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### Review

# Hospital ownership and efficiency: A review of studies with particular focus on Germany

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### ABSTRACT

The German hospital market has been subject over the past two decades to a variety of healthcare reforms. Particularly the introduction of diagnosis-related groups (DRGs) in 2004 aimed to increase efficiency of hospitals. The objective of the paper is to review recent studies comparing the efficiency of German public, private non-profit and private for-profit hospitals. The results of the studies are quite mixed. However, in line with the evidence found in studies from other countries, especially the US, the evidence from Germany suggests that private ownership (i.e., private non-profit and private for-profit) is not necessarily associated with higher efficiency compared to public ownership. This may be a surprising result to many policy makers as private for-profit hospitals are often perceived the most efficient ownership type by the public.

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## 1. Introduction

Because of increasing cost pressure, the hospital sector in Germany has been subject over the past two decades to a variety of healthcare reforms aiming to stabilize expenditures at sustainable levels. One major reform in recent years was the introduction of a new system of reimbursement based on DRGs. Since 2004, all 1800 German hospitals that provide inpatient acute care receive DRG payments from statutory health insurance funds and private health insurance companies. In addition, the introduction of DRGs was preceded by the implementation of an external quality assurance program (as opposed to the internal system of an individual hospital). It includes a number of mandatory measures, including a nation-wide benchmarking exercise based on more than 300 quality indicators. These two

elements represent the most significant reforms in the German hospital sector since the system of dual financing was introduced in 1972 where the state is responsible for capital costs, whereas running costs are paid by sickness funds or private patients. 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 [1,2].

Due to substantial overcapacities and the rapid changes currently taking place in the regulatory and competitive environment, the German hospital sector is now facing an extensive process of consolidation and reorganization. In this context, hospitals are considering mergers, acquisitions, and cooperative agreements as ways to improve competitiveness. Germany traditionally has a multi-ownership structure in the hospital market which is even legally stipulated (e.g., hospitals' capital costs are covered by the state independently of actual ownership on an annual basis) [3]. Therefore, three different types of hospital ownership have co-existed for decades: private for-profit (FP), private non-profit (NP), and public (PB). As

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their classification implies, both types of private hospitals are owned by private entities, whereas public hospitals are owned by public entities such as local or regional governments. Between 1995 (i.e., share of inpatient beds: 56% PB, 38% NP and 6% FP) and 2008 (i.e., share of inpatient beds: 49% PB, 36% NP and 15% FP), a substantial number of local and regional governments in Germany sold their hospitals to private for-profit and private non-profit owners. The total number of private for-profit hospitals increased by 164, or 44%, which represented a rise in market share from 6% to 15%, measured in terms of inpatient hospital beds. During the same period, the market share of private non-profit hospitals decreased slightly, from 38% to 36%, because some non-profit hospitals were also converted to for-profit ownership [4]. The objective of the paper is to perform a review on the findings of empirical research on the association between hospital ownership and efficiency in Germany.

## 2. Criteria and methods to measure hospital performance

There are different concepts used to measure financial performance of organizations. Measures often used in other industries such as return on investment or other profitability measures are not regarded as appropriate to compare the financial performance between public, private non-profit and for-profit providers. A critical difference between public, private non-profit and for-profit hospitals is their orientation towards financial performance. Private entities have access to the capital market and are thus incentivized to show the highest possible profits in their reports to attract investors. Public and non-profit hospitals are expected to be generally averse to seek profit maximization as, in particular public hospitals, may be faced with the problem that their profits are taken away by public owners and spend for other public goods [5].

It thus seems reasonable to assume that using financial performance criteria, such as profit margins, in comparisons of ownership types may lead to bias. Therefore, measures of performance are needed that are rather homogenous in terms of incentives for different ownership types. For this reason, measures such as cost per case, and efficiency are used in this context. In particular, governments clearly have an interest in assessing the efficiency of their health care organizations and therefore efficiency is a measure that has been frequently used in the hospital context over the last decade.

The character of public services (e.g., health care, education, public transportation) often implies that the service quality is a primary 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 assumption is that better quality of care requires more resources and therefore reduces efficiency. However, differences in the trade-off between efficiency and quality of care among public and private non-profit providers have attracted little attention from empirical studies in that field of research. There is a rich body of literature on the impact of hospital ownership on quality of care but only very few studies have analyzed the relationship between

ownership, efficiency and quality of care simultaneously. Eggleston et al. [6] provide a comprehensive review on the findings regarding hospital ownership and quality of care.

