

Strategic alliances effects over hospital efficiency and capacity utilization in México

Abstract

This paper aim to investigate the efficiency implications of belonging to a strategic hospital alliance (SHA) and measuring the effects over 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 gaps ratios are calculated by using 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 *Consortio Mexicano de Hospitales, A.C.* in México which has 29 general private hospitals and a group of 47 hospitals with same characteristics from a database made by the *Instituto Nacional de Estadística y Geografía* for year 2014. The results indicate that efficiency is better at hospitals that belong to an alliance, it also shows an improvement of installed capacity management for hospital alliances in México.

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

JEL codes: L25, L26

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 companies' structures change, healthcare industry is not an exception to this trend. The current healthcare environment worldwide is much more volatile, and both environmental and organizational context need to be taken into account in strategic decision making. Alliance formation in 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 the advantages of centralized management without loss of individual hospital control (Zinn, Proenca and Rosko, 1997; Zuckerman and D'Annunio, 1990; Zuckerman and Kaluzny, 1991).

Early research on hospitals and strategic alliances in the 1990's focuses on the economic impact of these alliances on hospital financial performance. Initial findings were that hospitals in strategic alliances yielded higher net revenues but they were not effective at controlling cost 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 2000's, SA were studied as an approach for efficient development of health care service delivery systems in the face of health care reforms in the United States (Kaluzny, Zuckerman and Ricketts, 2002; McSweeney-Feld, Discenza and De Feis, 2010).

The Organization for Economic Co-operation and Development (OECD) health statistics 2013 indicates that 70% of all hospitals in México are private, although public hospital infrastructure has made significant investments during the period 2003-2013. However, beds in private owned hospitals have grown 10% in the same period above 6% made in public hospitals. There are 27,176 medics in private medicine, an increase of 56% in 2013 compared to 2003 according to *Ministry of Health in México*. In 2013, private health spending concentrated 44% of total health spending (World Health Organization, 2013), around 96% of this expenditure are out-of-pocket (OOP) payments (includes medicines and hospital service as the main expenses) and only 4% corresponds to pay private health insurance premiums. Likewise, Mexican Association of Insurance Institutions (AMIS) 2013 annual report indicates that the number of people affiliated with health insurance has grown by 131% from 2003 to 2013.

Private hospitals have seen a great opportunity to participate in the health market in México, 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 its resources and to rethink its business model by establishing adequate operational and capacity management practices to meet patient's demand requirements and changing general health and economic conditions at the same time without losing healthcare quality, and obtaining an adequate return to its shareholders in the short and long term (Zuckerman and Kaluzny, 1991; Bates, Mukherjee and Snatterre, 2006; Roh, Moon and Jung; 2013).

Capacity management in the health sector have been analyzed in different ways, mainly related to capacity planning (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); healthcare reforms (Cseh, Koford and Phelps, 2015; Valdmanis, DeNicola and Bernet, 2015); and future constraints events such as natural disasters, terrorism and epidemics (Ferrier, Leleu and Valdmanis, 2009; Valdmanis, Bernet and Moise, 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 healthcare are inefficient due to high costs.

This research contains two objectives using data from Mexican hospitals that have decided to establish a SA. 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 metafrontier ratio; and, the second objective is to measure if actual capacity is better utilized by hospitals members of SA who are not in an alliance, as an important consequence, since the investment previously made in infrastructure is really optimized by hospital capacity utilization (*HCU*).

LITERATURE REVIEW

Strategic hospital alliances

The literature review examines the nature of an evolution of alliances, characteristics and the main economic theories which support them. The overview of the literature is applicable to all organizations engaging in strategic alliances, but the main focus will be in the context for health care organizations.

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 hospitals' 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) opine 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.

Different authors recognize that in a diverse phenomenon such 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). For the purpose of this paper, transaction cost economics (Williamson, 1985), support 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 an SHA in México, will exceed the efficiency levels of hospitals that are not in any kind of agreement (Büchner, Hinz and Schreyögg, 2016). Economic theory will be used as a framework for the analysis of installed capacity to measure their effects on the SHA members, as part of the benefits they obtain through an infrastructure synergy where it is possible to share fixed resources (Johansen, 1968).

