Effects of strategic alliances on hospital efficiency and capacity utilization in Mexico

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Abstract

This paper aims to investigate the efficiency implications of belonging to a strategic hospital alliance (SHA) and measuring the effects on capacity utilization of such agreements in a Mexican health care context. Data Envelopment Analysis (DEA) is the nonparametric methodology used which supports both objectives. Technological gap ratios are calculated by using the DEA-metafrontier approach to compare efficiency between SHA members and a hospitals control group. Also, hospital capacity utilization ratios are used as the maximum rate of output possible from fixed inputs in a frontier setting using directional distance functions. Data were collected from an alliance called *Consorcio Mexicano de Hospitales, A.C.* in Mexico which has 29 private general hospitals and a group of 47 hospitals with the same characteristics from a database created by the National Institute of Statistics and Geography (INEGI) for 2014. The results indicate that efficiency is better in hospitals that belong to an alliance. It also shows an improvement in installed capacity management for hospital alliances in Mexico.

Keywords: Strategic hospital alliances, metafrontier, Data Envelopment Analysis, capacity utilization, CLADEA2018

JEL codes: L25, C61, H51, I18.

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INTRODUCTION

Strategic alliances (SA) have been widely studied in different industries and countries. However, they are still an important research topic since business conditions and company structures change and the health care industry is no exception to this trend. The current health care environment worldwide is much more volatile, characterized by escalating costs and uncertainty (Abdulsalam *et al.*, 2018) and both environmental and organizational contexts need to be taken into account in strategic decision-making. Alliance formation in the hospital industry emerged as a defensive strategy in response to the rapid growth of investor-owned chains in the mid-1970s mainly in the United States, originally intended to provide non-profit facilities with some of the advantages of centralized management without loss of individual hospital control (Zinn *et al.*, 1997; Zuckerman and D'Annuno, 1990; Zuckerman and Kaluzny, 1991).

Early research on hospitals and strategic alliances from the 1990s focuses on the economic impact of these alliances on hospitals' financial performance. Initial findings were that hospitals in strategic alliances yielded higher net revenues, but they were not effective at controlling costs or producing higher cash flow as a result of being in the alliance (Clement *et al.,* 1997). With the growth of integrated health care service delivery systems during the 2000s, SA were studied as an approach towards the efficient development of health care service delivery systems in the context of health care reforms in the United States (Kaluzny *et al.*, 2002; McSweeney-Feld *et al.*, 2010).

The Organization for Economic Co-operation and Development's (OECD) health statistics for 2013 indicate that 70% of all hospitals in Mexico are private, although significant investment was made in the public hospital infrastructure during the period 2003-2013. However, beds in privately-owned hospitals increased by 10% in the same period compared to 6% in public hospitals. There are 27,176 medics in private medicine, an increase of 56% in 2013 compared to 2003 according to the Ministry of Health in Mexico. In 2013, private health spending made up 44% of the total health spending (World Health Organization, 2013), with around 96% of this expenditure being out-of-pocket (OOP) payments (including medicines and hospital service as the main expenses) and only 4% corresponding to paying private health insurance premiums. Likewise, the 2013 annual report issued by the Mexican Association of Insurance Institutions (AMIS) indicates that the number of people affiliated with health insurance grew by 131% from 2003 to 2013.

Private hospitals have seen a great opportunity to participate in the health market in Mexico, seeking to replace the inefficiencies of the public sector and the absence of timely medical attention through a high-quality standard (OECD, 2016). However, this leads to private hospitals being more efficient in managing their resources and to rethinking their business model by establishing adequate operational and capacity management practices to meet patient demand requirements and changing general health and economic conditions at the same time without reducing health care quality, and obtaining an adequate return for their shareholders in the short and long term (Zuckerman and Kaluzny, 1991; Bates *et al.*, 2006; Roh *et al.*, 2013). Capacity management in the health sector has been analyzed in different ways, mainly related to capacity planning (Kim et al., 1999, Green, 2002; Gnalet and Gilland, 2009; Jeang and Chiang, 2012; Ma and Demeulemeester, 2013; Kang and Kim, 2015); changes in demographics and service characteristics (Fisher *et al.,* 2000; Li and Benton, 2003); health care reforms (Cseh *et al.*, 2015; Valdmanis *et al.*, 2015); behavior of costs related with capacity utilization (Balakrishnan et al, 2004) and future potential events such as natural disasters, terrorism and epidemics (Ferrier *et al.*, 2009; Valdamis *et al.*, 2010; Yi *et al.,* 2010). The vast majority of authors indicate that there is a perception of excess capacity or oversupply seen from the economic point of view, which indicates that the resources invested in public and private health care are inefficient due to high costs.