Researchers often employ two different methodologies to assess hospitals efficiency: stochastic frontier analysis (SFA) and data envelopment analysis (DEA). In general, SFA measures technical or cost efficiency while DEA mainly measures technical efficiency. In particular, technical efficiency is a measure of how well a hospital produces output from a given amount of input, or alternatively produces a given amount of output with minimum quantities of inputs. Cost efficiency occurs when a hospital chooses a cost-minimizing input mix, given input prices.

Both approaches make inferences about efficiency from a residual. The major empirical difference between the two approaches is that SFA assumes the residual term reflects both inefficiency and random factors, while DEA is a purely deterministic model that assumes all departures from best-practice frontier reflect inefficiency. The deterministic nature of DEA means that this method depends on available data points to identify inefficiency. On the other hand, SFA is criticized for relying on parametric assumptions about the functional form, and for the weaknesses of regression in extrapolation to identify inefficiency. However, DEA and SFA differ in ways in which they identify inefficiency. In either case, wrong assumptions about the functional form, misspecification of the models, or omitted variables can easily bias the results [7–9]. When comparing DEA to SFA, Linna [10] and Webster et al. [11] found that both methods yielded comparable results in measuring hospital efficiency. We included studies using both DEA and SFA in our review.

## 3. Theoretical background

Most of the existing research relies on agency theory, property-rights theory, or public choice theory to describe the behavior in mixed ownership markets for health services. All three theories provide different explanations of a common outcome and posit that private ownership (i.e., private non-profit and private for-profit) is superior to public ownership in terms of efficiency due to differences in objectives, incentives, and control mechanisms.

Agency theory assumes that agents (e.g., managers) seek to maximize their own utility rather than that of the organization or its principals (e.g., owners). Consequently, in all three types of hospitals, owners are faced with a principal-agent dilemma. The agency theory assumes that private for-profit hospitals are better able to address this dilemma and are thus more likely to achieve greater efficiency [12–15]. For example, the owners of this type of hospital may use profits as their measure of a manager's success and can limit divergences from their interest by making the manager's compensation a positive function of these profits. The income of physicians in private for-profit hospitals can also be tied to a hospital's financial performance. Within public and private non-profit hospitals, the income of individual decision makers is rarely tied to a hospital's performance, creating little incentive to enforce efficient behavior.

According to the property-rights theory, owning a firm brings with it two essential rights, namely the right to control the firm and the right to appropriate the firm's profits. The defining difference between private for-profit hospitals and their public and private non-profit counterparts is thus that the latter two hospital types are precluded from distributing their financial surplus to those in control of the organization – a limitation otherwise known as a non-distribution constraint. In private for-profit hospitals, assigning some of the financial surplus to the individual who manages the hospital provides a way to monitor his or her activities. In such a case, it is assumed that the monitoring of a hospital's performance will be automatic and self-imposed by the manager, and that managers will have strong incentives to behave in the interests of the owners [16–18]. In addition, the property-rights theory postulates that potential divergences of interests between owners and managers in private for-profit organizations are reduced yet further by external mechanisms, including a market for ownership rights that enables the owners to sell their shares if they are not satisfied with managerial performance; the threat of takeover; the threat of bankruptcy; and an extensive managerial labor market [19]. For all of these reasons, the property-rights theory posits that private for-profit ownership leads to higher efficiency than other types of ownership.

The public choice theory, as put forward variously by Buchanan and Tollison [20], Niskanen [21], and Shleifer and Vishny [22], assumes that politicians impose their objectives on public organizations in order to gain votes, and that these objectives may be at odds with profit maximization and, consequently, efficiency. Newhouse [15] and Weisbrod [23] argue that because private non-profit providers lack an incentive to maximize profit, they should be expected to diverge from strict cost- or inefficiency-minimizing behavior and instead maximize quality, quantity, prestige or some combination of these characteristics. Pestieau and Tulkens [24] and Sloan [25] support this view and add that productive efficiency will decline if objectives are vague and contradictory, which, they assert, is typically the case in public and private non-profit hospitals.