Transaction costs economics

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 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 implies that over time and

after a number of successful transactions, the alliance partners develop a sense of trust in each other that hopefully brings a reduced wish by individual partners to seek selfish and opportunistic openings (Lowensberg, 2010).

For a TCE perspective, healthcare 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 healthcare 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. More hospital service provision of the network or system level may also be considered an indicator of stronger ties between hospitals 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 allow a better efficiency largely among hospital members. On the other hand, collaboration may also result in increased costs of administration; 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 of 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 played important roles in the hospital industry: economic capacity affects competitive viability and engineering capacity (especially at the community level), affects the levels of hospital care potentially available (Ferrier, Leleu and Valdemanis, 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”. 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 competitor set higher than expected prices (Benoit and Krishna, 1987).

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 compensated by existing payment methods and thus may detract from hospitals 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 foregone revenues if capacity is so low that they have to turn away patients (Bazzoli *et al.*, 2003; Bazzoli *et al.*, 2006; Valdmanis, Bernet and Moises, 2010). Accurate measurement of theoretical and available capacity is of vital importance for healthcare organizations managers as well as public healthcare regulators and supervisors.

METHODOLOGY AND DATA

Efficiency measurement between hospitals groups, operating with different technologies and agreements, requires to make a comparison of individual efficiencies in each group with respect to a metafrontier concept. The objective is to determine if technical efficiency is better when a hospital belongs to an SHA.

Metafrontier

The metafrontier is originally related to the concept of the metaproduction function defined by Hayami and Ruttan (1971) that “the metaproduction function can be regarded as the envelope of commonly conceived neoclassical production functions”. Battese and Rao (2002) propose a stochastic metafrontier model by which comparable technical efficiencies can be estimated for companies that operate under a given production technology, assuming a different data-generation

mechanism for the metafrontier than for each different group frontiers. One explains deviations between observed outputs and (fixed) group frontiers, and another that explains deviations between observed outputs and the metafrontier (also fixed). Afterward, Battese, Rao and O'Donnell (2004), assumes that there exists only one data-generation process for the firms that operate under a given technology. This explains deviations between observed outputs and group frontiers, and defines the metafrontier to be a function that envelops the deterministic components of the group frontier. O'Donnell, Rao and Battese (2008) explores the issues of technological change, time-varying technical inefficiency, multiple outputs, different efficiency orientations, and firma heterogeneity by using non-parametric and parametric methods in a metafrontier analysis.

A metafrontier can be defined according to O'Donnell, Rao and Battese (2008), as a boundary of an unrestricted technology set for individual r hospitals, which envelops group frontiers as shown in Figure 4.1. Each group frontiers is the boundaries of restricted technology set from the distinctiveness of the production environment, to which hospitals of each group are subject. Efficiencies measured relative to 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 TE); and a component that measures the distance between the group frontier and the metafrontier (representing the restrictive nature of the production environment) by TGR .

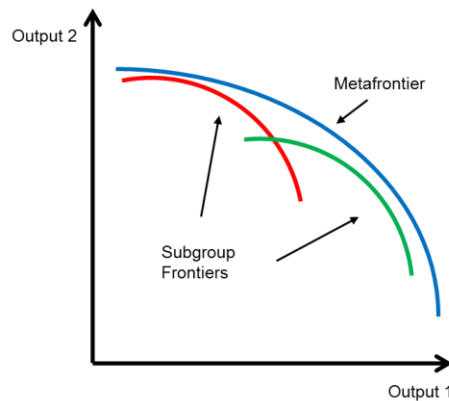


Figure 4.1. Metafrontier and group frontiers with two outputs

It is assume that there is a production technology (T) that allows transformation of ax vector of inputs ($I \times 1$), into a y vector of outputs ($O \times 1$). Formally:

$$T = \{ (x, y): x \text{ can produce } y; x \geq 0; y \geq 0 \} \quad (1)$$

The output set is defined for any input vector, x , representing the boundary of this output set as the output metafrontier, as:

$$P(x) = \{y: (x, y) \in T\} \quad (2)$$

The output distance function is defined as the output metadistance function, defined as:

$$D(x, y) = \inf_{\theta} \{ \theta > 0; (y/\theta) \in P(x) \} \quad (3)$$

Group's frontiers

The hospitals used in this paper will be divided into two groups, K , those who belong to an SHA and those who have no agreement. Each group frontier has different technology and factor levels, T^k . Under these considerations, metatechnology set can be written for each group as follows:

$$T^k = \left\{ \begin{array}{l} (x, y): x \text{ can be used by hospitals in group } k \\ \text{to produce } y; x \geq 0; y \geq 0 \end{array} \right\} \quad (4)$$

