lead to incorrect results if one is interested in explaining part of the inefficiency with a variable that does not change over time, such as the institutional form.

In this paper, we hypothesize that there are two forms of inefficiency: a persistent, institutional form-related component, and a time-varying part related to managerial skills. The institutional form cannot be controlled by the manager but defines organizational differences between NHs, which affects the managerial decision process. To capture differences in the institutional form, we incorporate a dummy variable directly into the deterministic part of the cost frontier and estimate a TRE model. This methodology allows us to purge the individual effects from the impact of the institutional form, which is then added to the traditional time-varying inefficiency estimator. Consequently, the novelty of our approach as compared to previous comparative studies on hospital efficiency (e.g. Grosskopf and Valdmanis, 1987; Ozcan, Wogen and Mau, 1998) is that it combines the approach of including the dummy variable in the deterministic part of the frontier with the TRE model.

The remainder of the paper is organized as follows. In section 2 we sketch a theoretical model of managerial behavior in NHs and derive hypotheses on the impact of different institutional forms on cost efficiency. In section 3 we present the empirical analysis and the data. Section 4 discusses the methodology used to validate the hypotheses derived in section 2. Section 5 summarizes the results and suggests some policy implications of our analysis. Section 6 concludes.

2 The model

Our theoretical approach draws from studies that model the bargaining process between the management and the ownership (e.g. Schmitz, 2000) or the management and workers (e.g. Glaeser, 2002).[1] To capture the behavior of public-law and private-law NHs, we sketch a model where low managerial effort translate into low efficiency levels, as in Haskel and Sanchis (1995). The governing board of the NH (G) may take two different institutional forms: public-law ($i = Pu$) or

[1] One alternative approach to investigate the effect of the ownership on firm's performance is the principal-agent approach (e.g. Kessler and Lülfesmann, 2001; Pint, 1991).

private-law ($i = Pr$). A Manager (M) runs the organization and a regulator (R) defines the financial resources for the NH. The total costs of the NH are described by the following equation:

$$C_i = \theta - \alpha_i e. \tag{1}$$

The first term to the right hand side of equation (1), θ, is a structural parameter defining costs that are independent from managerial effort and only partially observable by the regulator. This parameter depends, for instance, on the severity mix of patients, the number and quality of professional staff members, or the location of the NH. Costs include a fixed remuneration for the manager (W). For simplicity, we assume that θ is a random variable which takes only two values: $\underline{\theta}$ and $\overline{\theta}$, with $\overline{\theta} > \underline{\theta}$. The probability that $\theta = \underline{\theta}$ and $\theta = \overline{\theta}$ is q and $(1 - q)$ respectively. The last term in the equation, e, is the manager's effort to reduce total costs. The parameter $\alpha_i \in (0, 1)$ reflects the effectiveness of managerial effort, i.e. the marginal impact of effort on costs. This parameter varies with the institutional form of the NH and represents a constraint on managers' autonomy in the decision-making process. The parameter α_i can also be interpreted as the impact of bureaucratic decision-making processes.

In Switzerland, NHs are local monopolies and the demand for NH services is assumed to be independent from actions undertaken by other homes. We normalize to one the population of patients in each market area. Therefore, equation (1) can also represent the average cost per patient.

Costs are observed at the end of the year by the regulator. However, the regulator cannot distinguish between structural costs and the impact of managerial effort. An ex-ante budget is applied to finance NHs based on the following rule:

$$B = q\underline{\theta} + (1 - q)\overline{\theta} = \widehat{\theta}. \tag{2}$$

The regulator knows the mean and the variance of the distribution of the structural cost parameter. However, the realization of θ for a given NH is unknown. Hence, the regulator can only set a budget based on the weighted average of the structural parameters.

2.1 Nursing homes objectives

The behavior of NHs is defined by the interaction between the board and the manager. The utility function of the board is given by the following equation:

$$U_{G_i} = S_i - \lambda_i (B - C_i)^2, \tag{3}$$

where S_i represents exogenous benefits from the production of nursing home services that may also vary with the institutional form.[2] Disutility from an unbalanced budget is a quadratic function which also varies with the institutional form, with $\lambda_{Pu} < \lambda_{\text{Pr}}$, and $\lambda_i \in (0, 1)$ captures the impact of deviations from an unbalanced budget. Note that unbalanced budgets generate a disutility both if financial resources are greater than costs and vice versa. This is because the fund-raising activity to match the lack of resources is costly. Also, an excess of financial resources is detrimental since these resources cannot be retained. Within the Swiss Italian budgeting system, NHs are required to pay back the regulator the remaining resources at the end of the year. This means that efficient NHs are not rewarded for their effort in controlling costs. Consequently, NHs maximize their objective function when the budget is balanced.[3]