#### 4. Evidence from other countries

We identified all relevant studies on the association between hospital ownership and efficiency (i.e., published and unpublished articles or book chapters in English between January 1990 and July 2011) through a systematic procedure. Our search in several databases was limited to general, acute care hospitals and to empirical studies (i.e., excluding theoretical papers and case studies). In addition, the scope of our review was confined to studies that have compared all three different types of ownership in terms of efficiency (i.e., technical efficiency and cost efficiency). At the end of this search and selection process, we identified 12 international studies, which are summarized in Table 1 (sorted according to the year of publication).

Among the 12 studies, only 4 had the explicit objective of estimating the impact of hospital ownership on efficiency [26–29], while the other 8 studies [30–37] merely

included ownership as a control variable and primarily explored the impact of market factors (e.g., competition) and other determinants of hospital performance (e.g., managerial issues) or compared statistical methods.

Out of the 12 included studies, 7 applied SFA [26,27,30–32,35,37], while 4 studies conducted DEA [28,29,34,36], and 1 study compared both methodological approaches [33]. Among the five DEA studies, only two studies [34,36] have used a two-stage analysis (i.e., DEA followed by some form of regression analysis), despite the fact that in recent years it has become the state-of-the-art approach when applying DEA [38]. In addition, the study periods of 10 studies are dated back to the late 1980s or 1990s, thus limiting the generalizability of their results.

In the hospital sector of the United States (U.S.) all three different types of ownership have co-existed for decades and numerous studies have investigated whether private non-profit, private for-profit and public hospitals differ in terms of efficiency, or other measures of hospital performance. Among the 12 included studies, 11 studies relied on a sample of U.S. hospitals, while 1 study used data of the Italian hospital market to determine the impact of ownership on hospital efficiency. Furthermore, we identified 8 studies that have a large nation-wide sample (between 382 and 4075 hospitals), while four studies are focused on subregions with comparable small samples (between 108 and 360 hospitals). Table 1 shows that the three studies that analyze a single U.S. state (i.e., Florida [32,33]) or a limited number of U.S. states (i.e., Arkansas, Louisiana, Oklahoma, Texas [36]) – none of which focuses explicitly on ownership – all found private for-profit hospitals to be more efficient than private non-profit hospitals. In addition, two studies [32,36] indicated that private for-profit hospitals also operate more efficiently than their public counterparts, while the other study [33] observed the opposite. Out of these three studies, the two conducted in Florida found public hospitals to be more efficient than private non-profit hospitals [32,33]. Daidone and D'Amico [26] conducted the fourth study that was based on a subregion in Italy (i.e., Lazio Region) and their results indicated that inefficiency was highest for private for-profit hospitals and lowest for public hospitals, with private non-profit hospitals being in between. In addition, five out of eight nation-wide studies showed private for-profit hospitals to be less efficient than their public [28,29,32,35,37] and private non-profit counterparts [29–31,35,37]. Among these eight studies, four studies found that private non-profit hospitals operate more efficiently than their public counterparts [27,30,31,37], while three studies observed the opposite [28,29,35]. Burgess and Wilson [34] found no significant efficiency differences associated with ownership. Thus, our review of international studies indicates that in contrast to the arguments put forward by authors in the field of agency theory and property rights theory, as well as public choice theory and against the often assumed behavior by policy makers, there is no clear evidence that private hospital ownership (i.e., non-profit and for-profit) is associated with higher efficiency compared to public hospital ownership.

If one's purpose is to compare different types of ownership it is of crucial importance to disentangle the impact