The K group-specific technologies can also be represented by the following group-specific output sets and output distance functions:

$$P^k(x) = \{y: (x, y) \in T^k\}, k=1, 2, \dots, K; \text{ and} \quad (5)$$

$$D^k(x, y) = \inf_{\theta} \{ \theta > 0; (y/\theta) \in P^k(x) \}, k=1, 2, \dots, K \quad (6)$$

The boundaries of the group-specific output set as group frontiers. If the output sets, $P^k(x), k=1, 2, \dots, K$, satisfy standard regularity properties then the distance functions, $D^k(x, y), k=1, 2, \dots, K$, also satisfy standard regularity properties.

The convexity property for a metafrontier was described by Presada, O'Donnell and Battese (2003) which defines the metafrontier as the convex hull of the union of group of group-specific technologies denoted by:

$$(x, y) \in T^k \text{ for any } k \text{ then } (x, y) \in T \quad (7)$$

$$T = \text{convex hull} \{ T^1 \cup T^2 \cup \dots \cup T^k \} \quad (8)$$

TGR's

After the measure of each group TE , it is required to calculate $TGR's$. This ratio measures the ratio of the output for the frontier production function for the k th group relative to the potential output that is defined by the metafrontier function, given the observed inputs (Battese and Rao,

2002; Battese *et al.*, 2004). Figure 4.2. assumes two outputs, hospital r with respect to metafrontier (M) is the distance of Or/OM , and the same hospital r with respect to his group frontier (k) is denoted as Or/Ok . It is possible to calculate the ratio as follows:

$$TGR_r = \frac{D(x,y)}{D^k(x,y)} = \frac{Or/OM}{Or/Ok} = \frac{Ok}{OM} \quad (9)$$

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

An empirical efficiency analysis and metatechnology ratio requires an empirical description of the methodology used. There are different techniques assessing hospital efficiency indicators, including hospital performance ratios, Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA), among others. SFA estimation is especially complicated by the theoretical requirement that the metafrontier envelops the group frontiers (O'Donnell *et al.*, 2008). For this reason, the paper uses DEA methodology.

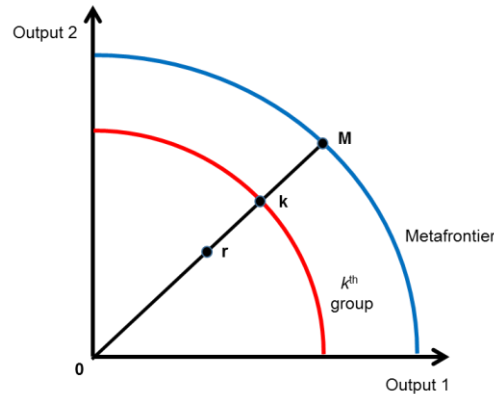


Figure 4.2. *TGRS* Representation with two outputs

Data Envelopment Analysis

DEA is a non-parametric technique introduced by Charnes, Cooper and Rhodes (1978). It is a linear programming technique for evaluating the relative efficiency of individual organizations based on observed data assuming that not all firms are efficient. The DEA method draws a production possible curve or data envelope from combination of unit's inputs ($i = 1, \dots, I$) and outputs ($o = 1, \dots, O$). Let y_{on} be the output o corresponding to unit n and x_{in} the input i

corresponding to unit n . This curve is also called the efficient frontier. In this paper, the purpose of applying the DEA technique is to establish comparison among private hospitals (r) and to evaluate, if approximately, hospitals within a SA are more efficient, in relative terms, than those who are not in an alliance. It is necessary to define the orientation of DEA model. In this paper, it is defined as an output-oriented DEA model which seeks the maximum proportional increase in output production, with input to be constant, because in the short term some input variables can't be modified immediately, (*i.e.* operating rooms or censable beds).

