

Tiemann, Oliver; Schreyögg, Jonas

**Conference Paper**

## Investigating the effects of hospital privatization on performance and quality of care

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Health Policy: Patients, Doctors, Hospitals, No. D18-V3

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Tiemann, Oliver; Schreyögg, Jonas (2010) : Investigating the effects of hospital privatization on performance and quality of care, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Health Policy: Patients, Doctors, Hospitals, No. D18-V3, Verein für Socialpolitik, Frankfurt a. M.

This Version is available at:

<https://hdl.handle.net/10419/37374>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

**Investigating the effects of hospital privatization on efficiency and quality of  
care**

## **Investigating the effects of hospital privatization on performance and quality of care**

### **ABSTRACT**

In this paper, we investigated the post-acquisition effects of privatization on hospital performance in Germany. Our findings show that there was a significant positive impact of privatization on hospital performance. Private for-profit privatizations, in particular, outperformed hospitals privatized by private non-profit organizations, both in terms of efficiency and quality-adjusted efficiency. These key findings remained unchanged after conducting a number of sensitivity checks. Taking the effect of the introduction of DRG payments in 2003 into account it is striking that the efficiency gains of privatized hospitals were significantly larger in the post-DRG era. Moreover, privatized hospitals operating in regions with less competition realize significantly larger efficiency improvements.

### **1. INTRODUCTION**

What kinds of goods and services should be provided by public as opposed to private organizations? Until the mid of the 20th century, governments throughout the world favored public ownership of organizations as soon as market inequities or imperfections, such as monopoly power or externalities, were even suspected. In contrast, during the last two decades governments in market economies have privatized a large number of public organizations in steel, energy, telecommunications, financial services and health care. The evidence on the failures of public ownership (e.g., politically motivated resource allocation), and advances in government contracting and regulation have induced a trend towards privatization. Proponents of privatization are convinced about a positive impact of privatization on the organizational performance, especially in terms of efficiency. In contrast, opponents are concerned about a

divergence between private and social objectives. In particular, non-contradictable quality is expected to vary between public and private organizations due to information asymmetries (Vickers & Yarrow, 1991; Megginson, Nash, & van Randenborgh, 1994; Shleifer 1998). However, a comparable small number of empirical studies have investigated the post-acquisition effects of privatization, and especially the dynamic effects of privatization on the organizational performance. In addition, these studies have data and methodological problems limiting the generalizability of their findings. The hospital market in Germany is a fruitful field for studying the impact of privatization on the organizational performance. It is large, and was subject to an extensive trend towards privatization during the past decade, ensuring an appropriate sample size.

The objective of the present study was to determine the post-acquisition effects of privatization on the organizational performance (i.e. efficiency and quality-adjusted efficiency). To do so, we used a bootstrapped DEA approach followed by a second-step random-effects linear regression model for truncated longitudinal data with bootstrapped DEA efficiency scores as dependent variable. A difference-in-difference specification of the regression model was applied to examine whether privatization improved hospital performance while controlling for patient heterogeneity and the impact of hospital organizational and environmental characteristics. Furthermore, a propensity score matching approach was used to ensure the comparability (i.e. hospital organizational and environmental characteristics, and patient heterogeneity) between the group of privatized hospitals and the control group of non-privatized hospitals. Failing to take proper account of these characteristics can lead to seriously flawed conclusions (Fried, Knox Lovell, Schmidt, & Yaisawarng, 2002).

The paper is structured as follows. The next (i.e. second) section reviews the relevant theoretical and empirical literature on the impact of privatization on the organizational performance. The third section presents the setting, data, and methodology used in this paper to

explore this relationship. The fourth section describes and discusses the estimated results, and the final section draws conclusions and suggests topics for future research.

## **2. THEORETICAL AND EMPIRICAL BACKGROUND**

By ownership, hospitals can be generally divided on the one hand into private hospitals (i.e. private for-profit and private non-profit), invested and owned by private entities (i.e. individual or several private owners) and on the other hand public hospitals, invested and owned mainly by public entities such as governments. In our study privatization is defined as the incidence or process of transferring ownership of a publicly owned organization (i.e. hospital) to the private sector (i.e. non-profit or for-profit).

When selecting central performance criteria for our analysis, we followed the example of other theoretical and empirical studies that have dealt with the evaluation of privatization. In general, there are different concepts used to measure performance of organizations. In predominantly private industries these measures are often return on investment or other profitability measures that are not regarded as appropriate to compare the performance of public and non-profit entities (Leibenstein, 1966; Feldstein, 1967; Ramamurti, 1987; Rees, 1988). As our study design requires a comparison between public, non-profit and private entities, we focus our analysis on technical efficiency, which is a key concept in measuring performance as it refers to the optimal use of resources in the production process. In particular, technical efficiency (i.e. productive efficiency) is a measure of how well an organization produces output from a given amount of input, or alternatively produces a given amount of output with a minimum amount of inputs. In order to address a key limitation of previous studies, our study examines both the efficiency, and the quality (i.e. quality of care) implications of privatization.

## **2.1 Theoretical Perspectives and Development of Hypotheses**

Agency theory, property-rights theory, and public choice theory that underlie most of the extant research on privatization provide different explanations for a common outcome. Private ownership, they hypothesize, is superior to public ownership and that privatization should, therefore, lead to improved performance, i.e. in terms of productive efficiency. These theories emphasize that differences in productive efficiency are due to substantial dissimilarities in objectives, incentives, and control mechanisms between ownership types. The following discussion highlights the main arguments.

The agency theory assumes that managers (i.e. agents) seek to maximize their own utility rather than that of the organization or its owners (i.e. principals). Consequently, in all three types of hospital ownership owners face a principal-agent problem with those whom they hire for the management. Although both public and private hospitals face this problem, it is assumed that especially private for-profit hospitals have better means to solve the principal-agent dilemma and therefore their performance in terms of productive efficiency is expected to differ significantly. The owners of a profit-seeking hospital have profits as their measure of the manager's success. The owner can limit divergences from his interest, by making the manager's compensation a positive function of the profits (i.e. a correlation between profits and managerial salaries and promotions). In addition, the income of executive physicians in private for-profit hospitals might also be tied to hospital's financial performance. Within the public and private non-profit hospitals, individual decision makers rarely have their income tied to the hospital's performance (e.g., pay scales designed for civil servants); therefore no individual has a strong incentive to enforce efficient behavior. Accordingly, it is expected that private for-profit hospitals realize a higher level of efficiency than their public and private non-profit counterparts (Newhouse, 1970; Pauly & Redisch, 1973; Grossman & Hart, 1983; Fama & Jensen, 1983).

According to the property-rights theory, ownership of a firm involves two essential rights: (1) the right to control the firm and (2) the right to appropriate the firm's profits (i.e. financial surplus). Accordingly, the defining difference is that public and non-profit hospitals are precluded from distributing, in financial form, its surplus to those in control of the organization (i.e. non-distribution constraint). Within for-profit hospitals, assigning some of the financial surplus to the individual who manage the hospital thus provides a way to monitor his activities. In this case, it is expected that the monitoring is automatic and self-imposed by the manager and that managers will have strong incentives to behave in the interests of the owners (Clarkson, 1972; Jacobs, 1974; Hansmann, 1988). In addition, potential divergences of interests between owners and managers in private for-profit organizations are further reduced by external mechanisms, including (a) a market for ownership rights that enables the owners to sell their shares if they are not satisfied with managerial performance; (b) the threat of takeover; (c) the threat of bankruptcy; and (d) an extensive managerial labor market (Cuervo & Villalonga, 2000). Thus, property-rights theory assumes that private for-profit ownership is associated with a higher efficiency compared to the other types of ownership.