**Table 1**  
Empirical studies on the association between hospital ownership and efficiency.

	Study and sample characteristics				Methods and control variables					Differences in efficiency between ownership types (more efficient type indicated)		
	Covered region	Covered years	Sample size	Ownership focused	Method used to determine efficiency	Patient heterogeneity	Hospital characteristics	Market characteristics	Quality of care	PB vs. FP	PB vs. NP	FP vs. NP
Ozcan et al. [29]	U.S. <sup>a</sup> Nation-wide	1987	3000	x	DEA (one-stage) – technical efficiency	x	x	–	–	PB	PB	NP
Zuckerman et al. [37]	U.S. Nation-wide	1986–1987	1600	–	SFA – cost efficiency	x	x	x	x	PB	NP	NP
Burgess and Wilson [28]	U.S. Nation-wide	1988	2246	x	DEA (one-stage) – technical efficiency	x	–	–	–	PB <sup>b</sup>	PB <sup>b</sup>	FP <sup>b</sup>
Ferrier and Valdmanis [36]	U.S. <sup>c</sup> West South Central	1989	360	–	DEA (two-stage) – cost and technical efficiency	x	x	–	x	FP	NP	FP
Koop et al. [35]	U.S. Nation-wide	1987–1991	382	–	SFA – cost efficiency	x	x	–	–	PB	PB	NP
Burgess and Wilson [34]	U.S. Nation-wide	1985–1988	1480	–	DEA (two-stage) – technical efficiency	x	x	x	–	n.s.	n.s.	n.s.
Chirikos and Sear [33]	U.S. Florida	1982–1993	186	–	DEA (one-stage) and SFA – cost and technical efficiency	x	x	–	–	PB	PB	FP
Brown [30]	U.S. <sup>a</sup> Nation-wide	1992–1996	613	–	SFA – technical efficiency	x	x	x	–	FP	NP	NP
McKay et al. [31]	U.S. Nation-wide	1986–1991	4075	–	SFA – cost efficiency	–	x	x	–	PB	NP	NP
Sari [32]	U.S. Florida	1990–1997 <sup>d</sup>	125	–	SFA – cost efficiency	x	x	x	x	FP	PB	FP
Mutter and Rosko [27]	U.S. <sup>a</sup> Nation-wide	1999–2002	869	x	SFA – cost efficiency	x	x	x	x	FP	NP	FP
Daidone and D'Amico [26]	Italy Lazio region	2001–2005	108	x	SFA – cost and technical efficiency	x	x	–	–	PB	PB	NP

FP – private for-profit; NP – private non-profit; PB – public; n.s. – not significant.

<sup>a</sup> The data set covers a sample of U.S. hospitals in Metropolitan Statistical Areas (i.e., urban).

<sup>b</sup> Results are based on the comparison of the mean efficiency scores by ownership type and were not verified by statistical tests regarding the significance of differences of efficiency scores.

<sup>c</sup> The data set covers a sample of 360 rural U.S. hospitals operating in the West South Central United States (i.e., Arkansas, Louisiana, Oklahoma, Texas).

<sup>d</sup> The data set covers all years from 1990 to 1997, except 1993 due to data inconsistencies.

of ownership from effects of patient heterogeneity, market competition and other confounding factors. Among all identified studies, most included a case-mix index (e.g., Medicare case-mix index) to control for patient heterogeneity among hospitals and hospital characteristics (e.g., hospital size measured by the number of beds) to ensure the comparability of the observed hospitals. In addition, six studies [27,30–32,34,37] included market characteristics (e.g., market competition) to control for exogenous market effects potentially affecting hospital efficiency [39]. Out of the 12 studies, only 4 studies considered parameters for the quality of care in addition to efficiency, although the relationship between ownership, efficiency and quality of care is of considerable practical and policy importance. One reason for this might be the paucity of validated measures of quality of care. The absence of quality measures requires the implicit assumption that there are no systematic variations in quality of care among public, private non-profit and private for-profit hospitals, or that variations in quality do not systematically affect efficiency. The large empirical literature on ownership does unfortunately not provide evidence on the impact of ownership on quality of care. However, studies examining the relationship between efficiency and quality of care have provided evidence of a trade-off between these two measures [6].

## 5. Findings from Germany

In the past, there was a lack of detailed data on the German hospital sector, which means that the quality and the quantity of the information used to assess efficiency and the impact of ownership types, was very limited. Thus, before 2008 the evidence on efficiency of German hospitals was very scarce. Table 2 summarizes the eight empirical studies on the association between hospital ownership and efficiency in Germany (sorted according to the year of publication). Among the eight studies, five had the explicit objective of estimating the impact of hospital ownership on efficiency [40–44], while the other three [44–48] merely included ownership as a control variable.