The decision to use the CRS model or VRS model depends on the purpose of the analysis. From a societal viewpoint, the CRS model may be appropriate, because the focus might be on efficiency regardless of scale of operations. However, the managerial viewpoint might be more concerned with the extent to which the scale of operations influences efficiency, so the VRS model may be preferred (Roh, Moon and Jung, 2013), therefore, this paper employed the VRS model.

Coelli *et al.*, (2005) pointed out that “the output- and input- oriented models will estimate exactly the same frontier and therefore, by definition, identify the same set of DMU's as being efficient. It is only the efficiency measures associated with the inefficient DMU's that may be different between the two methods.”

Therefore, if group k consists of data on r^k hospitals the VRS output –oriented DEA problem is as follows:

$$D^k(x, y) = \min_{\theta_r z_n} \theta_r$$

Subject to:

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

$$\sum_{n=1}^N z_n \cdot x_{in} \leq x_{ir}, \quad i = 1, \dots, I$$

$$\sum_{n=1}^N z_n = 1$$

$$z_n \geq 0, \quad n = 1, \dots, N$$

$$\theta_r \geq 0 \tag{10}$$

Where:

y_{on} is the output o corresponding to hospital n ;

y_{or} is the output o corresponding to hospital r under assesment;

x_{in} is the input i corresponding to hospital n ;

x_{ir} is the input i corresponding to hospital r under assesment;

z_n is the activity coefficient for those hospitals that forms the frontier; and

θ_r is the distance function.

When the result of θ_r is less than 1, inefficient hospitals are considered; if the result is close or equal to 1, the hospital will be at the efficiency frontier. The model above will apply also for a metafrontier group by substituting de supraindex k by M , being $M = 1, 2, \dots, k, \dots, K$.

DEA capacity measurement

This paper used a DEA frontier approach for capacity measurement, since it has been widely-used in hospital productivity studies due to its salient features, that includes the ability to calculate multiple output capacity given multiple inputs, both fixed and variable (Färe, Grosskopf, Valdmanis, 1989; Färe, Grosskopf and Kirkley, 2000; Ouellette and Vierstraete, 2004; Kuntz, Scholtes and Vera, 2007; Ferrier; Leleu and Valdemanis, 2009). SHA can exploit economies of scale and scope in the long term (Dranove, Durkac and Shanley, 1996), improve facility utilization as well as cost performance in the short term (Coddington and Moore, 1987). Another benefit of this approach is that capacity can be determined in terms of what the sample hospitals best practices (Valdmanis, Bernet and Moises, 2010).

A range of DEA models have been developed that measure efficiency and capacity in different ways. These principally fall into the categories of being either input-oriented or output-oriented models. With input-oriented DEA, the linear programming model is configured so as to determine how much the input use of a firm could contract if used efficiently in order to achieve the same output level. For the measurement of capacity, the only variables used in the analysis are the fixed factors of production. As these cannot be reduced, the input-oriented DEA approach is less relevant in the estimation of capacity utilization. In contrast, with output-oriented DEA, the linear

programming is configured to determine a firm's potential output given its inputs if it is operated efficiently as firms along the best practice frontier (Färe, Grosskopf and Kokkelenberg, 1989; Färe, Grosskopf and Lovell, 1994).

According to Färe, Grosskopf and Kirkley (2000), and Ferrier, Leleu and Valdmanis (2009), capacity utilization is measured in three steps: first, determine the maximum amount of output obtainable from the observed (fixed and variable) inputs; second, determine the maximum amount of output that could be obtained from the observed fixed inputs if variable inputs are not constrained; third, take the ratio of the results of the first two steps to obtain a measure of capacity utilization. Rather than using the standard distance function usually associated with DEA models of efficiency measurement, capacity utilization in a frontier setting using directional distance functions is derived. The advantage of a feature unique to directional distance functions—additivity—allows the collection of the capacities of individual hospital to determine hospital capacity for a group (Färe and Grosskopf, 2000).