The identification of organizational practices that may contribute to the greater efficiency of private health care is especially relevant for those countries where it represents a substantial percentage of total health expenditure. Specifically, the decision to join a strategic health alliance can contribute to cost containment, which in turn could have a positive impact on the prices incurred by patients, for instance, through regulation when the competition mechanisms fail. In this sense, this research has two objectives using data from Mexican hospitals that have decided to establish a SA, since Mexico is a good example of a country where private participation in the health system is significant. The first objective seeks to assess if technical efficiency (TE) is higher when the hospital belongs to a SA, especially since it becomes an important part of general strategy for a private hospital to increase operational efficiency measured using the metafrontier ratio; and, the second objective is to measure if actual capacity is better utilized by hospitals which are members of SA as an important consequence, since the investment previously made in infrastructure is really optimized by hospital capacity utilization (HCU). The contribution of this work is twofold. First, because, to the best of our knowledge, there are no similar studies in Mexico. Second, because its results can be useful for both private health organization managers and regulators themselves to adopt management practices that may end up having a favorable impact on cost and prices. We have selected and adapted a powerful and rigorous methodology, a metafrontier analysis estimated through Data Envelopment Analysis models, in order to identify the potential gains in performance that private hospitals could obtain from a SA. To achieve this goal, we compare the performance of a group of hospitals belonging to a SA with a control group, which can shed light on the interest of stimulating the formation of SA to potentially contribute towards containing the recurring rise of health system costs and, consequently, the prices paid by the patients as well.

LITERATURE REVIEW

The literature review examines the nature of an evolution of alliances, their characteristics, the impact on the levels of efficiency and the main economic theories supporting them. Additionally, this section presents an overview of the concept of capacity utilization since this is an expected positive effect of these alliances. The overview of the literature is applicable to all organizations engaging in strategic alliances, but the main focus will be on the context for health care organizations.

Strategic alliances and efficiency

SA embraces a diversity of collaborative forms. The activities covered include supplier-buyer partnerships, outsourcing agreements, technical collaboration, joint research projects, shared new product development, shared arrangements, common distribution agreements, cross-selling arrangements, and franchising. While the defining governance mode is the informal ‘relational contract', strategic alliances may involve contractual agreements (e.g. franchising and cross-licensing agreements) and ownership links (e.g. cross equity holdings and joint ventures) (Grant and Baden-Fuller, 2004).

The American Hospital Association (AHA) defines a hospital alliance as a formally organized group of hospitals or hospital systems that have come together for specific purposes and have specific membership criteria. An alliance is controlled by independent and autonomous member institutions. Clement *et al.,* (1997) consider that a strategic hospital alliance (SHA) is formed when two or more hospitals in a local market join forces to compete with other local hospitals, hospital systems, and other providers.

Rosko and Proenca (2005) argue that hospitals' use of a network or system to provide services should have an effect on hospital performance in general, based on the notion that hospitals participate in such collaborative ventures in order to obtain necessary resources and knowledge, create scale and scope economies, share costs, and gain leverage. The Resource Dependence Theory (RDT)[2] suggests that hospitals should be able to provide services at a lower cost and with greater efficiency by collaborating in service delivery with other institutions as part of a network or a system. Previous research has identified the ability to share costs, pool resources and capabilities, improve coordination, and gain greater access to markets as benefits of collaboration (Oliver, 1990; Granderson, 2011). When services are centralized at the network or system level, it should be easier to achieve the critical mass needed for optimal productivity, to centralize and reduce administrative overheads, and to reduce marketing and customer acquisition costs (Bazzoli et al., 2000). As more services are provided in a joint platform, the combined size of the collaborating entities increases and so should their leverage in negotiating terms with care vendors and buyers. Thus, hospitals that provide a greater percentage of their services at the network or system level should be more efficient than hospitals that provide few or no services in this manner (Rosko *et al.*, 2007)

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[2] Murray, Kotabe and Zhou (2005) indicate that the resource dependence theory focuses on the effects of environmental factors on how firms should organize themselves in order to compete in the marketplace.

Previous studies have addressed the association between hospital networks and hospital performance/efficiency. Some studies found a positive relationship between membership of a network and operational efficiency (Carey, 2003; Mascia and Di Vicenzo, 2010; Chukmaitov *et al.*, 2009; Roh, Moon and Jung, 2013;). In a follow-up study, Bazzoli *et al.* (2000) reported that it appears that system membership *per se* does not guarantee better financial efficiency in United States hospitals. It requires that hospitals belonging to a health network that has higher centralization of decision-making and service delivery generally have a better performance, measured by lower costs and higher profitability than hospitals in decentralized networks or systems. Rosko et al., (2007) support that the benefits of system membership depend on system characteristics when comparing hospitals that were members of centralized health systems. Membership of centralized physician/insurance or decentralized systems was associated with decreased inefficiency; membership of independent systems was associated with increased inefficiency. Wan, Ma and Lin (2001) found no positive association between hospital network and performance in terms of efficiency or profit. The results of the literature review on SHA are mixed. Búchner, Hinz and Schreyögg (2016), analyzed the potential changes in hospital performance after entering a health system, and found that there is an increase in hospitals' technical and cost efficiency with permanent effects.