Staat and Hammerschmidt [45] were the first to employ DEA to determine the impact of ownership on hospital efficiency (i.e., technical efficiency) in Germany, based on data of 160 hospitals in 1994. To ensure their comparability hospitals were chosen with respect to the number and type of departments (i.e., in terms of size and clusters based on the international classification of diseases (ICD)). The authors compared the mean DEA efficiency scores by ownership type and found that private non-profit hospitals were, on the average, substantially less efficient than their public and private for-profit counterparts. They also found comparably small differences in terms of efficiency between public and for-profit hospitals, with an advantage towards the latter. Staat [46] applied a refined DEA approach to the same sample of 160 hospitals for the year 1994 and found no significant efficiency (i.e., technical efficiency) differences associated with ownership. The lack of precision in the results of the two studies might be due to the small size of the subsamples in the data set, especially of private for-profit hospitals ( $n=5$ ). Helmig and Lapsley [40] and Werblow and Robra [47] also employed DEA based on

aggregated state-level data to determine hospitals' technical efficiency. Helmig and Lapsley [40] showed for 1991 to 1996 that public and non-profit hospitals appeared to use relatively fewer resources than private for-profit hospitals. They found no significant efficiency differences between public and private non-profit hospitals in their sample. Werblow and Robra [47] compared the mean DEA efficiency scores of ownership types for 2004 (the first year under DRGs) and their results indicate that public hospitals performed less efficient (i.e., technically efficient) than their private for-profit and non-profit counterparts. Private for-profit hospitals in their sample operated on a slightly higher level of efficiency than private non-profit hospitals.

Although these four studies were pioneers in their approach and focus, they have several important weaknesses. One of these is the lack of detailed data, which means that the quality and the quantity of the information used to assess efficiency is limited (i.e., aggregate state-level data and small sample size), thus limiting the generalizability of results. Another drawback of these studies is their use of DEA. From a methodological point of view, some authors argue that results of DEA analysis are much more robust when study samples are very large [8,9]. All of the DEA studies that have investigated the efficiency of the German hospital sector thus far have used DEA alone – without using a two-stage approach (i.e., DEA followed by some form of regression analysis), despite the fact that in recent years this has become the state-of-the-art approach [38]. In addition, only two of these German studies used hospital-level information to control for patient heterogeneity and to ensure the comparability of the observed hospitals in terms of hospital characteristics (e.g., hospital size).

Only a few years ago data on all hospitals in Germany were opened for research purposes enabling new perspectives on the rather black box hospital efficiency. Four studies have been conducted since the hospital database was opened up for research purposes and these studies used the same data with different methods to determine technical efficiency of hospitals [41–44]. DEA was applied by two studies [42,43], while also two studies conducted SFA [41,44]. However, empirical evidence on the impact of ownership on hospital efficiency in Germany has remained mixed. Out of these four studies, three studies [41–43] found that ownership was associated with differences in hospital efficiency, while one study [44] observed no significant differences. However, there is no clear evidence to support the conventional assumption that private hospitals, both private non-profit and private for-profit, operate more efficiently. Only Werblow et al. [43] found that private for-profit hospitals were significantly more efficient than their public and private non-profit counterparts. The authors applied a two-stage DEA approach to a sample of 1036 hospitals for the years 2002 to 2007 – i.e., before and after the introduction of DRGs – and integrated a large set of covariates (e.g., DRG case-mix index, hospital characteristics, regional competition and quality of care) in the second stage regression. In contrast, Herr [41] and Tiemann and Schreyögg [42] found clear evidence that public hospitals have a substantially higher efficiency than hospitals with private ownership

**Table 2**  
Empirical studies on the association between hospital ownership and efficiency in Germany.

	Study and sample characteristics				Methods and control variables					Differences in efficiency between ownership types (more efficient type indicated)		
	Covered region	Covered years	Sample size	Ownership focus	Method used to determine efficiency	Patient heterogeneity	Hospital characteristics	Market characteristics	Quality of care	PB vs. FP	PB vs. NP	FP vs. NP
Staat and Hamerschmidt [45]	Germany <sup>a</sup> West	1994	160	–	DEA (one-stage) – technical efficiency	Based on ICD clusters on hospital level	x	–	–	FP <sup>b</sup>	PB <sup>b</sup>	FP <sup>b</sup>
Helmig and Lapsley [40]	Germany <sup>c</sup> State level data	1991–1996	288 <sup>d</sup>	x	DEA (one-stage) – technical efficiency	–	–	–	–	PB	n.s.	NP
Staat [46]	Germany <sup>a</sup> West	1994	160	–	DEA (one-stage) – technical efficiency – bootstrapping	Based on ICD clusters on hospital level	x	–	–	n.s.	n.s.	n.s.
Werblow and Robra [47]	Germany <sup>c</sup> State level data	2004	48 <sup>d</sup>	–	DEA (one-stage) – technical efficiency	–	–	–	–	FP <sup>b</sup>	NP <sup>b</sup>	NP <sup>b</sup>
Herr [41]	Germany Nation-wide	2001–2003	1565	x	SFA – cost and technical efficiency	Based on individual patient length of stay, diagnoses, certain procedures and age	x	–	In-hospital mortality	PB	PB	NP
Tiemann and Schreyögg [42]	Germany Nation-wide	2002–2006	1046	x	DEA (two-stage) – technical efficiency – bootstrapping	Based on individual patient diagnoses, certain procedures and age	x	x	In-hospital mortality	PB	PB	n.s.
Werblow et al. [43]	Germany Nation-wide	2002–2007	1036	x	DEA (two-stage) – technical efficiency	Based on DRG case-mix 2007	x	x	In-hospital mortality	FP	PB	FP
Herr et al. [44]	Germany Nation-wide	2002–2006	541	x	SFA – profit, cost and technical efficiency	Based on individual patient length of stay, diagnoses, certain procedures and age	x	x	In-hospital mortality	n.s.	n.s.	n.s.