We can now turn to the objectives of the manager. The manager's utility can be defined by the following expression:

$$U_{M_i} = W - \phi(e) + \gamma_i U_{G_i}, \tag{4}$$

where W is the manager's wage, $\phi(e)$ is disutility of effort, and $\gamma_i \in (0, 1)$ is the degree the goals of the board are internalized by the manager. Substituting for U_{G_i} in (4), the marginal impact of an unbalanced budget on manager's utility is $\gamma_i \lambda_i$. We assume that manager's utility is additive in effort and the degree of sharing of the board's objectives, with $d\phi/de > 0$ and $d^2\phi/de^2 > 0$. We also hypothesize that the disutility of effort takes the form $\phi(e) = \frac{\eta}{2} e^2$, with $\eta > 0$. The marginal impact of effort on manager's utility is then captured by the parameter η. Finally, the level of effort is bounded to take a value in the interval $e \in [0, e_{max}]$, where

[2] For example, a public-law board may value the preferences of the whole voters' community while a private-law board may value those of the donors or of particular groups of interest.

[3] The nonprofit literature is rich of models following this approach (e.g. Zweifel et al., 2009).

$e_{max} = \frac{q}{\alpha_i}(\overline{\theta} - \underline{\theta})$.[4] For simplicity, the reservation utility is assumed to be zero so that the participation constraint of the manager is always satisfied for any level of the wage.

2.2 Managerial effort

The optimal choice of effort for the manager is obtained from the first-order conditions to maximize (4) under two possible scenarios: over financing ($\theta = \underline{\theta}$) and under financing $\left(\theta = \overline{\theta}\right)$. Remember that the budget is defined by the regulator as a weighted average of the structural cost parameter (2). Using (1) and (2), we then observe that for $\theta = \underline{\theta}$ we have $B - C_i > 0$ for any level of effort e. Conversely, for $\theta = \overline{\theta}$, we have $B - C_i \leq 0$ for any $e \in [0, e_{max}]$. To write the first-order conditions for the two scenarios, we first substitute (1) and (2) into (3). Using (3) we then replace U_{G_i} in (4), and finally derive (4) for the level of effort to get:

$$\frac{dU}{de}|_{\theta=\underline{\theta}} = -\eta e - 2\alpha_i\gamma_i\lambda_i \left[\alpha_i e + (1-q)(\overline{\theta} - \underline{\theta})\right] \leq 0, \tag{5}$$

$$\frac{dU}{de}|_{\theta=\overline{\theta}} = -\eta e - 2\alpha_i\gamma_i\lambda_i \left[\alpha_i e + q(\underline{\theta} - \overline{\theta})\right] = 0. \tag{6}$$

Solving the two equations we get the equilibrium levels of effort as:

$$e^* = \begin{cases} 0 & : \ \theta = \underline{\theta} \\ \frac{\alpha_i\beta_i q(\overline{\theta}-\underline{\theta})}{\eta+\alpha_i^2\beta_i} & : \ \theta = \overline{\theta} \end{cases}, \tag{7}$$

where $\beta_i = \gamma_i\lambda_i$. Note that for $\theta = \underline{\theta}$, the manager has no incentive to make a positive effort. This is because any positive level of effort would increase economic profits which cannot be retained by the firm. Conversely, for $\theta = \overline{\theta}$, a positive level of effort is valuable to reduce losses. The optimal level of effort clearly depends on the magnitude of the difference between high structural costs ($\overline{\theta}$) and low structural costs ($\underline{\theta}$).

2.3 Model predictions

From eq. (7) above, note that managerial effort varies according to the type of productivity constraint of NHs defined by the institutional form ($i = Pu, Pr$).

[4] This ensures that the manager can decrease costs up to the level where $B = C$. Beyond this level, more effort would reduce the utility of the manager since a higher level of effort produces resources that cannot be exploited.

Given the features of the funding system, there are no behavioral differences between the two institutional forms if NHs are generally over financed, i.e. if $\theta = \underline{\theta}$. In this case, the choice of effort does not depend on the institutional form-specific parameters. Therefore, we focus on the choice of effort when $\theta = \overline{\theta}$, i.e. when NHs incur a loss or just cover costs. Managerial effort depends on the marginal disutility of a loss (λ_i) and the importance of the board's objectives (γ_i), which is captured by the parameter β_i. Finally, managerial effort depends on the marginal impact of manager's effort on costs (α_i).

Looking at the comparative static properties of the equilibrium in the case of underfinancing, we can shortly discuss how the other parameters of interest affect the optimal choice of effort. For $\theta = \overline{\theta}$, we get:[5]

$$\frac{de^*}{d\alpha_i} \begin{cases} > 0 & : \quad \alpha_i < \frac{\eta}{2\beta_i} \\ \leq 0 & : \quad \text{otherwise} \end{cases}, \tag{8}$$

The optimal level of effort exerted by the manager increases for low levels of α_i and decreases when α_i is relatively high. Since α_i represents the marginal impact of effort on costs, eq. (8) implies that a higher level of effort is required to cover costs when the marginal impact of effort is relatively low, given the marginal disutility of an unbalanced budget and the degree the goals of the board are internalized (β_i) and the marginal cost of effort for the manager (η).