Assume that for a specific hospital, let y be a vector of outputs ($O \times 1$) and x a vector of inputs ($I \times 1$). Given that it is examining a short-run setting, the inputs need to be categorized as fixed (x^f) or variable (x^v), that is, $x = (x^f, x^v)$. The transformation of inputs into outputs is governed by technology, which can be represented by:

$$\begin{aligned} T(x, y) &= (x^f, x^v, y) \\ &= \{ y : y \text{ can be produced from } x = (x^f, x^v) \} \end{aligned} \quad (11)$$

If the objective is to measure the maximum amount of output that can be produced, it is required to find the frontier, or envelope, of the technology. This can be provided by a directional output distance function, which under standard assumptions is a complete representation of technology (Färe and Grosskopf, 2000).

By moving in an output direction, observations below the envelope of technology have their outputs expanded until they are projected onto the technological frontier. Therefore, the directional output distance function is:

$$\widehat{D}_o [(x^f, x^v), y; g^y] = \sup\{ \beta : [(x^f, x^v), y + \beta g^y] \in T \} \quad (12)$$

Where g^y is a directional vector of dimension outputs that determines the projection path onto the frontier and β is a scalar that indicates the amount that outputs must be expanded in the direction g^y in order to place an observation on the frontier. For all elements of T , $\widehat{D}o [(x^f, x^v), y; g^y] \geq 0$; values equal to zero indicate that outputs cannot be expanded, thus an observation lies on the frontier and is efficient, while values greater than zero indicate that an observation lies below the frontier considered as inefficient, and the direction output distance function give the proportion by which outputs must be scaled in order for a data to be projected onto the envelope of the technology.

The traditional input and output distance functions are closely related to the directional distance function, setting $g^y = y$ for the i th observation, where Do , is the standard output distance function:

$$\begin{aligned} \widehat{D}o[(x^f, x^v), y_i; g^y] &= \widehat{D}o[(x^f, x^v), y_i; y_i] \\ &= 1/Do [(x^f, x^v), y_i] - 1 \end{aligned} \quad (13)$$

The first step in determining HCU is to find the value for the directional output distance function while restricting both variable and fixed inputs to be no greater than their current levels. Suppose there are $n = 1, 2, \dots, N$ hospitals in the data sample, under variable returns to scale, the value of the directional output distance function for the r hospital can be found by solving the following linear programming:

$$\widehat{D}o [(x_r^f, x_r^v), y_r; g^y] = \max_{\beta_r, z_n} \beta_r$$

Subject to:

$$\sum_{n=1}^N z_n \cdot y_{on} \geq y_{or} \cdot (1 + \beta_r), \quad o = 1, \dots, O$$

$$\sum_{n=1}^N z_n \cdot x_{i1n}^f \leq x_{i1r}^f, \quad i_1 = 1, \dots, I_1$$

$$\sum_{n=1}^N z_n \cdot x_{i2n}^v \leq x_{i2r}^v, \quad i_2 = 1, \dots, I_2$$

$$\sum_{n=1}^N z_n = 1,$$

$$\begin{aligned} z_n &\geq 0, & n = 1, \dots, N \\ \beta_r &\geq 0 \end{aligned} \tag{14}$$

Where:

y_{on} is the o output corresponding to hospital n ;

y_{or} is the o output corresponding to hospital r under assessment;

$x_{i_1n}^f$ is the i_1 fixed input quantities corresponding to hospital n ;

$x_{i_1r}^f$ is the i_1 fixed input quantities corresponding to hospital r under assessment;

$x_{i_2n}^v$ is the i_2 variables input quantities corresponding to hospital n ;

$x_{i_2r}^v$ is the i_2 variables input quantities corresponding to hospital r under assessment;

z_n is the activity coefficient for those hospitals that forms the frontier; and

β_r is the efficiency distance function for the r hospital.

In other words, the coefficient β_r is the maximum proportional expansion that can be achieved in the outputs.