As part of public choice theories Buchanan and Tollison (1972), Niskanen (1975), and Shleifer and Vishny (1994) argue that politicians impose their objectives on public organizations in order to gain votes, which may conflict with profit maximization and, therefore, with productive efficiency. In the case of private non-profit providers Newhouse (1970) and Weisbrod (1988) argue that, because they lack the incentive to maximize profit, they should be expected to diverge from strict cost- or inefficiency-minimizing behavior and instead maximize quality, quantity, and/or prestige. Sloan (2000) supports this view and adds that productive efficiency will decay if objectives are vague and contradictory, which is typically the case in public and private non-profit hospitals.

According to the theories mentioned above, the rationale for privatization is that it implies a change in organization's objectives, incentives, and control mechanisms, which, in turn, lead to improved productive efficiency. Public hospitals acquired by a private for-profit organization are expected to maximize profits on the basis of a high level of productive efficiency. These hospitals will produce services to the point where the marginal costs equal the marginal revenue. Public hospitals acquired by a private non-profit organization are assumed to suppress the politically motivated resource allocation in order to improve efficiency. These hospitals will expand their output at least to the point where the hospital just breaks even – that is, where the total cost equals total revenue (Haskel & Szymanski, 1993; Shleifer & Vishny, 1994; Bös, 1991; Boycko, Shleifer, & Vishny, 1996; Laffont & Tirole, 1993; Sappington, 1987; Schmidt, 1996; Vickers & Yarrow, 1997; Steinberg, 2006).

*Hypothesis 1a. Privatization leads to improved hospital efficiency.*

*Hypothesis 1b. Hospitals acquired by private for-profit organizations outperform hospitals acquired by private non-profit organizations in terms of productive efficiency.*

The character of privatized public services (e.g., education, health care, public transportation) often implies that the service quality is one major objective in addition to efficiency. Indeed, quality of care is one major objective for hospitals in addition to efficiency. For the hospital sector, a common theoretical assumption is that better quality of care requires more resources and therefore reduces efficiency. It is further assumed that due to information asymmetries between hospitals and other actors (e.g., patients and purchasers) hospitals may be able to vary their quality of care (Newhouse, 1970; Weisbrod, 1988). However, differences in the trade-off between productive efficiency and quality of care among public and private non-profit providers have attracted little attention from a theoretical point of view. Given the strong efficiency focus



of private for-profit providers it is argued that due to the trade-off those hospitals offer a lower quality of care than hospitals of other ownership types. In contrast, private non-profit and public hospitals allow more room for objectives other than efficiency and are therefore able to provide a higher quality of care than private for-profit hospitals.

Another group of theorists argues that particularly physicians represent a group that is typically acting driven by high intrinsic motivation (Arrow, 1963; Zismer, 1999; Feess & Ossig, 2007). Thus, physicians are intrinsically motivated to deliver high quality of care. The enhanced behavioral discretion conditioned by the non-distribution constraint of public and private non-profit hospitals might provide a fruitful field for intrinsic motivation of physicians to act in the patient's best interest. In contrast, the extrinsic motivation conditioned by financial incentive schemes usually provided in private for-profit hospitals can be expected to result in a crowding out of intrinsic motivation (Osterloh & Frey, 2000; Frey & Jegen, 2001). This effect lends support to the notion that private for-profit hospitals provide a lower quality of care. However, as physicians have to act in accordance with regulations and ethical rules (e.g., clinical guidelines, Hippocratic Oath) a certain minimum standard of quality of care will be ensured.

*Hypothesis 2. The improvements in productive efficiency of privatized hospitals will decrease if quality of care is taken into account to determine efficiency (i.e. quality-adjusted efficiency) due to an inevitable trade-off between efficiency and quality of care.*

## **2.2 Empirical Evidence**

In general there are two types of studies that deal with ownership and privatization. The first type of studies compares the performance of public and private entities in industries in which both types of ownership coexist. There are a large number of these cross-sectional studies in the literature. Meta reviews for this type of studies on different industries including the hospital industry conclude that the usual assumption that private for-profit hospitals outperform other ownership types can not be supported by the available studies (Villalonga 2000; Shen 2007). However, this type of studies does usually not investigate ownership changes and thus does not focus on the effects of privatization of public entities. Therefore, the second type of studies, which is rather scarce compared to the first, focuses on the effects of privatization on organizational performance and usually uses a longitudinal design.

From a methodological perspective the literature followed two different approaches to evaluate privatization effects. The first approach was initiated by Megginson et al. (1994) who compared means and medians of the periods before and after privatization according to defined performance criteria. Few of these studies have incorporated control groups of non-privatized state-owned organizations into this design. The second stream of literature used much larger sample sizes of privatized entities and regarded the privatization event as an intervention and thus applied methods proposed in the program evaluation literature (Heckman and Hotz 1989; Heckman, Ichimura, & Todd 1997). The majority of these studies used some sort of difference-in-difference approach comparing the privatization effects on performance relative to the performance trend in the control group of non-privatized entities and thus controls for time invariant differences between the groups. We identified the following studies which used a difference-in-difference approach to evaluate privatization effects: Frydman et al. (1999); La Porta and López-de-Silanes (1999); Picone et al. (2002); Shen (2002); Shen (2003); Beck et al.

(2005); Gupta (2005); Loc et al. (2006); Jefferson and Su (2006). Out of these only one study has addressed problems arising from causal inference (Shen 2002). Shen (2002), who focused on effects of privatization on quality, used a difference-in-difference approach in combination with a matching approach.

The available studies use a large variety of performance criteria to measure the impact of privatization. Most studies use financial performance criteria, some studies use measures of efficiency or productivity and only few studies use quality as a performance criteria. In the context of privatization the use of financial performance criteria may however lead to bias. This is due to fact that public entities are rather encouraged to show profit in financial reports as they may even fear budget cuts in the next year. In contrast privatized entities have access to the capital market and are thus incentivized to show the highest possible profits in their reports to attract investors. This problem arises in pre-post comparisons of privatized entities as well as control group designs. For this reason productivity or efficiency may be more adequate criteria to measure changes in performance.

Moreover, privatization tends to occur in public service industries where the quality of produced services or goods is of particular interest for the general public. Public or privatized entities in these industries do either have a public mandate to deliver at a defined level of quality or privatization processes are even initiated with the aim of increasing the quality of goods and services. Thus, quality can be regarded as important performance criteria in privatization processes in addition to efficiency or productivity. Among the three studies that used quality as performance criteria two studied the quality of care in the hospital industry and found that private for-profit privatization had a significant negative impact on the quality of care (Picone, Chou, & Sloan 2002; Shen 2002). This may lead to the assumption that there is trade-off between the two goals of increasing efficiency or productivity on the one hand and increasing quality on the other

hand. The trade-off between these two performance measures has not been investigated so far in the context of privatization. However, studies examining the trade-off between efficiency and quality in the hospital context have provided evidence for a trade-off between these two measures (Morey, Fine, Loree, Retzlaff-Roberts et al. 1992; Deily & McKay 2006).