As for the impact of β_i, we have $de^*/d\beta_i > 0$.[6] Since $\beta_i = \gamma_i \lambda_i$ with both γ_i and λ_i lower than 1, we also conclude that $de^*/d\gamma_i > 0$ and $de^*/d\lambda_i > 0$. Therefore, higher marginal disutility of unbalanced budgets for the board (λ_i) which is shared by the manager (γ_i), leads to higher levels of managerial effort in equilibrium. Finally, from (8) we get $de^*/d\eta < 0$ which implies that a higher marginal cost of effort for the manager decreases the equilibrium level of effort to reduce costs, as expected.

Previous studies suggest that parameters α_i and β_i differ across institutional forms. We hypothesize that $\alpha_{Pu} < \alpha_{Pr}$ and $\beta_{Pu} < \beta_{Pr}$. The first parameter of interest, α_i, is a key factor in our analysis. It seems plausible that governmental

[5] By deriving (7) for $\theta = \overline{\theta}$ with respect to α_i we get $\frac{de^*}{d\alpha_i} = \frac{\beta_i q(\overline{\theta} - \underline{\theta})(\eta - \beta_i \alpha_i^2)}{(\eta + \beta_i \alpha_i^2)^2}$. This is positive if the last term at the numerator is positive, which leads to (8).

[6] Deriving (7) for $\theta = \overline{\theta}$ with respect to β_i, we obtain: $\frac{de^*}{d\beta_i} = \frac{\alpha_i \eta q(\overline{\theta} - \underline{\theta})}{(\eta + \beta_i \alpha_i^2)^2}$ which is always satisfied.

boards put more bureaucratic curbs on the management decisions than boards of foundations. This leads to higher marginal costs of innovations to reduce costs and, therefore, to less effective managerial effort (lower α_i). This argument has already been recognized by other authors, for instance Worthington and Dollery (2000).

The second parameter of interest, β_i, refers to the marginal impact of an unbalanced budget on manager's utility. This impact is expected to be higher in the case of private-law NHs for two reasons. First, private-law NHs face higher fund-raising costs as compared to public-law NHs (Kornai, 1980; Duggan, 2000). This is because the local government is likely to cover costs of public-law NHs that exceed the resources allocated by the regulator. Second, the degree to which managers working in private-law NHs share the objectives of the council is expected to be higher, or at least equal, than that of managers working in public-law NHs. This idea relies on factors suggested by different authors in the literature (Rose-Ackerman, 1996; Lakdwalla and Philipson, 1998; Wilson, 1989). Managers working in foundations are more likely to be driven by altruistic motives and to be punished in case of poor performance, and are less likely to follow multiple objectives with which the manager may not agree.

To summarize, our model predicts that the behavior of NHs varies with the institutional form. In the case of under financing, the utility-maximizing effort of managers in private-law NHs is likely to be higher than the effort of managers in public-law NHs, which leads to higher efficiency in private-law NHs. To investigate this hypothesis empirically, we specify a cost function for public-law and private-law NHs operating in Switzerland and compare their cost efficiency.

3 Empirical specification and data

3.1 Detailing the cost function

We assume that the NH transforms two inputs, capital and labor, into a single output, measured by the number of patient-days of nursing care.[7] As mentioned in section 2, we can rule out strategic interactions among NHs and their effect on the demand of patients since Swiss NHs are local monopolies. The number of

[7] A similar approach is followed, for instance, by Farsi and Filippini (2004).

patient-days can then be considered a good indicator of the level of production after controlling for differences in quality. The total costs function depends on output (Y), the prices for capital and labor (P_k and P_l), technological progress captured by a time trend (τ), two output characteristics (Q_1 and Q_2) and a dummy variable which takes value equal to 1 for public-law NHs, and 0 otherwise (Z):[8,9]

$$C = f(Y, P_k, P_l, \tau, Q_1, Q_2, Z). \quad (9)$$

Our dummy variable captures differences in the parameters α_i and β_i across institutional forms, as hypothesized in section 2.

The price of labor is calculated as the weighted average wage of different professional categories employed in the NH (doctors, nurses, administrative and technical staff), while the price of capital is derived from the residual approach: labor costs are subtracted from total costs and the residual is divided by the capital stock approximated by the number of beds.