Different authors recognize that in such a diverse phenomenon as SHA, there are likely to be multiple motives and that a single theory cannot address all types of alliances (Grant and Baden-Fuller, 2004). Transaction Cost Economics (TCE) (Williamson, 1985) supports the conceptual framework to understand the circumstances determining whether organizations will surrender some autonomy in inter-organizational relationships in exchange for improved efficiency in a SHA. Therefore, it is expected that the efficiency results of a SHA in Mexico will exceed the efficiency levels of hospitals that are not in any kind of agreement (Büchner *et al.*, 2016). Economic theory will be used as a framework to analyze the installed capacity to measure the effects on SHA members, as part of the benefits they obtain through an infrastructure synergy where fixed resources can be shared.

Transaction cost economics (TCE) belongs to the new institutional economics paradigm, which complements traditional neoclassical economics. According to TCE, all economic activity revolves around a transaction, which is simply some form of exchange of a good or service between two or more economic actors. To optimize that exchange, an appropriate governance mechanism must be matched to the nature of the transaction (Williamson, 1985). Barringer and Harrison (2000) take one of the basic decisions firms are often faced with within the TCE framework, namely "make or buy", and expand it by suggesting that with the advent of an alliance, the choice would be "make or buy or partner". They also introduced the concept of "trust" which means that over time, and after a number of successful transactions, the alliance partners develop a sense of trust in each other that hopefully reduces individual partners' desires to seek selfish and opportunistic openings (Lowensberg, 2010).

From a TCE perspective, health care transactions are exceedingly complex: they involve physical, mental and even spiritual aspects on the buyer's side and technological, regulatory, medical and financial aspects on the supplier's side. Furthermore, the health care industry is exceptionally fragmented, and the TCE offers a framework for coordinating care more efficiently among SHA members (Judge and Dooley, 2006).

TCE suggests that centralizing hospital services at the network or system level should reduce the costs of monitoring the actions of other institutions and the costs of coordinating services with them. Erwin *et al.* (2019) state that health care organizations must coordinate very professional teams (Anderson and McDaniel, 2000; Bartram, Stanton, Leggat, Casimir and Fraser, 2007) while competition and costs, and technology development, increase. These new trends require new ways of organization and collaborations among the health institutions in order to be more efficient, being able to offer more services with better quality but with fewer resources (Bellandi, 2000; Swayne, Duncan and Ginter, 2008; Walters and Bhuian, 2004).

More hospital service provision at the network or system level may also be considered an indicator of stronger ties between hospital members, leading to quicker and more accurate transmission of vital information (such as better health practices and compliance with obligations to health authorities), as well as greater cost efficiency for each hospital. This will lead to greater efficiency largely among hospital members. However, collaboration may also result in increased administration costs; these may include the cost of additional staff at the network or system level, the cost of expanded information systems needed to coordinate services, and the costs associated with managing scale differences and agency problems among network or system members (Rosko and Proenca, 2005). However, according to TCE, efficiency gains are expected to outweigh this increase in administrative costs resulting from belonging to a SHA.

Capacity utilization estimation in economic theory

The concept of production capacity can be defined either in economic or engineering terms. Economic capacity is associated with objectives such as cost minimization, while engineering capacity refers to a firm's maximum rate of output (Winston, 1977; Nelson, 1989). Both play important roles in the hospital industry: economic capacity affects competitive viability, and engineering capacity (especially at the community level) affects the level of hospital care potentially available (Ferrier *et al.*, 2009). Capacity measurement has its roots in Johansen (1968), who defines plant capacity as "the maximum amount that can be produced in a unit of time with existing plant and equipment, provided that the availability of variables, factors or production is not restricted". After this seminal approach, new proposals developing and integrating the concept in cost efficiency can be found in De Borger et al. (2012).

Models in industrial organization economics offer a rational explanation about excess capacity. A profit-maximizing firm in a market with few competitors maintains some excess capacity so that it can absorb additional business that it may receive if competitors set higher than expected prices (Benoit and Krishna, 1987). Although there is a scarcity of papers combining the capacity utilization measurement in health care, there is some evidence; see for instance Hu and Huang (2004), Zere et al. (2006), Kuntz, Scholtes and Vera (2007), Van Houdenhoven et al. (2008) or Karagiannis (2015).

If a hospital believes that it does not have optimal capacity, it is likely to adjust its supply of services. Maintaining too much capacity can entail costs that may not be offset by existing payment methods and thus may detract from the hospital's viability. The amount of excess capacity may be particularly high depending on the economic and medical risk aversion of hospital decision-makers. A number of studies find that excess capacity maintained by hospitals comes with increased costs or lower technical efficiencies (Carey, 1997; Smet, 2004). Too little capacity means that the hospital is turning away too many patients. Although hospital managers may want to keep their reservation quality low in order to minimize costs, they risk foregoing revenues if the capacity is so low that they have to turn away patients (Bazzoli *et al.,* 2003*,* 2006; Valdmanis *et al.*, 2010). In a different context, Van Houdenhoven et al. (2008) found a potential improvement of 6.3 % in capacity utilization in the intensive care unit of the operating theater at the Erasmus University Medical Center. As a conclusion, it is clear that accurate measurement of theoretical and available capacity is of vital importance for health care organization managers as well as public health care regulators and supervisors to control operating costs.