FP – private for-profit; NP – private non-profit; PB – public; n.s. – not significant.

<sup>a</sup> The identical sample includes only hospitals from Western Germany.

<sup>b</sup> Results are based on the comparison of the mean efficiency scores by ownership type and were not verified by statistical tests regarding the significance of differences of efficiency scores.

<sup>c</sup> Study is based on aggregated data on state level.

<sup>d</sup> Exact number of hospitals could not be identified from the paper due to the aggregation of data on state level.

status (i.e., private non-profit and private for-profit hospitals) after controlling for a large set of explanatory variables representing patient heterogeneity, organizational and environmental characteristics. Based on different methods to determine hospital efficiency these two studies found public hospitals to be able to use the available resources most efficiently to produce a given amount of output. Herr [41] employed SFA to investigate the efficiency (i.e., cost and technical efficiency) of 1565 German hospitals between 2001 and 2003, while Tiemann and Schreyögg [42] made use of bootstrapped DEA within a two-stage approach to evaluate the efficiency (i.e., technical efficiency) of a panel of 1046 hospitals between 2002 and 2006. Herr et al. [44] re-estimated cost and technical efficiency in a different context using the same methodology as Herr [41] based on 541 German hospitals between 2002 and 2006. Their findings again point in the direction that private for-profit hospitals operate less cost and technical efficient than public hospitals in Germany, but the observed differences are not statistically significant, which might be due to the smaller sample size compared to the other three studies [41–43]. Herr et al. [44] relied on a reduced data sample of German hospitals in order to be able to include hospitals' balance sheets for further analyses.

The findings of both Herr [41] and Tiemann and Schreyögg [42] in terms of the impact of private for-profit ownership on efficiency are in line with previous studies from the US, but may be surprising from a policy perspective and in contrast to the assumed behavior outlined in theory (i.e., agency theory, property rights theory and public choice theory). Private for-profit hospitals are often perceived as the most efficient ownership type. Herr [41], Tiemann and Schreyögg [42], Werblow et al. [43] found public hospitals to be more efficient than private non-profit hospitals. Regarding the incentive structures of private non-profit providers, agency theory and property-rights theory predict that the owners and managers of non-profit organizations frequently diverge from cost- or inefficiency-minimizing behavior and instead maximize quality, quantity, and/or prestige [15,23]. Therefore, other measures not considered in the analyses, such as patient satisfaction, might have led to different results. However, despite the large number of empirical studies on hospital ownership and efficiency (taken together all international and German studies) there remains a certain disconnect between theory and the empirical evidence. Only very few empirical papers elaborate on different economic theories regarding ownership type. This disconnect arises due to the fact that much of the literature in health services research does not focus on testing economic theories. In essence, the majority of researchers in this field consider ownership to be a potentially important factor for explaining variation in hospital efficiency but based on the existing studies it is difficult to theoretically predict how and when ownership shapes hospital efficiency [8].