Additionally, we control for some output characteristics that may explain cost differences across NHs.[10] Q_1 is an index which measures average patients assistance by means of normal daily activities such as eating, personal care or physiological activities. This is calculated on a yearly basis by the Regional Department of Public Health (RDPH). Patients are classified in one out of five categories according to their severity level. A value between 0 and 4 is assigned where higher values indicate more severe cases. Q_2 is the nursing staff ratio, that is the ratio between the number of nurses employed and the number of nurses that should be employed according to the guidelines of the RDPH. Because nursing care is a labor-intensive service, the ratio can be considered as an indicator for quality.[11]

[8] In addition to the specified cost function, we considered an alternative specification which includes a third input factor called material. However, we dropped this option due to difficulties in defining an appropriate measure for this input quantity.

[9] In a non-competitive environment such as the Swiss one, there is no reason to assume that NHs minimize costs. In this case, the estimated costs function is a "behavioral cost function" (Evans, 1971) and can still be used to make a comparison among firms. Moreover, by estimating a total costs function instead of a variable costs function we avoid the risk related to a possible high correlation between capital stock and output leading to a positive relationship between variable cost and capital stock (Filippini, 1996).

[10] In order to estimate a cost function, either the output is assumed to be homogenous or we need to control for service intensity and patients' characteristics (Birnbaum et al., 1981).

[11] The cost of labor represents about 85% of total costs. Consequently, a small change in

In order to impose as few restrictions as possible, we adopt a flexible translog functional form approximated at the median value, a less sensible statistic to outliers than the mean. Input prices and total costs are then divided by the capital price in order to satisfy the homogeneity condition in input prices.[12] The translog approximation to (9) is:

$$
\begin{aligned}
\ln\left(\frac{C}{P_k}\right) &= \alpha_0 + \alpha_Y \ln Y + \alpha_{Q_1}\ln Q_1 + \alpha_{Q_2}\ln Q_2 + \alpha_{P_l}\ln\frac{P_l}{P_k} \\
&+ \tfrac{1}{2}\alpha_{YY}(\ln Y)^2 + \tfrac{1}{2}\alpha_{Q_1Q_1}(\ln Q_1)^2 + \tfrac{1}{2}\alpha_{Q_2Q_2}(\ln Q_2)^2 \\
&+ \tfrac{1}{2}\alpha_{P_lP_l}\left(\ln\frac{P_l}{P_k}\right)^2 + \alpha_{YQ_1}\ln Y \ln Q_1 + \alpha_{YQ_2}\ln Y\ln Q_2 \\
&+ \alpha_{YP_l}\ln Y \ln\frac{P_l}{P_k} + \alpha_{Q_1P_l}\ln Q_1 \ln\frac{P_l}{P_k} + \alpha_{Q_1Q_2}\ln Q_1 \ln Q_2 \\
&+ \alpha_{P_1Q_2}\ln\frac{P_l}{P_k}\ln Q_2 + \alpha_t\tau + \alpha_z Z + \varepsilon_{it}
\end{aligned}
\tag{10}
$$

Finally, the concavity condition in input prices is checked after the estimation of the parameters.

3.2 Data and descriptive statistics

Our study exploits a panel data set of 44 NHs operating in Canton Ticino, Switzerland, over a 7-years period (1999-2005).[13] Since the sample includes all skilled NHs in cantonal nursing home planning, their production process is highly homogenous.

Data are extracted from annual reports delivered to the RDPH by regulated NHs. NHs with foyers are excluded from our sample.[14] Three NHs show unrea-

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the nursing staff ratio may affect total cost considerably. For this reason, NHs with high costs may decide to decrease the proportion of workers. On the other hand, efficient NHs may hire new workers or increase the working time in order to justify additional costs to the regulatory authority. This endogeneity issue is checked using the robust Durbin-Wu-Hausman test (Cameron and Trivedi, 2005). We perform this test using the lagged of Q_2 as instrumental variable. The test statistic is chi-squared distributed with a robust score $\chi^2(1) = 0.49$ or $F(1, 234) = 0.395$. The null hypothesis of exogenous Q_2 cannot be rejected at any standard levels of significance.

[12] The cost function is linear homogenous of degree 1 in input prices when a 10% increase in all input prices leads to a 10% increase in total cost.

[13] Data are available until year 2010. However, in 2006 a new financing system was introduced. This change may have affected the relative efficiency of different institutions. Consequently, we excluded the period 2006-2010 from the present analysis. The impact of the new reform on the performance of NHs will be analyzed in a separate paper.

[14] Foyers are external residential apartments where nursing care is provided to the most "in-health" patients. Since the production process may differ substantially, when a considerable share of patient-days is spent in foyers ($> 10\%$), these observations are dropped.