METHODOLOGY, DATA AND VARIABLES

In order to perform an efficiency measurement between hospital groups, operating with different technologies and agreements, individual efficiencies in each group need to be compared to a metafrontier concept. The objective is to determine if technical efficiency is better when a hospital belongs to a SHA. Frontier models are commonly used in the literature for the efficiency measurement, since it is a powerful and rigorous methodology based on concepts provided by the theory of production. These models estimate the production frontier from the available data based on two methodological approaches (Bogetoft and Otto, 2010). The first is to use parametric techniques, assuming a priori a functional form for the production function to be estimated using econometric techniques. The main advantage of this approach is that it serves to easily perform statistical inference, although it is complicated to apply when the units to be analyzed produce multiple outputs from the consumption of multiple inputs. The second approach is to use non-parametric models based on linear optimization. These models build an envelope based on best practices, regardless of the number of outputs and inputs in the production process. Since in our case study the production process is multi-input and multi-output, we estimate the levels of efficiency using non-parametric models.

Metafrontier

Hayami and Ruttan (1971) defined the metafrontier, saying that "the metaproduction function can be regarded as the envelope of commonly conceived neoclassical production functions". It is originally related to the concept of the metaproduction function. Battese and Rao (2002) propose a stochastic metafrontier model via which comparable technical efficiencies can be estimated for companies operating under a given production technology, assuming a different data-generation mechanism for the metafrontier for each different group frontier. A metafrontier can be defined according to O´Donnell *et al.* (2008), as a boundary of an unrestricted technology set for the complete sample of *N* hospitals, which envelops group frontiers as shown in Figure 1. Each group frontier is the boundary of restricted technology set from the distinctiveness of the production environment, to which hospitals from each group are subject. Efficiencies measured against the metafrontier can be divided into two parts: first, a component that measures the distance from an input–output point to the group frontier (a common measure of Technical Efficiency, TE, that will be defined in the following Section); and a component that measures the distance between the group frontier and the metafrontier (representing the restrictive nature of the production environment) by the Technological Gap Ratio (TGR). In our case, they will be grouped into two groups: those belonging to a SHA and those which have no agreement.

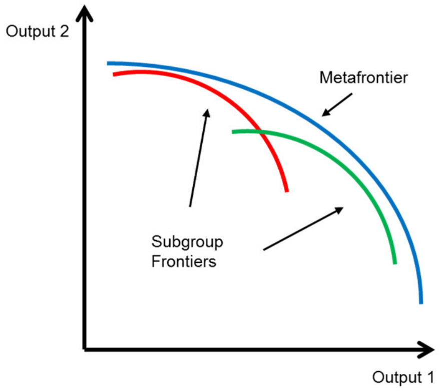

Figure 1. Metafrontier and group frontiers with two outputs

$\boldsymbol{TGRs}$

After measuring each group$'s$ TE, TGRs must be calculated. This ratio measures the ratio of the output for the frontier production function for the kth group compared to the potential output defined by the metafrontier function, given the observed inputs (Battese and Rao, 2002; Battese *et al.*, 2004). Figure 2 assumes two outputs, hospital *r* compared to metafrontier (*M*) is the distance of $0r/0M$, and the same hospital *r* compared to this group frontier (*k*) is denoted as $0r/0k$. The ratio can be calculated as follows:

$$TGR_r = \frac{0r/0M}{0r/0k} = \frac{0k}{0M} \quad (1)$$

This ratio has values between zero and one. If the values are closer to one, it means that the hospitals are nearer the maximum potential output, given the technology available for all hospitals in the database. For example, a value of 0.90 means that the potential efficiency for hospital *r* in group *k* technology is 90% of that represented by the metatechnology.

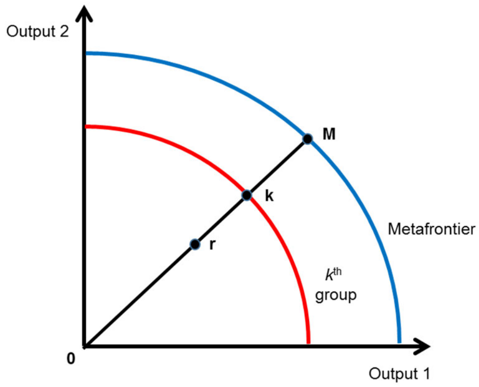

Figure 2. TGR Representation with two outputs

An empirical efficiency analysis and metatechnology ratio requires an empirical description of the methodology used. There are different techniques assessing hospital efficiency indicators, including performance ratios, Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA), among others. In our case we choose DEA for three main reasons: 1) there is no requirement to define a functional form before the estimations, 2) there is no requirement about the residuals distribution, and 3) it works perfectly in technologies with multiple outputs and multiple inputs, as in our case. Thus, we use DEA models to obtain the estimations for the metafrontier (as defined by O´Donnell *et al.,* 2008).