The second step in measuring *HCU* is to determine each hospital's capacity. Holding the constant fixed inputs, but allowing the variable inputs to be unrestricted, consistent with Johansen (1968) definition of capacity, hospital r 's capacity is given by the solution to the following linear programming problem:

$$\widehat{D}o [(x_r^f, y_r); g^y] = \max_{\theta_r z_n} \theta_r$$

Subject to:

$$\sum_{n=1}^N z_n \cdot y_{on} \geq y_{or} \cdot (1 + \theta_r), \quad o = 1, \dots, O$$

$$\sum_{n=1}^N z_n \cdot x_{ni_1}^f \leq x_{i_1r}^f, \quad i_1 = 1, \dots, I_1$$

$$\sum_{n=1}^N z_n = 1,$$

$$z_n \geq 0, \quad n = 1, \dots, N \tag{15}$$

Where:

y_{on} is the o output corresponding to hospital n ;

y_{or} is the o output corresponding to hospital r under assessment;

$x_{i_1n}^f$ is the i_1 fixed input quantities corresponding to hospital n ;

$x_{i_1r}^f$ is the i_1 fixed input quantities corresponding to hospital r under assessment;

z_n is the activity coefficient for those hospitals that forms the frontier; and

θ_r is the efficiency distance function for the r hospital.

The difference between the linear programming problems given by equations 14 and 15 is the treatment for variable input. In equation 14 variable inputs are restricted to not more than the levels currently available to a specific hospital, while in equation 15 variable inputs are unrestricted (it is assumed that a hospital has access to as many variable inputs as needed to reach its capacity).

The last step in the process of measuring *HCU* is to take the ratio of the solutions to the linear programs given by equations 14 and 15 to determine hospital r 's capacity utilization rate:

$$HCU(x_r, y_r) = \frac{\hat{D}_o[(x_r^f, x_r^v), y_r; g^y] + 1}{\hat{D}_o(x_r^f, y_r; g^y) + 1} \quad (16)$$

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 that is currently being provided by a hospital. Alternatively, $(1 - HCU(x_r, y_r))$ this gives the potential percentage increase in hospital r 's services if its variables inputs are not constrained (Ferrier, Leleu and Valdmanis, 2009).

Data

The data was collected from a SHA in México called *Consortio 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* include 36 private general hospitals located in 35 cities across México. It include 5,000 medics and 6,000 employees, who have entered into SHA in order to exchange medical, administrative, legal and operational information; training focused mainly on patient care; sharing best practices and creating a bargain power with suppliers related to medicines, medical equipment and insurance; as well as sharing marketing strategies for their healthcare 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 close substitutes, 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 year 2014 because not all hospitals provided information.

The efficiency assessment for *CMH* hospitals requires control group that do 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 *Instituto Nacional de Estadística y Geografía (INEGI)* in México 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 it was required to remove hospitals that have missing values, information that do not match or are inconsistent (*i.e.* some hospitals reported operating rooms without any surgical procedure done). In addition, hospitals from States where *CMH* do not operate as well as hospitals located in cities without the same population density according to *INEGI* 2010 population census were removed. Similarly, specialized hospitals in this sample were eliminated, since *CMH* does not have this type of hospitals. Finally, non-SHA group consist 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 basically grouped around doctors, censable beds, operating rooms, 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 are described by Mexican Official Norm, are describe in Table 4.1.

Table 4.1. Variables description

<i>Outputs</i>	<i>Inputs</i>
y_j : 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	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.

means, performed within or outside of an operating room.

y2: 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.

x2: 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.

x3: Censable beds. This bed is available for hospitalization services.

x4: Operating rooms. Hospital's area, furniture, equipment and facilities, in order to perform surgical procedures.

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 4.2.

Table 4.2. Group's basic descriptive statistics: SHA hospitals and Non-SHA hospitals

SHA: <i>CMH</i> (n= 29 hospitals)	Mean	Std. Dev.	Min.	Max.
Outputs				
y1: Surgical medical procedures	1,214	1,163.93	95	5,736
y2: Days of stay	4,024	3,583.10	245	14,110
Inputs				
x1: Doctors in direct contact with the patient	9	10.05	2	48
x2: Nurses	51	42.05	10	176
x3: Censable beds	24	12.91	8	62
x4: Operating rooms	3	1.65	2	8
Non-SHA: <i>INEGI</i> (n= 47 hospitals)	Mean	Std. Dev.	Min.	Max.
Outputs				
y1: Surgical medical procedures	519	778.13	158	4,186
y2: Days of stay	2,557	3,190.89	331	12,778
Inputs				
x1: Doctors in direct contact with the patient	8	11.36	2	58
x2: Nurses	19	41.73	10	206
x3: Censable beds	17	15.27	8	61
x4: Operating rooms	2	1.24	2	6