Variables	Mean	S.D.	Median	Min.	Max.
Average cost (Sfr/resident day)	227.77	27.66	225.02	160.92	309.23
Total annual resident days (Y)	23227	9398.50	21656	9925	58324
Average dependency index (Q_1)	3.05	0.36	3.08	0.80	3.80
Nursing staff ratio (Q_2)	0.96	0.09	0.95	0.74	1.55
Average labor price in Sfr per employee per year (P_l)	78855	5274	79282	63604	93237
Average capital price in Sfr per bed (P_k)	13103	3263	12636	6370	33171
Number of beds	66	26.4	62	28	162

Notes: All monetary values are in 2005 Swiss francs (Sfr), adjusted by the national Consumer Price Index.

Table 1: Descriptive statistics of the main costs and input variables (287 observations).

sonable values, hence they are also excluded from the analysis. The final sample contains 287 observations of 24 private-law NHs and 20 public-law NHs.

Table 1 presents the summary statistics for the main costs and input variables of interest: mean, standard deviation, median, minimum and maximum values for our sample. All input prices, total cost and variable cost are inflated to 2005 constant currency units (Swiss francs) using the national Consumer Price Index.

Variables	Private-law NHs (Pr)	Public-law NHs (Pu)	t-value
Average cost (Sfr/resident day)	233.685	221.389	3.852***
	(29.964)	(23.422)	
Total annual resident days (Y)	20103.05	26599.89	-6.225***
	(7046.662)	(10425.21)	
Average dependency index (Q_1)	3.079	3.014	1.506
	(0.366)	(0.359)	
Nursing staff ratio (Q_2)	0.992	0.981	0.774
	(0.154)	(0.078)	
Average labor price in Sfr per	79014.65	78682.59	0.532
employee per year (P_l)	(5092.768)	(5476.3)	
Average capital price in Sfr	14353.95	11752.38	7.346***
per bed (P_k)	(3790.485)	(1780.969)	
Number of beds	58.087	75.427	-5.873***
	(20.556)	(29.031)	
Number of homes	24	20	-
Number of observations	149	138	-

Notes: Standard deviations are given in brackets. All monetary values are in 2005 Swiss francs (Sfr), adjusted by the national Consumer Price Index. Significance levels: * = 10%, ** = 5%, *** = 1%.

Table 2: Differences in mean costs and inputs among institutional forms.

The average cost per resident day in the most expensive NH is twice the average cost of the less expensive home, with an average of about 228 Swiss francs. This difference is at least partially explained by the large heterogeneity in NHs characteristics. In particular, facilities vary in size. The number of beds ranges from a minimum of 28 to a maximum of 162, which leads to a high standard deviation also in the total annual resident days. Differences in output characteristics are also remarkable. The average patient dependency index ranges from 0.8 to 3.8, while the nursing staff ratio varies between 0.74 and 1.55. If NHs followed the guidelines of the RDPH and emploied as many nurses as it is suggested, the nursing staff ratio would be 1. Finally, we consider the input prices. The largest variation is observed for the price of capital. The highest price for a bed is five times higher than the lowest price. This remarkable heterogeneity may be explained by the investments made during the 90's in order to increase the number of beds available. Due to the length of our panel, part of the increase in the number of beds may also derive from a technological change.

To focus on differences between public-law and private-law NHs, we calculate the mean and the standard deviation of some characteristics separately for each subsample (Table 2). In the last column of Table 2, we report the results of a two-sided t-test under the null hypothesis of equal means between the two groups. The statistics show that, on average, private-law NHs spend more money per patient day than public-law homes do, and the difference is highly statistically significant. However, public-law homes have access to cheaper capital and are generally bigger. While the average number of beds in foundations is around 58, the average number of beds in public-law NHs is 30% higher, which suggests that public-law homes may enjoy decreasing average costs, as suggested in previous studies (Farsi et al., 2008; Hoess et al., 2009). Regarding output characteristics, the two groups do not show significant differences. The mean dependency index and the nursing staff ratio are very close. Similarly, the average labor price per employee does not differ.

4 Methodology

We investigate the effect of institutional form on the performance of NHs by applying two different econometric approaches. Both methods estimate a benchmarking cost frontier against which the actual performance of the firms in the sample is compared.[15] The main difference between the two approaches lies in the way exogenous factors are treated in the analysis of efficiency.[16]

The first approach (Model 1) relies on the assumption that the institutional form affects the degree of inefficiency directly. The performance of each NH is measured in relation to a single best practice frontier and the impact of the institutional form on inefficiency is tested afterwards by means of the non-parametric Kruskal-Wallis test.