Data Envelopment Analysis

After a general presentation of the concept of the metafrontier analysis, we present the DEA methodology used to calculate all the efficiency scores required for our specific case study. DEA is a non-parametric technique introduced by Charnes *et al.* (1978). It is a linear programming technique used to evaluate the relative efficiency of individual organizations based on observed data assuming that not all firms are efficient. The DEA method draws a possible production curve or data envelope form by combining the existing units' outputs and inputs. Let $y_r\,(y_{1r}, y_{2r}, \dots y_{Or})$ be the corresponding output vector, $x_r^f\left(x_{1r}^f, x_{2r}^f, \dots, x_{I_f r}^f\right)$ the fixed input vector and $x_r^v\left(x_{1r}^v, x_{2r}^v, \dots, x_{I_v r}^v\right)$ the variable input vector for unit *r*. Regarding the total sample of *K*, we can classify the units into two subsamples ($K = K_1 \cup K_2$). K_1 includes the hospitals belonging to the SA while K_2 refers to the control sample.

The reason we apply the DEA method is to establish a comparison among the *K* hospitals, and to evaluate if hospitals within K_1 are more efficient, in relative terms, than those classified in K_2.

Regarding the orientation of the DEA assessment, we defined an output-oriented DEA model which seeks the maximum proportional increase in output production, with input remaining constant. The assumption of the returns to scale (constant or variable) depends on the structure of the sample. Here, after observing the existence of substantial differences in size, we took a conservative approach by assuming variable returns to scale (VRS).

The output-oriented metafrontier can be estimated by solving the following linear program:

$$D^r\left(x_r^f, x_r^v, y_r\right) = \min_{\theta_r z_n} \theta_r$$

Subject to:

$$\sum_{n \epsilon M} z_n \,.\, y_{on} \geq y_{or} . \theta_r^{-1}, \quad o = 1, \dots, O$$

$$\sum_{n \epsilon M} z_n \,.\, x_{in}^f \leq x_{ir}^f, \quad i = 1, \dots, I_f$$

$$\sum_{n \epsilon M} z_n \,.\, x_{pn}^v \leq x_{pr}^v, \quad p = 1, \dots, I_v$$

$$\sum_{n \epsilon M} z_n = 1,$$

$$z_n \geq 0, \qquad n \epsilon M$$

$$\theta_r \geq 0 \tag{2}$$

Where $M = K$, z_n is the activity coefficient for those hospitals that form the frontier; and θ_r is the output – oriented distance function. A value of θ_r less than 1 means that the evaluated hospital is inefficient. For θ_r close to or equal to 1, the hospital will be at the efficiency frontier. The model above will also apply for a local group by defining $M = K_1$ and $M = K_2$.

Capacity utilization measurement with DEA

We also used DEA estimations to determine the use of the capacity, since it has been widely-used in hospital productivity studies due to its salient features, including the ability to calculate multiple output capacity given multiple inputs, both fixed and variable (Färe *et al.*, 1989; Färe *et al.*, 2000; Ouellette and Vierstraete, 2004; Kuntz *et al.*, 2007; Ferrier *et al.*, 2009). SHA can exploit economies of scale and scope in the long term (Dranove *et al.*, 1996), and improve facility utilization as well as cost performance in the short term (Coddington and Moore, 1987). Another benefit of this approach is that capacity utilization can be determined for both samples of hospitals (Valdmanis *et al.*, 2010).

A range of DEA models have been developed that measure efficiency and capacity in different ways. According to Färe *et al.* (2000), and Ferrier *et al.* (2009), capacity utilization is measured in three steps: first, by determining the maximum amount of output obtainable from the observed (fixed and variable) inputs; second, by determining the maximum amount of output that could be obtained from the observed fixed inputs if variable inputs are not constrained; third, by taking the ratio of the results of the first two steps to obtain a measure of capacity utilization.

We can calculate the capacity utilization indicator for hospital r (HCU_r) with the following expression:

$$HCU_r = \frac{D^r\left(x_r^f, x_r^v, y_r\right)}{D^r\left(x_r^f, y_r\right)} \qquad (3)$$

Where $D^r\left(x_r^f, x_r^v, y_r\right)$ is estimated by using program (2) and the denominator removes the restriction of the variable inputs from program (2).

This measure is devoid of any inefficiency and will be less than or equal to 1 since the numerator, with more constraints, must be less than or equal to the denominator. The capacity utilization rate can be interpreted as the proportion of potential output currently being provided by a hospital. Alternatively, $(1 - HCU_r)$ this gives the potential percentage increase in hospital r's services if its variable inputs are not constrained (Ferrier *et al.*, 2009).

Data and variables

The data was collected from a SHA in Mexico called *Consorcio Mexicano de Hospitales, A.C.* (CMH). Conceptually, CMH is considered an equity joint venture because the member hospitals pool resources to create a separate legal entity and all hospitals benefit from the success of the new entity. The CMH includes 36 private general hospitals located in 35 cities across Mexico. It includes 5,000 medics and 6,000 employees, who have joined the SHA in order to exchange medical, administrative, legal and operational information; to perform training focused mainly on patient care; to share best practices and create a bargain power with suppliers related to medicines, medical equipment and insurance; as well as to share marketing strategies for their health care services as mentioned by Hennart (1988). Following the classification made by Conrad and Shortell (1996), CMH is a horizontal integration where two or more separate firms, producing either the same service or services that are very similiar, join to become either a single firm or a strong inter-organizational alliance. The study was performed with information available on 29 general hospitals belonging to CMH for 2014 because not all hospitals provided information.