Finally, the majority of studies implicitly assume that changes in performance can be primarily attributed to the ownership conversion. However, there may be other changes to the market environment such as the introduction of yardstick competition that have a substantial impact or interact with the privatization event. Only few studies have investigated interaction effects with privatization so far (Frydman et al. 1999; La Porta & López-de-Silanes 1999; Gupta 2005). Also differences in the ownership structure and the underlying incentives may explain differences in performance in privatization processes e.g. differentiation of non-profit and for-profit privatizations. We found the following papers that explicitly address the issue of different ownership structures (Frydman et al. 1999, Shen 2002, Shen 2003; Loc et al. 2006).

In this paper we explore the impact of hospital privatization on efficiency and quality in Germany. In doing so we consider a possible trade-off between efficiency and quality that may occur during the privatization process. We also examine the interaction effects between privatization and the competitive environment in which a privatization takes place as well as the interaction between privatization and the introduction of yardstick competition. In our analysis we differentiate between non-profit and for-profit privatizations. Finally, our econometric strategy aims to control for time invariant differences and causal inference by using a difference-in-difference matching approach.

### **3. RESEARCH DESIGN AND METHODS**

#### **3.1 First stage: Data Envelopment Analysis**

In the hospital sector, data envelopment analysis has been the most frequently used approach for measuring efficiency (Hollingsworth, 2008). DEA is a linear programming technique for evaluating the relative efficiency of individual organizations based on observed data. The relative efficiency of an organization is defined as the ratio of the weighted sum of its outputs to the weighted sum of its inputs. The weights are not pre-assigned, but rather determined by the model, thus avoiding any bias resulting from subjectively assigned weights. DEA assesses the efficiency of organizations in two stages. First, the location and the shape of the efficiency frontier are determined based either on organizations that use the lowest input mix to produce their outputs or on organizations that achieve the highest output mix given their inputs. The efficiency frontier is constructed by joining these observations and all linear observations in the input-output space. In our study, we used an input-oriented DEA approach to address the following question: "To what extent can the input factors, defined as supplies and labor, be reduced proportionally without changing the output quantities of hospitals?" Second, DEA measures inefficiency as the radial distance from the inefficient unit to the frontier and produces an efficiency score that reflects the relative efficiency of each unit (Cooper, Seiford, & Zhu, 2004).

DEA allows multiple inputs and outputs to be considered simultaneously, which seems particularly well-suited for measuring the efficiency of complex service organizations such as hospitals. In contrast to parametric methods, where a specific pre-defined functional form is assumed to apply to each observation, DEA has the advantage of requiring no assumptions about the functional form of the production or cost frontier. Although this reduces the need for a theoretical exposition of the model specification, there are other important considerations. The DEA results are sensitive to the number of variables included in the model. In general, the

number of inputs and outputs is limited by the sample size, which should not exceed one-third of the number of observed units (Banker, Charnes, Cooper, Swarts, & Thomas, 1989). It is important to recognize that the inputs and outputs are collected routinely by hospital accounting departments, making measurement errors less relevant. Based on our understanding of the market constraints within the German hospital sector, we assumed variable returns to scale, which may be appropriate when it is impossible to assume that all observed units are operating at an optimal scale (Banker, Charnes, & Cooper, 1984). In the healthcare sector, imperfect competition and budgetary constraints, as well as regulatory constraints on entry, mergers, and exits, may often result in organizations operating at an inefficient scale size (Jacobs, Smith, & Street, 2006).

### **3.2 Second Stage: Truncated Linear Regression Model**

In the second stage of our analysis, we applied a random-effects linear regression model for truncated longitudinal data with DEA efficiency scores as dependent variable. A difference-in-difference specification of the regression model was used to assess whether privatization led to improvements in organizational performance (i.e. relative efficiency and quality-adjusted efficiency) while controlling for patient heterogeneity and the impact of hospital organizational and environmental characteristics. Truncated regression models became the favored approach owing to the truncated distribution of the DEA-based relative efficiency estimates (Simar & Wilson, 2007). However, this approach has been found to result in inconsistent estimates unless the DEA efficiency scores are corrected by a bootstrapping procedure. The procedure applied in the present study follows the bootstrap approach developed by Simar and Wilson (1998, 2000). For our study, the bias-corrected scores were derived from 500 bootstrap iterations, which allowed us to estimate a robust regression model as the second-stage analysis (Simar & Wilson, 2007).

Based on our theoretical framework, the following empirical model was used in the analysis. In the input-oriented case, the variable returns to scale variant of the BCC (Banker, Charnes, and Cooper) model can be formulated as a linear programming problem as shown below (Banker, et al., 1984).  $\theta_i$ ,  $i = 1, \dots, n$ , is the hospital's efficiency where  $n$  represents the number of observations (i.e. the number of hospitals). Matrix  $\mathbf{X} \in \mathbb{R}^{k \times n}$  refers to  $k$  observed inputs of  $n$  compared hospitals and matrix  $\mathbf{Y} \in \mathbb{R}^{r \times n}$  refers to  $r$  observed outputs of the compared hospitals. Vectors  $\mathbf{x}_i \in \mathbb{R}^k$  and  $\mathbf{y}_i \in \mathbb{R}^r$  present the inputs and outputs of unit  $i$ , i.e. the  $i$ th columns of matrix  $\mathbf{X}$  and  $\mathbf{Y}$  respectively. Furthermore,  $\mathbf{1}$  refers to a column vector of ones with a suitable dimension. The DEA efficiency score, which is the reciprocal of the inefficiency,  $\theta_i$  can be obtained by solving the following BCC linear programming model:

- (1)  $\mathcal{G}_i = \text{Max } \theta_i$ ,
- (2) s.t.  $\mathbf{Y}\lambda - \mathbf{y}_0 \geq 0$ ,
- (3)  $-\mathbf{X}\lambda + \theta_i \mathbf{x}_0 \geq 0$ ,
- (4)  $-\mathbf{X}\lambda + \theta_i \mathbf{x}_0 \geq 0$ ,
- (5)  $\mathbf{1}^T \lambda = 1, \lambda \geq 0$ .

In the second step, we estimate:

$$(6) \mathcal{G}_{it} = \beta_0 + \beta_1 PRIV_i + \beta_2 POST_t + \beta_3 PRIV_i POST_t + \beta_4 Z_{it} + \varepsilon_{it}$$

where  $\mathcal{G}_{it}(\theta_1, \dots, \theta_n)$  is defined as the truncated set of  $\mathcal{G}_1, \dots, \mathcal{G}_m$  with  $\mathcal{G}_j \leq 1$  is the efficiency of the  $i$ th hospital at year  $t$ ,  $t = 1, \dots, 12$ .  $PRIV_i$  is a dummy variable for privatization where  $PRIV_i$  is assigned a value of 1 if a hospital was privatized at anytime between 1996 and 2007; 0 otherwise.  $POST_t$  is assigned a value of 1 in the years after privatization and 0 before (and including) the year the hospital changed its ownership status to private for-profit or private non-profit.  $Z_{it}$  is a vector of observable factors affecting the

efficiency of hospital  $i$  at year  $t$  (i.e. hospital characteristics, environmental characteristics, and patient heterogeneity). The random term  $\varepsilon_{it}$  is assumed to be normally distributed with zero mean.

The variable  $PRIV_i$  is included to control for time invariant differences between privatized public hospitals in the treatment group and non-privatized public hospitals in the control group. The coefficient of interest is the one of the interaction between  $PRIV_i$  and  $POST_t$ . It identifies the changes in performance after a hospital is privatized relative to the performance development in the comparator group. The DiD methodology assumes that all other temporal factors affecting hospital performance have the same impact for hospitals in the treatment and in the comparator group. Thus, we assume any changes over time that we do not control for affect all hospitals in the same way. For sensitivity purposes and to check the robustness of our estimates we allowed two alternative pre-privatization periods (i.e. 1 and 2 years) and four alternative post-privatization periods (i.e. 1, 2, 3 and 4 years). The pre-period is defined as the year before privatization and including the year that the hospitals changed its ownership status.