The second approach (Model 2) derives from the literature on *environmental characteristics*, where it has been recently applied to different industries. This approach includes a dummy for the institutional form directly into the main cost equation and estimates two distinct best practice frontiers. The rationale is that NHs with different institutional forms may face different operating environments and/or objectives. Consequently, they can adopt different combinations of inputs. The resulting inefficiencies are net of institutional characteristics (*net inefficiencies*) and can be interpreted primarily as an indicator of managerial performance (Coelli et al., 1999). The distance between the actual costs and the group-specific best practice frontier provides information about the within-group inefficiency of foundations and public NHs. Conversely, the between-groups inefficiency is measured as the distance between the two frontiers, i.e. the coefficient of the dummy variable.[17] Finally, by re-evaluating the traditional efficiency predictor with the formula applied by Coelli et al. (1999), all firms can be compared to the most

[15] We also estimate a cost function by means of regression models: OLS, random effect (RE) and fixed effect (FE) where the institutional form is captured by a dummy variable. The results are presented in the Appendix and support findings from stochastic frontier models.

[16] See Simar, Lovell, and Vanden Eeckaut (1994) for a review of approaches to include exogenous factors in efficiency measurement studies.

[17] The approach has been applied in the literature on hospital efficiency in order to study the impact of ownership (Grosskopf and Valdmanis, 1987) and size (Ozcan, Wogen, and Mau, 1998). In both cases the authors find evidence of different best practice frontiers for different groups of hospitals.

favorable best practice frontier. This is achieved by multiplying the usual time-varying efficiency predictor (u_{it}) with the exponential of the estimated coefficient related to the institutional form dummy, here called (α_{Pu}). Cost efficiency (CE) for NH i at time t is formally defined as:

$$CE_{it} = E\left[\exp\left(u_{it} + \alpha_Z\right)|\varepsilon_{it}\right] = E\left[\exp\left(u_{it}\right)|\varepsilon_{it}\right]\exp\left(\alpha_Z\right). \tag{11}$$

Eq. (11) allows to obtain a measure of *gross inefficiencies*. In particular, the (in)efficiency level of public-law NHs is derived under the assumption that these firms face the same operative environment and/or objectives than private-law NHs.

For both the approaches described above, we estimate a pooled frontier and a true random effects model (TRE) developed by Greene (2005). In both specifications, the random error term (ε_{it}) is composed by a symmetric term (v_{it}) capturing statistical noise and a one-sided non-negative disturbance representing the inefficiency (u_{it}). The pooled frontier estimator is based on the original cost frontier model proposed by Aigner et al. (1977) and considers the sample as series of cross-sectional observations. The firm-specific effects (α_i) are assumed to be zero. The TRE model is an extension to the Pooled frontier model in that it includes an additional firm-specific effect (α_i) to represent the unobserved heterogeneity among firms. This effect is considered as a random effect.

	Pooled model $Half-Normal$	TRE $Half-Normal$
Firm-specific effect α_i	None	N (0, σ_α^2)
Random error ε_{it}	$\varepsilon_{it} = u_{it} + v_{it}$ $u_{it} \sim N^+(0,\ \sigma_u^2)$ $v_{it} \sim N(0,\ \sigma_v^2)$	$\varepsilon_{it} = u_{it} + v_{it}$ $u_{it} \sim N^+(0,\ \sigma_u^2)$ $v_{it} \sim N(0,\ \sigma_v^2)$

Table 3: Econometric specification of the Pooled frontier and TRE models.

The adoption of the TRE model can be regarded as an improvement compared to the pooled frontier since the inclusion of firm-specific effects allows to control for the unobserved heterogeneity. However, if part of the inefficiency is constant over time, its impact is captured by the individual effects and, consequently, it is interpreted as heterogeneity rather than inefficiency. It follows that the overall inefficiency is underestimated and the term which is interpreted as inefficiency cannot capture the effect of the institutional form. This limitation is overcome by our second approach where gross inefficiencies include the impact of constant inefficiency due to the institutional form. Indeed, disentangling time-invariant inefficiency from latent heterogeneity is of major interest and may represent a valid improvement if compared to previous analysis of efficiency in NHs. Table (3) summarizes the econometric specification of the frontier models used in this study:

5 Results

We now discuss the results from the two approaches - with and without the institutional form dummy variable - estimated with a pooled frontier and a TRE model. In Table 4, we report the estimated coefficients together with their level of significance and, for Model 2 only, the impact of the dummy variable for the institutional form. Standard errors are given in brackets. All the coefficients are highly significant and positive. The interaction terms are not displayed but some of them are also statistically significant. The estimated coefficients are quite robust across different specifications. The only exception is the coefficient related to patients severity (α_{Q_1}). This coefficient is lower when the individual effects are considered, which provides some evidence of unobserved heterogeneity. However, this heterogeneity is at least partially taken into account in the TRE estimation. In fact, the estimated coefficient of the variable Q_1 in the TRE estimation is lower than the coefficient in the pooled frontier and approaches the estimated coefficient of the fixed effect model.[18]

The output coefficient (α_Y) is smaller than 1, which suggests the presence of economies of scale. The coefficients of the two output characteristics (α_{Q_1}, α_{Q_2}) show that more severe patients lead to higher costs. Similarly, more nurses per patient cause higher production costs. The estimated share of labor costs given by the coefficient of input prices (α_{P_l}) is about 80%. The actual share of labor costs

[18] In order to test the presence of unobserved heterogeneity, we estimate a fixed effect mode. This has the advantage of not suffering from heterogeneity bias. Estimated coefficients are very close in magnitude to the results of the pooled and the TRE models. Only the coefficient related to patient case-mix differs substantially and is around 0.17. The true fixed effect model cannot be applied because it does not converge.