The efficiency assessment for CMH hospitals requires a control group that does not belong to any SHA to establish comparisons with the same characteristics as CMH members. For this purpose, information from a questionnaire collected annually by the National Institute of Statistics and Geography (INEGI) in Mexico called "Statistics of private medical units with hospitalization service" (form PEC-6-20-A) was used. The 2014 original database contains 3,015 private hospitals. However, hospitals with missing values, information that did not match or inconsistent information (*i.e.* some hospitals reported operating theaters without any surgical procedures performed) had to be removed. In addition, hospitals from states where CMH do not operate as well as hospitals located in cities without the same population density according to the

INEGI 2010 population census were removed. Similarly, specialized hospitals in this sample were eliminated, since CMH does not have this type of hospitals. Finally, the non-SHA group consists of 47 private hospitals.

Although there is a variety in the variables used according to the approaches made by the authors, the input variables are essentially grouped around doctors, available beds, operating theaters, costs and total assets representing 63% of variables used; while the outputs are related to the surgical procedures, inpatient days, case-mix discharge patients and post-admission days, representing 65% of variables used. The variables for the paper collected from the databases and their current definitions as described by Mexican Official Norm, are describes in Table 1.

[Table 1 here]

More details on the sample size of each group (CMH and INEGI) as well as basic descriptive statistics for each variable are presented in Table 2.

[Table 2 here]

RESULTS

Metafrontier results

The results obtained by applying a metafrontier model as previously described seek to evaluate an appropriate efficiency comparison between hospitals belonging to a strategic alliance and hospitals that do not have these agreements. The metafrontier concept is used to account for business conditions and technological differences between groups derived from TGR calculations.

Previous research has shown mixed evidence on SHA's relationship with TE improvement (Bazzoli *et al.,* 2000; Wan *et al.,* 2001; Rosko and Proenca, 2005; Carey, 2003; Rosko *et al.,* 2007; Granderson, 2011; Bernardo *et al.*, 2012; Chu and Chiang, 2013; Roh *et al.*, 2013). In part, this is due to the fact that different methods are employed (parametric and non-parametric approaches), the diversity in the data collected and specific health care conditions such as a country's legal requirements or environmental factors like economic, social or cultural factors. Considering our theoretical approach, for this paper SHA are expected to improve efficiency. The results obtained for a DEA metafrontier model are presented in Table 3.

[Table 3 here]

The average efficiency for the SHA group in relation to the metafrontier is 97%, whereas for the non-SHA group it is 94%. This suggests that hospital operations in an alliance are more efficient in relation to the metafrontier than non-members, so these results seem to be consistent with the propositions from our theoretical framework stating that, by refining the coordination, strategic alliances are useful tools to obtain increases in efficiency and reductions in total costs. Even if non-SHA has 53% of hospitals at the metafrontier with a score of 1, compared with 48% of SHA, the results show that operations in SHA are producing on average 97% of their potential output compared to the metafrontier technology based on the TGR. This ratio is higher than the non-SHA group with an average of 94%. However, the Wilcoxon-Mann-Whitney (WMW) test was applied and the results obtained show there is no significant statistical evidence between these two groups. So, from a statistical point of view, we do not find evidence that SHA provides improvements in efficiency compared to the non-SHA hospitals.

As we concentrated on the concept of operating efficiency, the variables defined did not considered financial and accounting information that is directly dependent on the values of input and output prices. In order to complete a general view, we checked for this alternative piece of information and found that, according to CMH alliance reports, they have achieved significant cost savings of almost 15% in recent years when making consolidated purchases or negotiating medical equipment acquisitions which improve the available infrastructure of its members, around 86% from total joint purchases since the beginning of the alliance. So, it appears that rather than a reduction in total costs via improvements in efficiency and productivity, it seems that the immediate impact on costs comes from an increase in the capacity of negotiating acquisition prices for both operating and capital expenditures.

As regards the outputs, an additional effect of the alliance could impact directly on the prices patients face. In our case study, CMH has established a business partnership with a private insurer to provide users with basic insurance benefits. This insurance is not required to pay a deductible bill or co-insurance to be addressed to the hospitals members of the alliance. By purchasing this insurance, the beneficiary is entitled to discounts on services such as laboratory analyses, X-ray, ultrasound, emergency and hospitalization as well as preferential prices in general clinics, emergency departments and specialists at any alliance hospital. Thus, it seems that the immediate impact of the alliances is related with the output and input prices; In the more medium term, better use of the capacity utilization will also have a positive impact on the total costs and, subsequently, it could also affect the output prices customers face. However, in general terms, as Haas-Wilson and Gamon (2011), Tenn (2011) and Thomson (2011) point out, after a merger the market power may increase, leading to an increase in output prices. So, if necessary, regulators should carefully consider the impact of these operations in order to enhance the positive impact for consumers by controlling the negative effects of the increase of market power.