While the difference-in-differences estimator has the advantage of eliminating unobserved time-invariant hospital-level effects between non-privatized public hospitals and privatized public hospitals. However, it does not address the problem of baseline imbalance between the groups, i.e. differences in characteristics between the groups prior to privatization may be large, leading to selection bias. Thus, the results may be very sensitive to the model specification and the regression is effectively extrapolating outside of the support of the data. In this situation matching methods such as propensity score matching have been shown to avoid unreliable inference from parametric models. In this situation propensity score matching is one strategy to reduce this problem of causal inference. While the use of matching estimators alone is usually unsatisfactory



due to the strong assumption that selection is only based on observables several authors propose that a combination of difference-in-differences and propensity score matching methods increases the quality of non-experimental evaluation results significantly (Blundell & Dias, 2000; Smith & Todd, 2005).

In our case there are obvious imbalances between the two groups since the differences in the mean for most characteristics are large (see Table I). In order to make the groups more similar and to reduce selection bias both samples were matched according to defined covariates. To do so, we applied a propensity score matching approach proposed by Rosenbaum and Rubin (1983) and extracted a sub-sample of non-privatized hospitals in which the distribution of covariates was similar to the distribution in the sample of privatized public hospitals. In the first step, we estimated the conditional probability (referred to as propensity score) that any hospital in the two samples had been privatized during the study period given the vector of our defined covariates. The propensity scores were derived by performing a logistic regression. In order to achieve a propensity score model that minimizes the conditional bias it is important to determine predictors and confounders of the treatment–outcome relationship and to identify predictors of exposure (Austin, 2008). In order to determine appropriate predictors of exposure we tested different models allowing for interactions between our defined set of hospital, environmental and patient characteristics (detailed explanation for definition of characteristics is given Section 4.2). Subsequently, we calculated the predicted probabilities of belonging to the sample of privatized public hospitals. Based on this score, each non-privatized public hospital was matched to one privatized public hospital. As the propensity score was the only pre-treatment measurement, the matching algorithm minimized the absolute differences in propensity score (Rosenbaum, 1989). By using one-to-one matching with replacement, the total distance of matched pairs was also minimized, i.e. optimal matching. This method ensures that conditional bias is minimized (Rubin,

1973; Rosenbaum, 2002; Rubin, 2006). The number of pairs in the matched sample was further restricted by using calipers of width of 0.2 of the standard deviation. A comparison of different caliper widths found that a width of 0.2 of the standard deviation had superior performance for estimating treatment effects in order to reduce conditional bias (Austin, 2009). Appropriateness of the matching was assessed using standardized differences statistics for continuous variables and differences statistics for non-continuous variables as recommended by Austin (2008). Standardized differences represent a good measure for appropriateness of the matching as they do not depend on the unit of measurement or the size of the sample (see Table 1; Imai, King, & Stuart, 2008). We follow Rosenbaum and Rubin (1985) who suggest that a value of  $d_i > 20\%$  can be considered a balance imbalance.

-----  
Insert Table 1 about here  
-----

An important assumption of our study was that environmental and organizational factors may influence the performance of hospitals in addition to the change in ownership status (i.e. privatization). By considering the impact of covariates reflecting environmental and organizational factors on hospital performance we believe to provide a better explanation of the variation of performance and more robust results about the post-acquisition effects of privatization than previous studies that did not control for these effects. The use of control variables is of particular importance in the healthcare context because there are usually certain structural or regulatory determinants of hospital performance that a hospital cannot influence.

## **4. DATA**

### **4.1 The sample**

In Germany, approximately 1,800 hospitals provide inpatient care and receive DRG payments from social health insurance funds and private health insurance companies. The data for our study were derived from the annual hospital reports collected and administered by the Research Data Centre of the Statistical Offices of the Länder (Forschungsdatenzentrum der Statistischen Landesämter, 2008). This rich dataset covers all public, private for-profit, and private non-profit hospitals in Germany and contains hospital-level information on costs and hospital infrastructure, as well as patient-level information on age, diagnoses, and certain procedures performed per case. Our study is based on data from the fiscal years 1996 - 2007, and the unit of analysis was the hospital. Because of data privacy issues, we were able to obtain randomly selected data from only two-thirds of German acute care hospitals ( $n = 1,389$ ; including 127 hospitals that were privatized between 1996 and 2007). To ensure the comparability of the hospitals in the sample, hospitals providing only psychiatric care, day clinics, and hospitals with fewer than 50 beds were excluded from further analysis. In addition, content-based plausibility checks were conducted to reveal measurement errors. Finally, a total of 1,015 hospitals remained in the sample, including 86 privatized public hospitals between 1996 and 2007 (i.e. 70 public hospitals were acquired by a private for-profit organization, while 16 public hospitals were privatized by private non-profit organizations).

### **4.2 Description of variables**

When selecting inputs and outputs for the first-stage of our analysis, we followed the example of other studies that developed DEA frameworks for measuring hospital efficiency (Pilyavsky, Aaronson, Bernet, Rosko, Valdmanis, & Golubchikov, 2006; Jacobs et al., 2006; Burgess &

Wilson, 1998). For the purposes of our study, six inputs and two outputs were considered. The first input variable (SUPPLIES) is the amount spent on supplies per year, including operational expenses, but excluding payroll, capital, and depreciation expenses. Taking into account the relative importance of resource use in terms of labor in the hospital production process, additional input variables were the number of full-time equivalents (FTE) for the following personnel categories: clinical staff (CLIN), nursing staff (NURSE), medical-technical staff (MEDTECH), administrative staff (ADMIN), and other staff members (OTHER).

The first output variable (INPATIENT) reflects the number of treated inpatient cases per year in each hospital. To adjust for variations in the quality of care between hospitals, we used the average mortality rates per year in each hospital. Therefore, the second output represents 1 minus the average hospital mortality rate per year ( $1 - \text{MORTALITY}$ ). This could lead to the concern that patient heterogeneity (i.e. case mix) might vary systematically across the hospitals in our sample, which would be problematic because hospitals with a more complex case mix should receive lower efficiency scores in the first stage of our analysis. To help address this potential issue, we included case-mix measures in our regression analysis as control variables (see further details in section 3.2). Two model specifications were used. The first efficiency model (DEA I) used INPATIENT as the only output variable, whereas the second DEA model (DEA II) reflects quality of care using  $1 - \text{MORTALITY}$  as a second output.

A correlation analysis showed that our multiple inputs are positively correlated with our output set. This is an important prerequisite for applying DEA. In addition, subsets of inputs and outputs are often correlated. In our study especially the input variables are highly correlated. This might suggest that a limited number of inputs might adequately represent the selected input set in our efficiency assessment. However, several authors (e.g., Dyson, Allen, Camanho, Podinovski, Sarrico, and Shale 2001; Jacobs et al., 2006) argue that omission of a highly correlated variable

can lead to significant changes in the efficiency estimates. They emphasize that correlation is an aggregate measure of the closeness of two sets of observed data. Therefore, variations of the input levels of individual hospitals may have little effect on the correlation, but significant effect on the measured efficiency. It may also give evidence for a possible production technology that is common among all decision-making units. In addition Dyson et al. (2001) argue that the omission of variables in order to increase discrimination is less relevant for large data samples. Thus, we used all input variables for our DEA model.