Estimated coefficients	Stochastic frontier models (Model 1)		Stochastic frontier models with dummy variable (Model 2)	
	Pooled frontier	TRE	Pooled frontier	TRE
α_Y	0.927***	0.905***	0.913***	0.898***
	(0.008)	(0.007)	(0.009)	(0.007)
α_{Q_1}	0.430***	0.233***	0.444***	0.291***
	(0.009)	(0.024)	(0.029)	(0.025)
α_{Q_2}	0.459***	0.391***	0.473***	0.414***
	(0.029)	(0.023)	(0.037)	(0.019)
α_{P_l}	0.820***	0.791***	0.800***	0.775***
	(0.038)	(0.010)	(0.016)	(0.011)
α_Z	-		0.027***	0.033***
	-		(0.007)	(0.005)
$\lambda = \frac{\sigma_\mu}{\sigma_\nu}$	1.040***	2.062***	1.386**	1.813***
	(0.156)	(0.347)	(0.183)	(0.298)

Notes: Significance levels: * = 10%, ** = 5%, *** = 1%.

Table 4: Estimated first-order coefficients (287 observations) of pooled stochastic frontier models and TRE models.

is about 85%. Finally, the dummy variable for the institutional form in Model 2 is positive and highly significant. This indicates that, at the approximation point, public-law NHs are more costly than private-law NHs by about 3% on average.[19]

In the last row of Table 4, we provide the statistics for lambda (λ), the ratio between the standard deviation of the inefficiencies and the standard deviation of the stochastic term. Since the value of lambda defines the relative contribution of the inefficiency term with respect to the stochastic term, a positive and statistically significant number supports the existence of the two error components.[20] The difference in the lambda coefficient between the two models arises because of the different model specification. The concavity condition is not satisfied since the Hessian Matrix, $\frac{\partial^2 \ln C_{it}}{\partial w_j \partial w_i}$, is not negative semi-definite.[21]

[19] This result is consistent with the regression approach presented in the Appendix. Also, it confirms findings by Farsi and Filippini (2004), which can be explained with a relatively low (impact of) unobserved heterogeneity in the NH industry on the estimated inefficiency levels.

[20] In addition, we performed an analysis of the skeweness of the OLS residuals. As Waldman (1982) shows, when the OLS residuals are skewed in the "wrong" direction, the results from the maximum likelihood estimator are those of a simple OLS rather than a cost frontier. The normality test shows that the OLS residuals are right skewed (0.216) and the null hypothesis of normally distributed residuals can be rejected at 99% significance level. Therefore, data and model specification support the adoption of stochastic frontier models.

[21] Our results indicate that the Hessian matrix of the estimated cost functions as with respect to input prices (labor and capital) calculated at the approximation point is not negative semi-

It is worth pointing out at the results of the Kruskal-Wallis test on the null hypothesis of equal inefficiency mean between the two institutional forms (Table 5). P-values are reported in brackets. In the first two columns of Table 5 we report

Kruskal-Wallis test on H_0:	Inefficiencies Model 1		Gross inefficiencies Model 2		Net inefficiencies Model 2	
	Pooled	TRE	Pooled	TRE	Pooled	TRE
Pu=Pr	NO	NO	NO	NO	YES	YES
(p-value)	(0.000)	(0.045)	(0.000)	(0.000)	(0.168)	(0.559)

Table 5: Results of the Kruskal-Wallis test on the equality of mean inefficiency between public-law and private-law NHs.

the results of the test for Model 1, where we do not control for the institutional form in the main cost equation. The test rejects the null hypothesis at the 5% level of significance in both model specifications (pooled and TRE). However, the results of the pooled frontier model may suffer from heterogeneity bias, while the higher p-value in the TRE model may be explained by the fact that part of the inefficiency is captured by the individual effects.

The remaining columns of Table 5 report the results of the Kruskal-Wallis test for Model 2, respectively for the gross inefficiencies and the inefficiencies net of the institutional form effect. As for gross inefficiencies, the test confirms that public-law and private-law NHs differ. The p-value in the TRE model is smaller compared to Model 1, likely because this approach disentangles constant inefficiency due to the institutional form from latent heterogeneity. If this holds true, the null hypothesis in the Kruskal-Wallis test in previous studies applying the TRE model may have been under-rejected (e.g. Farsi et al., 2008). Finally, by comparing net inefficiencies, it is possible to shed further light on differences between private-law and public-law NHs. The Kruskal-wallis test suggests that managerial skills do not differ significantly across institutional forms. It might be that highly skilled managers are equally present in NHs with different institutional forms.

definite. Thus, the concavity condition is not satisfied in any of the specifications, meaning that firms' strategies are not responsive to changes in input factor prices. This can be explained by the fact that input choices in Swiss NHs are substantially limited by the regulation (Filippini and Farsi, 2004). The interpretation of the estimated coefficients in Table 3 relies on the behavioral cost framework proposed by Bös (1986).