Capacity results

Capacity assessment should improve for SHA members, since they can exploit economies of scale and scope by sharing infrastructure, eliminating duplication of equipment investment, and gaining market participation by sharing marketing strategies that increase patient flow, for example (Dranove, Durkac and Shanley, 1996). For this paper, the installed capacity was measured with the two most used inputs according to literature: operating theaters (Dexter and Epstein, 2005; Wullink *et al.,* 2007; Cardoen *et al.*, 2010; Yi *et al.,* 2010) and available beds (Green, 2002; Utley *et al.,* 2003; Nguyen *et al.,* 2005; Kuntz *et al.*, 2007; Rego *et al.*, 2010; Valdamis *et al.*, 2010; Bachouch *et al.*, 2012). The results obtained when performing the capacity model with available data are in Table 4.

[Table 4 here]

The results on capacity utilization with operating theaters as a fixed input, show that on average, Mexican private general hospitals from the database used, have 58% of capacity usage, but the group of hospitals in a SHA obtains a higher rate (67%) than non-SHA (52%). When using available beds as a fixed input in model definition, an increase in the capacity to 76% is obtained on average. Capacity comparisons in each group, in general terms, have improved, but usage is still higher for SHA (85%) than non-SHA (70%). The WMW test[3] was applied to these results and showed that there is significant statistical evidence between these two groups in each fixed input analyzed. This indicates that a SHA improves the use of installed capacity for private hospitals in Mexico, when using any of the two defined fixed inputs, ensuring the robustness of the results. In this regard, it appears that, as the differences found are statistically significant, SHA hospitals are able to plan a better use of the installed capacity provided by the fixed inputs. Considering the time frame assessed (that is, a cross-section analysis), it appears that the better use of the capacity does not generate mechanical improvements in the operating efficiency in the short term, but we can expect this situation to be different when considering a temporal evolution in the experience of the SHA.

In short, the results show that SHA hospitals are able to manage a better use of the fixed inputs and the implicit concept of capacity utilization. However, in the short term it appears that they have problems bringing about statistically significant improvements in the levels of operating efficiency through the better use of the fixed inputs (a more detailed analysis in future research could tell us what is the maturity time required to obtain improvements in productivity and reductions in total costs through the better use of the capacity installed). What seems to have an immediate impact on the total costs is the reduction of prices, both of operating and capital expenditures.

CONCLUSIONS

Changes facing the health system in Mexico are providing areas of opportunity for private hospitals, which encourages them to evaluate different ways of participating in partnerships, joint ventures or alliances. The aim of this paper is to analyze the strategic alliances created between

[3] WMW test results for operating rooms as fixed inputs is $z = 2.349$, $p = 0.018$; and for available beds is $z = 3.354$, $p = 0.000$

private hospitals to foster TE using a DEA-metafrontier model construction proposed by O´Donnell, Rao and Battese (2008) and capacity utilization using Johansen's (1968) definition. The total database is made up of 76 hospitals of which 29 are in a hospital alliance called *Consorcio Mexicano de Hospitales A.C.* (CMH) and the rest are considered part of a control group for 2014.

For hospital managers, the most important effects of strategic alliances are the increase in knowledge among health care members from different perspectives (medical issues, customer satisfaction, administrative and legal matters, among others), and reduced operating costs. Formally, CMH is an equity joint venture since each hospital member pools resources to create a separate legal entity and all benefit from the services and programs delivered. CMH has sought out new ways for its affiliated hospitals to be more attractive for the middle class market that does not have the ability to pay large private hospital chains and does not want to be treated in public hospitals as it perceives the quality and attention to be inferior.

Current findings show, based on TGRs, that, although not statistically significant in the short term, CMH private hospitals can be more efficient than hospitals without an agreement. These results are similar to those obtained by Dranove *et al.*, (1996), Bazzoli *et al.,* (2000), Rosko and Proenca (2005); Carey (2003); Granderson (2011); Chu and Chiang (2013); and, Roh *et al.* (2013), and they are also supported by TCE theoretical framework. These results may help hospital managers (e.g., by identifying best practices and compliance with health regulations) and policymakers (e.g., assessing the effects of deregulation, mergers, and market structure on industry efficiency) to promote hospital alliances as a means of increasing efficiency without sacrificing user satisfaction, a key objective in health care system management. What seems to have an immediate impact on total costs is the increase in the capacity to negotiate the input prices for the operating and capital expenditures. As regards output prices, our initial statement regarding the positive impact of improvements in efficiency seems to be confirmed in our case study. However, regulators should exercise caution should the potential contrary effect occur when the market power increases as a result of a SHA.