In the second stage of our analysis, heterogeneity in hospital characteristics was covered by the following variables. The first of these was the number of licensed and staffed beds (BEDS), an approach taken in previous studies to control for hospital size (Carey & Burgess, 1999; Dudley, Johansen, Brand, Rennie, & Milstein, 2000; Harrison, Coppola, & Wakefield, 2004). In the context of hospital planning in Germany, the number of beds per hospital can be seen, at least in the medium term, as an exogenous factor which is not under direct control of the hospital management. To account for higher resource consumption due to differences in teaching activities, we included a variable (TEACH) for the training of non-medical staff. These activities are represented by the ratio of trainee positions to the sum of all non-medical personnel. Another important point is that hospitals may hire out beds to self-employed ambulatory physicians (e.g., for ambulatory surgery). The estimated DEA efficiency scores in the first stage of our analysis were higher for these hospitals because the referring cases were counted as hospital output, whereas the corresponding resource use in terms of physicians was not considered on the input side. To control for this fact, we considered the proportion of all hospital beds that had been hired (HIRED BEDS) as variable in the regression models.

The set of explanatory variables representing the different environmental characteristics were as follows. The most important regressor is the Hirschman-Herfindahl index (HHI), which

measures competitive pressure in a hospital's market, a standard economic measure of industry concentration. The market area was defined as the county in which a hospital was located, which is a frequently used definition in hospital studies (Chang, Chang, Das, & Li, 2004; Rosko 1999, 2001, 2004; Rosko & Chilingerian, 1999; Chirikos & Sear, 1994). Although there has been some controversy about the appropriate definition of a hospital's market area, Garnick, Luft, Robinson, and Tetreault (1987) reported that, for the purpose of measuring competitive activity, it made little difference whether a hospital's market was defined as a county or as a radius. The HHI is obtained by squaring the regional market share of a hospital (reflected by the distribution of treated cases), and then summing the market shares of admissions for all of the hospitals in the county. The higher the HHI, the more concentrated the regional market. We used HHI to measure the effects through the changes over time in hospitals' competitive environment. This specification allowed us to differentiate between the effects of privatization and the effects of changes in market structure resulting from recent healthcare reforms. The most significant reform in recent years was the introduction of a new system of reimbursement based on diagnosis-related groups (DRGs). The chief motivation behind this fundamental overhaul of the old reimbursement system, which was based on per-diem charges, was to set financial incentives that would increase the efficiency of German hospitals (Schreyögg, Tiemann, & Busse, 2006). Therefore, we defined a dummy variable (DRG) which is assigned a value of 1 in the post-DRG era (i.e. 2003-2007).

Because resource consumption can vary substantially between patients, we also included case-mix variables to control for variations associated with case-mix complexity. We used patient-level information on diagnoses, and age to control for patient heterogeneity. To control for case-mix complexity, we compiled a comprehensive list of co-morbidities that have been found in other studies to affect mortality and resource use. This set of comorbidities was condensed to a single numeric score that summarizes disease burden, resource use and is adequately

discriminative for mortality in hospitals. In doing so, we relied on the Elixhauser Comorbidity Measures (Walraven, Austin, Jennings, Quan, & Forster, 2009). To control for the age of the patient population, we considered the proportion of all patients over the age of 65 years as variable (AGE) in the regression models. Thus, the full set of case-mix measures are included in all of the regression models deployed in our second-stage analysis. Another common approach would be to use the case-mix index whose weight reflects the relative costliness of DRGs. However, Carey (2000, 2002) reported that individual-level measures represent a vast improvement over aggregate case-mix measures and that the DRG case-mix index is therefore a relatively weak measure of sickness to control for patient heterogeneity.

## **5. FINDINGS AND DISCUSSION**

The regression results for the two different regression models (i.e. model I with DEA efficiency scores, and model II with quality-adjusted DEA efficiency scores as dependent variable) are summarized in Table 2. In addition, table 2 shows the differences between private for-profit and non-profit privatizations, and the regression results after propensity score matching. A correlation analysis of our explanatory variables suggested that multi-collinearity was not an issue in our study. The coefficients can be interpreted as marginal effects. The coefficients of interest are the ones of the DiD interaction between the variables PRIV and POST (for further details see section 3.2). The interaction terms identify the changes in performance after a hospital is privatized relative to the performance development in the comparator group.

The regression results for privatized hospitals (i.e. private for-profit and non-profit privatizations) in the first model showed that there was a significant increase in efficiency after privatization compared to the control group. For instance, four years after their privatization hospitals realized a 1.3-3.5% higher efficiency than their non-privatized public counterparts.

However, private for-profit privatizations, in particular, outperformed hospitals privatized by private non-profit organizations. These findings support our first hypotheses (i.e. 1a, and 1b) and are in line with the arguments put forward by authors in the field of agency theory and property-rights theory, as well as public choice theory. It is assumed that private for-profit entities have a stronger efficiency focus than their private non-profit counterparts. In addition, the increase of efficiency after positive privatization is consistent with the results of several earlier empirical studies which, however, as mentioned above, have certain methodological limitations.

We applied a set of explorative regressions to get an in-depth understanding of the restructuring that occurred after private for-profit privatizations in order to increase efficiency. Therefore, we applied the same model specification to determine the impact of privatization on the quantity and composition of resource use (i.e. input variables of the first-stage analysis as dependent variables). These explorative regressions revealed that nearly all labor inputs (i.e. nursing staff, medical technicians, administrative staff, and other staff) were substantially reduced in the post-privatization period, except clinical staff. Our finding that only the number of clinical staff remained unchanged might be explained by the fact that hospitals are different from most other organizations. Hospitals often have two lines of internal authority - medical and managerial. Executive physicians are often involved the decision making process and determine resource allocation in a given hospitals. Thus, it is likely that in this way they avoid reductions in clinical staff. Another explanation may be that no reductions of clinical staff may be a kind of compensation payment to physicians for coping with organizational changes associated with privatization and to avoid resistance to change.

-----  
Insert Table 2 about here  
-----



According to our second hypothesis a trade-off between efficiency and quality of care would imply that the consideration of quality of care to determine efficiency (i.e. model II with dependent quality-adjusted DEA efficiency scores) leads to lower efficiency gains compared to model I with DEA efficiency scores as dependent variable. In contrast to the assumed behavior, the efficiency gains of privatized hospitals were larger when quality of care was considered as an additional output, both for non-profit and for-profit privatizations. Thus, our findings do not confirm a trade-off between efficiency and quality of care and our second hypothesis has to be rejected. Moreover, our results indicate that privatized hospitals provide a higher quality of care than before their privatization. As mentioned above, theoretical approaches assume that information asymmetries exist in the hospital market and thus particularly for-profit hospitals have the incentive (i.e. profit-seeking) to increase productive efficiency at the expense of quality of care. However, in the German hospital sector information asymmetry has decreased over the last decade due to a variety of healthcare reforms aiming at quality assurance (e.g., mandatory publication of quality reports). Furthermore, the mentioned theoretical approaches do not account for the strategic importance of quality of care in markets with substantial overcapacities (i.e. cutthroat competition). There is evidence that private for-profit hospitals (and especially private for-profit hospital chains) operating in more competitive regions have improved their quality management and hospital outcomes in order to attract patients (Busse, Nimptsch, & Mansky, 2009).