Differences in the results on the impact of private for-profit ownership between the three empirical studies of Herr [41], Tiemann and Schreyögg [42] and Herr et al. [44] on the one hand and the study of Werblow et al. [43] on the other hand might be due to dissimilarities in the conceptual and methodological framework to

assess the impact of ownership on hospital efficiency in Germany. To control for patient heterogeneity, Werblow et al. [43] applied the DRG case-mix index from the year 2007, whose weights are based on a grouping algorithm using diagnoses, clinical interventions (i.e., medical procedures), patient characteristics (i.e., gender, age, weight), cause of hospital discharge (e.g., death) and length of stay. In essence, the frequently applied DRG case-mix index reflects the relative costliness of DRGs (i.e., a combination of the individual patient health status or patient severity and treatment patterns of the individual hospital). In contrast, Herr [41], Tiemann and Schreyögg [42] and Herr et al. [44] relied on a weighting approach based on individual patient demographics and diagnoses in order to take account of patients' clinical presentations in terms of patient severity (i.e., severity of illness). This can be treated as an exogenous effect affecting hospitals' efficiency while in Germany the DRG case-mix index is substantially determined by hospitals' treatment patterns especially in terms of medical procedures. Furthermore, Werblow et al. [43] employed a two-stage DEA approach without bootstrapping, despite the fact that this approach has been found to result in inconsistent estimates unless the DEA efficiency scores are corrected by a bootstrapping procedure [48,49]. In recent years, the application of a truncated linear regression model with bootstrapped DEA efficiency scores as dependent variable has become the state-of-the-art approach [38], although this might not entirely explain the differences in the findings. Differences in the results might also be due to dissimilarities in the sample selection and the referring exclusion criteria.

Herr [41], Tiemann and Schreyögg [42], Werblow et al. [43] and Herr et al. [44] considered the in-hospital mortality as a parameter for quality of care in their analysis and their findings do not provide evidence of an inevitable trade-off between efficiency and quality of care. Tiemann and Schreyögg [42] found private for-profit hospitals to provide a higher quality of care, measured as risk-adjusted in-hospital mortality, compared to other types of ownership. This contrasts with the common assumption that information asymmetries exist in the hospital market and thus particularly for-profit hospitals have the incentive (i.e., profit-seeking) to increase performance 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, a nationwide benchmarking exercise based on 206 quality indicators). Thus, the strategic importance of quality of care in markets with substantial overcapacities (i.e., cutthroat competition) may have been underestimated so far. There is also 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 [1].

Herr [41], Tiemann and Schreyögg [42], Werblow et al. [43] and Herr et al. [44] checked the robustness of their results in several ways and their key findings in terms of the impact of ownership on hospital efficiency remained unchanged. To begin with, except Herr et al. [44] all other three studies re-estimated their models with different

windows for hospital sizes at the lower and upper ends of the sample. The inclusion of in-hospital mortality as a measure of quality of care served as a sensitivity analysis in the three studies conducted by Herr [41], Tiemann and Schreyögg [42] and Herr et al. [44]. Herr [41], Werblow et al. [43] and Herr et al. [44] re-estimated their efficiency models without using a case-mix adjustment. Werblow et al. [43] applied the number of beds per hospital as input variable reflecting capital inputs and also as an output variable in their DEA model. Schreyögg and Tiemann [42] run their second-stage efficiency models modifying the number of periods used in their regression. Werblow et al. [43] changed their assumption of constant returns to scale to variable returns to scale in their DEA model. In Herr's study [41] efficiency in the SFA model was also estimated assuming inefficiency to be half-normally and exponentially distributed.

## 6. Policy implications

There is a growing body of literature on efficiency of hospitals in Germany. However, the evidence is not clear as study results are quite mixed. Among the studies based on the recently opened full database of German hospitals, Herr [41] and Tiemann and Schreyögg [42] found that hospitals with public ownership are more efficient than other ownership types. In contrast Werblow et al. [43] using the same database but with different variables and methods found that hospitals in private for-profit ownership are the most efficient ownership type. Herr et al. [44] found no significant efficiency differences associated with hospital ownership, both in terms of cost and technical efficiency.

The introduction of DRGs in Germany set incentives to increase the hospitals' focus on efficiency, which should help to improve the efficient allocation of health care resources, it should be taken into account that high hospital efficiency is usually due to low staffing ratios that may potentially result in lower quality of care. Consequently, it is of crucial importance to monitor outcomes when introducing and maintaining DRG-based payments. Future evaluations, not only in Germany, should thus closely monitor efficiency, as well as quality, changes over time, especially before and after reforms such as the introduction of DRG systems. In addition, future research in Germany should go beyond the standard administrative hospital database to further explain the wide variation in hospital efficiency which may be due to hospital decision making, market spillover effects or other reasons.

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