The above results can be illustrated by comparing the distribution of the estimated inefficiency scores for Model 1 and Model 2. Figure **??** shows how constant inefficiency due to differences in the institutional form may not be captured by the estimated inefficiency scores of models with individual effects (Model 1). The first graph on the left hand side shows the distribution of inefficiencies estimated according to Model 1 for public-law NHs and private-law NHs. The mean inefficiency level of public-law NHs is slightly higher as compared to the mean inefficiency level of private-law NHs. This difference disappears once we purge the mean inefficiencies from differences in the institutional form (Model 2), as shown in the graph in the middle. Finally, differences are more significant when we include the impact of constant inefficiency due to the institutional form into traditional predicted inefficiencies (last graph to the right).

6 Conclusions

Do NHs with different institutional forms but subject to the same regulatory incentives perform equally? To tackle this question we developed a model of cost efficiency in NHs where firms are local monopolists financed by the regional government through an ex-ante budget. Cost efficiency depends on the institutional form because of different legal constraints faced by the management in the decision-making process and the degree to which the management internalizes the objectives of the board. Our model hypothesizes that private-law institutions, both public and private, can be more efficient than public-law NHs, despite the tight regulation limiting and controlling the behavior of NHs. Using data from Swiss-Italian NHs, we provide empirical evidence that private-law NHs are on average less costly (about 3%) than public-law NHs, *ceteris paribus.* This result is consistent across different econometric approaches and model specifications.

The presence of latent heterogeneity related to patients severity of illness suggests that the TRE model may avoid biased estimates. However, this model suffers from the limitation of interpreting persistent inefficiency as latent heterogeneity. In order to address this issue, we include a dummy variable for the institutional form in the deterministic part of the frontier. The skewed term can be interpreted primarily as an indicator of managerial skills. From a policy point of view, our findings appear to suggest that the provision of nursing care services by publicly-owned organizations run as private-law firms, may be a preferable solution as compared to governmental NHs.

The main shortcoming of the present study is that it does not allow to say whether the efficiency gap results from the reduced probability of bailing out private-law NHs or their higher managerial flexibility. Therefore, efficiency differences are assumed to be the outcome of both factors. Finally, our quality indicator, the nursing staff ratio, may capture only partially differences in quality aspects such as staff experience, organizational skills or patients satisfaction. Further research is necessary to disentangle the impact of quality differences across institutional forms.

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Appendix

Estimated coefficients	OLS	Std.Err.	RE	Std.Err.	FE	Std.Err.
α_Y	0.914***	0.010	0.903***	0.014	0.845***	0.029
α_{Q_1}	0.433***	0.030	0.315***	0.040	0.172***	0.056
α_{Q_2}	0.469***	0.038	0.433***	0.034	0.413***	0.037
α_{P_l}	0.801***	0.016	0.777***	0.017	0.767***	0.019
α_T	0.012***	0.002	0.013***	0.001	0.015***	0.002
α_{YY}	-0.050	0.040	-0.113**	0.054	-0.372***	0.112
$\alpha_{Q_1Q_1}$	0.658***	0.111	0.577***	0.118	0.315**	0.147
$\alpha_{Q_2Q_2}$	-0.283	0.198	-0.193	0.177	-0.167	0.188
$\alpha_{P_lP_l}$	0.130	0.100	0.130	0.089	0.103	0.095
α_{YQ_1}	-0.018	0.081	-0.128	0.091	-0.104	0.114
α_{YQ_2}	0.532***	0.089	0.588***	0.087	0.597***	0.105
α_{YP_l}	0.003	0.039	0.025	0.040	0.047	0.044
$\alpha_{Q_1P_l}$	0.252	0.158	0.208	0.146	0.037	0.159
$\alpha_{Q_1Q_2}$	-1.296***	0.234	-0.845***	0.223	-0.616**	0.244
$\alpha_{P_lQ_2}$	-0.375**	0.170	-0.429***	0.145	-0.435***	0.157
α_z	0.024***	0.007	0.030***	0.011	-	-
α_0	15.346***	0.009	15.341***	0.010	-	-
R^2	0.988		0.987		0.992	

Notes: Significance levels: * = 10%, ** = 5%, *** = 1%.

Table 6: Results of the non-frontier models OLS, RE and FE (287 observations).

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