Among the control variables, market concentration and the introduction of a new system of reimbursement based on DRGs were important exogenous market effects, and the regression results revealed a significant positive association with the post-acquisition performance in terms of efficiency for all three models ( $P \leq 0.01$ ). In particular, the efficiency gains of privatized hospitals were significantly larger in the post-DRG era. This finding is in line with the arguments

put forward by authors in the field of the economics of regulation. The introduction of a new system of reimbursement based on DRGs induced a yardstick competition that set strong incentives to increase the individual efficiency. The DRG system is based on a mechanism in which the price per case the hospital receives depends on the average costs per case in the market (Shleifer, 1985; Schreyögg et al., 2006).

Our finding in terms of the impact of competition on the post-acquisition efficiency is likely to be thought-provoking, because it is counter-intuitive and not in line with classical economic theory. Sheshinski and Lopez-Calva (2003), in summarizing the theoretical literature, argue that there should be lower efficiency gains of privatized organizations in non-competitive markets as compared to those that are under the discipline of a competitive market. It is assumed that organizations in monopolistic or oligopolistic markets restrict output and have higher average costs and a lower productive efficiency than competitive organizations. In our study, market competition was measured using the Hirschman-Herfindahl index, which is defined over a range between zero and one such that increases in HHI correspond to decreases in competition. Therefore, the significant positive association lends support to the notion that the behavior of privatized entities is highly affected by competition in the German hospital market, though in a direction that is inverse to that expected and seen in markets for most other goods and services. In particular, we found that privatized hospitals operating in regions with less competition realize significantly larger efficiency gains.

In the German context, this finding is also related to the strict regulations in place regarding hospital planning. Competition between hospitals in Germany does not occur primarily in terms of individual patients, but with regard to the optimal fit of demand and supply in terms of hospital infrastructure (e.g., specialties, departments, number of beds). Our findings indicate that hospitals operating in monopolistic or oligopolistic markets are more likely to agree with the hospital

planning authorities on a hospital infrastructure that enables a convergence of demand and supply in the referring county. Overcapacities in urban areas result in greater competitive pressure (i.e. cutthroat competition), whereas counties with lower competitive pressure are likely to be more rural. As a regulatory instrument, hospital planning is supposed to lead to optimal hospital infrastructure and efficiency. Our results indicate, however, that this is a questionable assumption that needs to be addressed by further research. However, Rosko (1999, 2001, 2004) and Rosko and Chilingirian (1999) found efficiency in the US hospital sector to be negatively related to market competition, a finding similar to that in our own study.

As expected, other control variables also had a significant impact on hospital performance; the two case-mix variables (i.e. CMXI, and AGE), in particular, had a major explanatory value. Our set of case-mix variables accounted for approximately two-thirds of the explained variance in the three full models (based on ordinary least square estimates), which indicates the importance of adjusting for patient heterogeneity.

Our study has a number of strengths and adds value compared to previous approaches. First, it applies a more refined approach to investigate the post-acquisition effects of privatization on the organizational performance. To our knowledge, it is the first quantitative study to examine the effects of privatization on efficiency and quality of care using a panel data approach based on bootstrapped DEA efficiency scores. Second, this study adds value by using a difference-in-differences matching approach addressing problems arising from causal inference and time invariant differences at the same time. Third, our panel of privatized organizations is large ( $n = 86$ ), providing greater statistical power than in previous studies leading to more robust estimates. Third, the sample is rich, containing a large set of information (i.e. environmental and organizational characteristics) that allowed us to control appropriately for determinants of performance in addition to the impact of privatization, and is likely to have yielded more

consistent results. Fourth, to our knowledge, this is the first study on the post-acquisition effects of privatization on the organizational performance that incorporates quality and efficiency measures.

Our study also has several important limitations. First, additional inputs and outputs (e.g., ambulatory cases as an additional output, or capital as an additional input) would have helped us capture more of the resources required in and all of the output produced from the hospital production process. Considering the number of outpatient cases in addition to inpatient cases is generally recommended in order to measure patient care output (Jacobs et al., 2006). We intended to include a proxy for hospital outpatient activities (e.g., outpatient surgery). However, data inconsistencies and measurement errors did not allow us to use this information for further analysis.

Including other explanatory factors in addition to environmental and organizational characteristics might have provided a better explanation of variation in our estimates, thus potentially affecting our interpretation of the relationship between privatization and organizational performance. Another limitation may be that this study uses mortality as the only indicator for quality of care. Finally, our study employed only DEA, although it would have been possible to use SFA in addition to DEA. SFA was not included in the analysis, however, because it relies on assumptions about the functional form of the production or cost frontier that we aimed to avoid. Further, Linna (1998) found that both methods yielded comparable results for individual performance.

## **6. CONCLUSIONS**

In this paper, we investigated the post-acquisition effects of privatization on hospital performance in Germany. Our findings show that there was a significant positive impact of

privatization on hospital performance. Private for-profit privatizations, in particular, outperformed hospitals privatized by private non-profit organizations, both in terms of efficiency and quality-adjusted efficiency. These key findings remained unchanged after conducting a number of sensitivity checks. Taking the effect of the introduction of DRG payments in 2003 into account it is striking that the efficiency gains of privatized hospitals were significantly larger in the post-DRG era. Moreover, privatized hospitals operating in regions with less competition realize significantly larger efficiency improvements. The ongoing trend towards privatization in Germany may be an appropriate way to ensure a better use of the scarce resources in the hospital sector, because privatized hospitals appear to use relatively fewer resources and to provide a higher quality of care than before their privatization. Another important implication is that hospitals' behavior is highly affected by environmental characteristics (i.e. competition and reimbursement schemes) in the hospital sector. Additional longitudinal studies are thus needed to measure and compare the impact of the introduction of DRG payments on hospital performance. This could be a fruitful way to gain a better understanding of the incentives and behavioral consequences of the induced yardstick competition.

## 7. REFERENCES

- Arrow, K. J. 1963. Uncertainty and the Welfare Economics of Medical Care. *American Economic Review*, 53(5): 941-973.
- Austin, P. & Mamdani, M. 2006. A comparison of propensity score methods: a case-study estimating the effectiveness of post-AMI statin use. *Statistics in medicine*, 25(12): 2084.
- Austin, P. 2007. Propensity-score matching in the cardiovascular surgery literature from 2004 to 2006: A systematic review and suggestions for improvement. *The Journal of Thoracic and Cardiovascular Surgery*, 134(5): 1128-1135.
- Banker, R., Charnes, A., & Cooper, W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9): 1078-1092.
- Banker, R., Charnes, A., Cooper, W., Swarts, J., & Thomas, D. 1989. An introduction to data envelopment analysis with some of its models and their uses. *Research in governmental and nonprofit accounting*, 5: 125-163.
- Beck, T., Cull, R., & Jerome, A. 2005. Bank privatization and performance: Empirical evidence from Nigeria. *Journal of Banking & Finance*, 29(8-9): 2355-379.
- Blundell, R. 2000. Evaluation methods for non-experimental data. *Fiscal Studies*, 21(4): 427-468.
- Bös, D. 1991. *Privatization: a theoretical treatment*: Oxford University Press.
- Boubakri, N. & Cosset, J. 1998. The financial and operating performance of newly privatized firms: Evidence from developing countries. *The Journal of Finance*, 53(3): 1081-1110.
- Boycko, M., Shleifer, A., & Vishny, R. 1996. A theory of privatisation. *The Economic Journal*, 106(435): 309-319.
- Buchanan, J. & Tollison, R. 1972. *Theory of public choice*. Ann Arbor: University of Michigan Press.
- Burgess, J. & Wilson, P. 1998. Variation in inefficiency among US hospitals. *Information Systems and Operational Research*, 36(3): 84-102.
- Busse, R., Nimptsch, U., & Mansky, T. 2009. Measuring, Monitoring, And Managing Quality In Germany's Hospitals: Germany has made progress in measuring quality in hospitals and is extending its effort into its statutory health insurance system. *Health affairs*, 28(1).
- Carey, K. & Burgess Jr, J. F. 1999. On measuring the hospital cost/quality trade-off. *Health economics*, 8(6): 509-520.
- Carey, K. 2000. A multilevel modelling approach to analysis of patient costs under managed care. *Health economics*, 9(5): 435-446.
- Carey, K. 2002. Hospital Length of Stay and Cost: A Multilevel Modeling Analysis. *Health Services and Outcomes Research Methodology*, 3(1): 41-56.
- Chang, H., Chang, W.-J., Das, S., & Li, S.-S. 2004. Health care regulation and the operating efficiency of hospitals: Evidence from Taiwan. *Journal of Accounting and Public Policy*, 23(6): 483-510.