Additionally, the estimation of capacity utilization for hospital alliances is made, providing valuable information relevant to managers to evaluate short and long-term investments measured by operating theaters and available beds. The results of the model employed indicate that capacity utilization is best used by a hospital alliance, confirming that indicated by Li and Benton (2003), Jack and Powers (2009) and Rachel *et al.* (2011). What we can extract from our results is the difficulty to originate cost savings and improvements in efficiency from the better use of the capacity installed from the short term perspective. This means that a future work may be required to determine what is the maturity time needed to obtain significant cuts in costs from the better use of the CMH hospital infrastructure.

One of the main limitations of this piece of work is the number of hospitals assessed as well as the cross-sectional approach to the empirical analysis. Further research could focus on a dynamic analysis of quantities and prices in order to observe the temporality of the subsequent effects and the changes in the market power after the SHA is carried out.

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TABLES

Table 1. Variables description

Outputs	***Inputs***
y_1: Surgical medical procedures. Procedure involves removing, explore, replace, transplanting or repair a defect or injury or to make a change in a tissue or damaged or healthy organ, therapeutic, cosmetic, diagnostic or prophylactic purposes, by invasive techniques generally involve the use of anesthesia and cutting tools, mechanical or other physical means, performed within or outside of an operating room.	x_1: Doctors in direct contact with the patient. Health professional with a degree and license that practice the profession or specialty with direct attention to patients.
y_2: Days of stay. Number of days from the patient admitted to a hospital until discharge; it is obtained by subtracting the discharge date from the admission. If a patient goes in and out the same day generates one day stay.	x_2: Nurses. Provide medical assistance to sick or disabled, its focus is the maintenance and health care during illness and rehabilitation, as well as assistance to doctors and health diagnosis and treatment of patients.
	x_3: Censable beds. This bed is available for hospitalization services.
	x_4: Operating rooms. Hospital´s area, furniture, equipment and facilities, in order to perform surgical procedures.

Notes: The definition of production technology requires the determination of inputs and outputs used. The table shows the ones used in our case for the hospital production process. The inputs and outputs have been taken from the available databases, being similar to those used in other works measuring hospital efficiency.

Table 2. Group's basic descriptive statistics: SHA hospitals and Non-SHA hospitals

SHA: *CMH (n=29 hospitals)*	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Outputs				
y_1: Surgical medical procedures	1,214	1,163.93	95	5,736
y_2: Days of stay.	4,024	3,583.10	245	14,110
Inputs				
x_1: Doctors in direct contact with the patient.	9	10.05	2	48
x_2: Nurses	51	42.05	10	176
x_3: Censable beds	24	12.91	8	62
x_4: Operating rooms	3	1.65	2	8

Non-SHA: *INEGI (n=47 hospitals)*	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Outputs				
y_1: Surgical medical procedures	519	778.13	158	4,186
y_2: Days of stay.	2,557	3,190.89	331	12,778
Inputs				
x_1: Doctors in direct contact with the patient.	8	11.36	2	58
x_2: Nurses	19	41.73	10	206
x_3: Censable beds	17	15.27	8	61
x_4: Operating rooms	2	1.24	2	6

Notes: The total sample of hospitals analyzed is 76. They have been organized into two groups: 29 belonging to a private hospital alliance and 47 private hospitals not belonging to any alliance. The table shows the main descriptive statistics for each group.

Table 3. $TGRs$ for SHA (*CMH*) and Non-SHA (*INEGI* control group)

Frontiers	**n**	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**q1**	**q3**
SHA: *CMH*	29	0.97	0.04	0.86	1.00	0.95	1.00
Non-SHA: *INEGI*	47	0.94	0.09	0.66	1.00	0.85	1.00
Full sample	76	0.95	0.08	0.66	1.00	0.94	1.00

Notes: The average TGR is 0.95, which means that hospitals operate at 95% of the maximum potential output they could achieve given the resources they have used. The table also shows that the TGR is higher for the group of hospitals belonging to the SHA (0.97 vs. 0.94), which suggests higher efficiency levels in this group.

Table 4. Installed capacity based on fixed input "operating rooms" and "censable beds"

Fixed input: Operating rooms

Frontiers	n	Mean	Std. Dev.	Min.	Max.	q1	q3
SHA: *CMH*	29	0.67	0.28	0.09	1.00	0.41	0.98
Non-SHA: *INEGI*	47	0.52	0.25	0.12	1.00	0.32	0.76
Full sample	76	0.58	0.27	0.09	1.00	0.36	0.83

Fixed input: Censable beds

Frontiers	n	Mean	Std. Dev.	Min.	Max.	q1	q3
SHA: *CMH*	29	0.85	0.16	0.44	1.00	0.77	0.98
Non-SHA: *INEGI*	47	0.70	0.18	0.27	1.00	0.57	0.86
Full sample (metafrontier)	76	0.76	0.18	0.27	1.00	0.61	0.91

Notes: On average "censable beds" is the input with a greater capacity utilization (76%) with respect to obtained in the use of the "operating rooms" (58%). By groups, this same overall trend is confirmed, however, a greater utilization of capacity among hospitals belonging to the SHA is observed in both fixed inputs. This result could help to explain the best levels of efficiency identified previously in this group as well as confirm one of the potential advantages highlighted of joining an alliance.