- Chirikos, T. & Sear, A. 1994a. Technical efficiency and the competitive behavior of hospitals. *Socio-Economic Planning Sciences*, 28(4): 219-227.
- Clarkson, K. 1972. Some Implications of Property Rights in Hospital Management. *Journal of Law and Economics*, 15: 363-376.
- Cooper, W. W., Seiford, L. M., & Zhu, J. 2004. *Sensitivity analysis in DEA*. In W. W. Cooper & L. M. Seiford & J. Zhu (Eds.), *Handbook on data envelopment analysis*: 95-98. Boston: Kluwer Academic Publishers.
- Cuervo, A. & Villalonga, B. 2000. Explaining the variance in the performance effects of privatization. *The Academy of Management Review*, 25(3): 581-590.
- D'souza, J. & Megginson, W. 1999. The financial and operating performance of privatized firms during the 1990s. *The Journal of Finance*, 54(4): 1397-1438.
- Deily, M. & McKay, N. 2006. Cost inefficiency and mortality rates in Florida hospitals. *Health economics*, 15(4): 419-432.
- Dudley, R., Johansen, K., Brand, R., Rennie, D., & Milstein, A. 2000. Selective referral to high-volume hospitals: estimating potentially avoidable deaths. *JAMA*, 283(9): 1159.
- Dyson, R., Allen, R., Camanho, A., Podinovski, V., Sarrico, C., & Shale, E. 2001. Pitfalls and protocols in DEA. *European Journal of Operational Research*, 132(2): 245-259.
- Fama, E. F. & Jensen, M. C. 1983. Separation of ownership and control. *The Journal of Law and Economics*, 26(2): 301.
- Feess, E. & Ossig, S. 2007. Reimbursement schemes for hospitals, malpractice liability, and intrinsic motivation. *International Review of Law & Economics*, 27(4): 423-441.
- Feldstein, M. S. 1967. *Economic Analysis for Health Service Efficiency*. Amsterdam.
- Forschungsdatenzentrum der Statistischen Landesämter (2008): Krankenhausstatistik (Teil I: Grunddaten, Teil II: Diagnosen und Teil III: Kostennachweis) der Jahre 2002–2006, Antrag 842-2008.
- Frey, B. S. & Jegen, R. 2001b. Motivation crowding theory: A survey of empirical evidence. *Journal of Economic Surveys*, 15(5): 589-611.
- Fried, H., Lovell, C., Schmidt, S., & Yaisawarng, S. 2002. Accounting for environmental effects and statistical noise in data envelopment analysis. *Journal of Productivity Analysis*, 17(1): 157-174.
- Frydman, R., Gray, C., Hessel, M., & Rapaczynski, A. 1999. When Does Privatization Work? The Impact of Private Ownership on Corporate Performance in The Transition Economies. *Quarterly Journal of Economics*, 114(4): 1153-1191.
- Garnick, D., Luft, H., Robinson, J., & Tetreault, J. 1987. Appropriate measures of hospital market areas. *Health Services Research*, 22(1): 69.
- Grossman, S. & Hart, O. 1983. An analysis of the principal-agent problem. *Econometrica*, 51(1): 7-45.
- Gupta, N. 2005. Partial Privatization and Firm Performance. *The Journal of Finance*, 60 (2): 987-1015

- Hansmann, H. 1988. Ownership of the Firm. *Journal of Law, Economics, and Organization*, 4(2): 267-304.
- Harrison, J. P., Coppola, M. N. & Wakefield, M. 2004. Efficiency of federal hospitals in the United States, *Journal of Medical Systems*, 28 (5): 411-422.
- Haskel, J. & Szymanski, S. 1993. Privatization, Liberalization, Wages and Employment: Theory and Evidence for the UK, *Economica*, 60 (238): 161-182.
- Heckman, J. J., Ichimura, H. & Todd, P. E. (1997), "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *Review of Economic Studies*, 64 (4): 605–654.
- Heckman, J. J. & Hotz, V. J. 1989. Choosing among Alternative Nonexperimental Methods for Estimating the Impact of Social Programs: The Case of Manpower Training. *Journal of American Statistical Association*, 84 (408): 862–880.
- Hollingsworth, B. 2008. The measurement of efficiency and productivity of health care delivery. *Health economics*, 17(10): 1107-1128.
- Imai, K., King, G., & Stuart, E. 2008. Misunderstandings among experimentalists and observationalists about causal inference. *Journal of the Royal Statistical Society, Series A*, 171(2): 481-502.
- Jacobs, P. 1974. A survey of economic models of hospitals. *Inquiry*, 11(2): 83-97.
- Jacobs, R., Smith, P. C. & Street, A. 2006. *Measuring Efficiency in Health Care: Analytic Techniques and Health Policy*, Cambridge University Press.
- Jefferson, G. H. & Su, J. 2006. Privatization and restructuring in China: Evidence from shareholding ownership, 1995–2001. *Journal of Comparative Economics*, 34(1): 146-166
- Laffont, J.-J. & Tirole, J. 1993. Privatization and incentives, in: Jean- Jacques Laffont and Jean Tirole (eds.): *A theory of incentives in procurement and regulation*, MIT Press, Cambridge, 637-659.
- La Porta, R. & Lopez-de-Silanes, F. 1999. The Benefits of Privatization: Evidence From Mexico\*. *Quarterly Journal of Economics*, 114(4): 1193-1242.
- Linna, M. 1998. Measuring hospital cost efficiency with panel data models, *Health Economics*, 7 (5): 415-427.
- Loc, T., Lanjouw, G., & Lensink, R. 2006. The impact of privatization on firm performance in a transition economy: The case of Vietnam. *Economics of Transition*, 14(2): 349-389.
- Mathur, I. & Banchuenvijit, W. 2007. The effects of privatization on the performance of newly privatized firms in emerging markets. *Emerging Markets Review*, 8(2): 134-146.
- Meggison, W. L., Nash, R. C. & van Randenborgh, M. 1994. The Financial and Operating Performance of Newly Privatized Firms: An International Empirical Analysis, *Journal of Finance*, 49 (2): 403-452.
- Morey, R. C., Fine, D. J., Loree, S. W., Retzlaff-Roberts, D. L. & Tsubakitani, S. 1992. The trade-off between hospital cost and quality of care. An exploratory empirical analysis, *Medical Care*, 30 (8): 677-698.



- Newhouse, J. P. 1970. Toward a Theory of Nonprofit Institutions: An Economic Model of a Hospital, *American Economic Review*, 60 (1): 64-74.
- Niskanen, W. A. 1975. Bureaucrats and politicians, *Journal of Law and Economics*, 18 (3): 617-643.
- Pauly, M. V. & Redisch, M. S. 1973. The Not-for-Profit Hospital as a Physician's Cooperative. *The American Economic Review*, 63(1): 87-99.
- Picone, G., Chou, S., & Sloan, F. 2002. Are for-profit hospital conversions harmful to patients and to Medicare? *RAND Journal of Economics*: 507-523.
- Pilyavsky, A. I., Aaronson, W. E., Bernet, P. M., Rosko, M. S., Valdmanis, V. G. & Golubchikov, M. V. 2006. East-west: does it make a difference to hospital efficiencies in Ukraine?, *Health Economics*, 15 (11): 1173-1186.
- Ramamurti, R. 1987. Performance evaluation of state-owned enterprises in theory and practice. *Management Science*, 33(7): 876-893.
- Rees, R. 1988. Inefficiency, public enterprise and privatisation. *European Economic Review*, 32(2-3): 422-431.
- Rosenbaum, P., Rubin D.B. (1985) Constructing a control group using a multivariate matched sampling method that incorporates the propensity score. *American Statistician* 39: 33-38.
- Rosenbaum, P. 1989. Optimal matching for observational studies. *Journal of the American Statistical Association*, 84(408): 1024-1032.
- Rosenbaum, P. 2002. *Observational studies*: Springer Verlag.
- Rosko, M. D. 1999. Impact of internal and external environmental pressures on hospital inefficiency, *Health Care Management Science*, 2 (2): 63-74.
- Rosko, M. D. 2001. Cost efficiency of US hospitals: a stochastic frontier approach, *Health Economics*, 10 (6): 539-551.
- Rosko, M. D. 2004. Performance of US teaching hospitals: a panel analysis of cost inefficiency, *Health Care Management Science*, 7 (1): 7-16.
- Rosko, M. D. & Chilingerian, J. A. 1999. Estimating hospital inefficiency: does case mix matter?, *Journal of Medical Systems*, 23 (1): 57-71.
- Sappington, D. & Stiglitz, J. 1987. Privatization, information and incentives. *Journal of Policy Analysis and Management*, 6(4): 567-582.
- Schmidt, K. 1996. The costs and benefits of privatization: an incomplete contracts approach. *Journal of Law, Economics, and Organization*, 12(1): 1.
- Schreyögg, J., Tiemann, O. & Busse, R. 2006. Cost accounting to determine prices: how well do prices reflect costs in the German DRG-system?, *Health Care Management Science*, 9 (3): 269-279.
- Shen, Y. C. 2002. The effect of hospital ownership choice on patient outcomes after treatment for acute myocardial infarction. *Journal of Health Economics*, 21 (5): 901-22.
- Shen, Y. C. 2003. Changes in hospital performance after ownership conversions. *Inquiry*, 40 (3): 217-34.

- Shen, Y.-C., Eggleston, K., Lau, J. & Schmid, C. 2007. Hospital ownership and financial performance: what explains the different findings in the empirical literature?, *Inquiry*, 44 (1): 41-68.
- Sheshinski, E. & Lopez-Calva, L. 2003. Privatization and its benefits: theory and evidence. *CESifo Economic Studies*, 49(3): 429.
- Shleifer, A. 1985. A theory of yardstick competition. *The Rand Journal of Economics*: 319-327.
- Shleifer, A. & Vishny, R. W. 1994. Politicians and Firms, *Quarterly Journal of Economics*, 109 (4): 995-1025.
- Simar, L. & Wilson, P. W. 1998. Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models, *Management Science*, 44 (1): 49-61.
- Simar, L. & Wilson, P. W. 2000. A general methodology for bootstrapping in non-parametric frontier models, *Journal of Applied Statistics*, 27 (6): 779-802.
- Simar, L. & Wilson, P. W. 2007. Estimation and inference in two-stage, semi-parametric models of production processes, *Journal of Econometrics*, 136 (1): 31-64.
- Smith, J. & E. Todd, P. 2005. Does matching overcome LaLonde's critique of nonexperimental estimators? *Journal of econometrics*, 125(1-2): 305-353.
- Sloan, F. 2000. *Not-for-profit ownership and hospital behavior*. Handbook of health economics, 1: 1141-1174.
- Steinberg, R. 2006. *Nonprofit organizations and the market*. In W. W. Powell & R. Steinberg (Eds.), *The nonprofit sector: A research handbook*. New Haven: Yale University Press.
- van Walraven, C., Austin, P., Jennings, A., Quan, H., & Forster, A. 2009. A Modification of the Elixhauser Comorbidity Measures Into a Point System for Hospital Death Using Administrative Data. *Medical Care*, 47(6): 626.
- Vickers, J. & Yarrow, G. 1991. Economic perspectives on privatization. *The Journal of Economic Perspectives*, 5(2): 111-132.
- Villalonga, B. 2000. Privatization and efficiency: differentiating ownership effects from political, organizational, and dynamic effects, *Journal of Economic Behavior and Organization*, 42 (1): 43-74.
- Weisbrod, B. A. 1988. *The Nonprofit Economy*, Harvard University Press.
- Wu, H. & Parker, D. 2007. The Determinants of Post-Privatization Efficiency Gains: The Taiwanese Experience. *Economic and Industrial Democracy*, 28(3): 465.
- Zismer, D. 1999. *Physician Compensation Arrangements: Management & Legal Trends*: Jones & Bartlett Publishers.

**TABLE 1**

**Balance in measured covariates before and after matching**

Variable name	Group No. of hospitals	Unmatched sample			Matched sample		
		control n=456	treatment n=86	$d_i$	control n=83	treatment n=75	$d_i$
<b>HHI</b>		0.388	0.339	18.74%	0.384	0.391	4.89%
<b>BEDS</b>		289	270	21.46%	310	319	5.60%
<b>TEACH</b>		0.149	0.190	16.55%	0.161	0.159	4.83%
<b>HIRED BEDS</b>		0.048	0.064	26.89%	0.048	0.047	4.45%
<b>CMXI</b>		0.890	0.954	3.21%	0.905	0.935	1.27%
<b>AGE</b>		0.405	0.402	8.16%	0.402	0.406	1.47%

**TABLE 2**

**Regression results for each model**

	<b>Public-&gt;private non-profit and private for-profit</b>		<b>Public-&gt;private for-profit</b>	
<i>DiD (PRIV*POST)</i>	<i>Coefficients</i>			
<i>Model I - dependent: DEA efficiency score</i>				
1 year post-privatization period	- 0.008	(0.009)	- 0.006	(0.011)
2 years post-privatization period	0.017	(0.008)	0.025	(0.009)
3 years post-privatization period	0.013	(0.008)	0.022	(0.008)
4 years post-privatization period	0.013*	(0.008)	0.035*	(0.009)
<i>Model II - dependent: Quality- adjusted DEA efficiency score</i>				
1 year post-privatization period	- 0.004	(0.008)	- 0.005	(0.001)
2 years post-privatization period	0.010	(0.007)	0.011	(0.008)
3 years post-privatization period	0.020*	(0.008)	0.022*	(0.008)
4 years post-privatization period	0.028**	(0.009)	0.043**	(0.008)

\* p≤0.05; \*\* p≤0.01; \*\*\* p≤0.001; SE in parentheses