RESULTS

Metafrontier results

The results obtained by applying a metafrontier model previously described, have the main objective to evaluate an appropriate efficiency comparison between hospitals belonging to a strategic alliance and hospitals that do not have this 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 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, Valls and Casadesus, 2012; Chu and Chiang, 2013; Roh, Moon and Jung, 2013), this is due to different methods employed (parametric and non-parametric approaches), diversity in data collected and specific healthcare conditions such as a country legal requirements or environmental factors like economic, social or cultural. For this paper, SHA are expected to improve efficiency. Results obtained for a DEA metafrontier model are presented in Table 4.3.

Table 4.3. *TGRs* for SHA (*CMH*) and Non-SHA (*INEGI* control group)

Frontiers	n	Mean	Std. Dev.	Min.	Max.	q1	q3
SHA: <i>CMH</i>	29	0.97	0.04	0.86	1.00	0.95	1.00
Non-SHA: <i>INEGI</i>	47	0.94	0.09	0.66	1.00	0.85	1.00
Metafrontier	76	0.95	0.08	0.66	1.00	0.94	1.00

The average efficiency for SHA group relative to the metafrontier is 97%, whereas for the no-SHA group it is 94%. This suggests that hospitals operations in an alliance are more efficient relative to the metafrontier, than non- members. Even if non-SHA has 53% of hospitals at the metafrontier with a score of 1, compared with a 48% of SHA, results show that operations in SHA are producing on average a 97% of their potential output with respect to the metafrontier technology based on the *TGR*. This ratio is higher than non- SHA group with an average of 94%. Wilcoxon-Mann-Whitney (WMW) test was applied and the results obtained shows there is no significant statistical evidence between this two groups.

The previous models defined in this paper have not used financial information. This is an opportunity for the alliance and hospitals members to standardize collection, processing and analysis of financial data as a group. According to *CMH* alliance reports, they have achieved significant cost savings in recent years by almost a 15% when making consolidated purchases or negotiating medical equipment acquisitions which improve the available infrastructure of its members, around of 86% from total joint purchases since the alliance beginning.

Capacity results

Capacity assessment should improve SHA members, given that they can exploit economies of scale and scope by sharing infrastructure, eliminating duplication of equipment investment, or gaining market participation by sharing marketing strategies that increase patient flow, for examples (Dranove, Durkac and Shanley, 1996). For this paper, the installed capacity was measured with the two most used inputs according to literature: operating rooms (Dexter and Epstein, 2005; Wullink *et al.*, 2007; Cardoen, Demeulemeester and Beliën, 2010; Yi *et al.*, 2010) and censable beds (Green, 2002; Utley *et al.*, 2003; Nguyen *et al.*, 2005; Kuntz, Scholtes and Vera, 2007; Rego, Nunes and Costa, 2010; Valdamis, Bernet and Moises, 2010; Bachouch, Guinet and Hajri-Gabouj, 2012). Results obtained when performing the capacity model with available data are on Table 4.4.

Table 4.4. Installed capacity based on fixed input “operating rooms” and “censable beds”

Fixed inputs: Operating rooms

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

Fixed inputs: Censable beds

Frontiers	n	Mean	Std. Dev.	Min.	Max.	q1	q3
SHA: <i>CMH</i>	29	0.85	0.16	0.44	1.00	0.77	0.98
Non-SHA: <i>INEGI</i>	47	0.70	0.18	0.27	1.00	0.57	0.86
SHA and Non-SHA	76	0.76	0.18	0.27	1.00	0.61	0.91

The results on capacity utilization with operating rooms as a fixed input, show that on average, Mexican general private hospitals from database used, has 58% of capacity usage, but the group

of hospitals in an SHA obtain a higher rate (67%) than non-SHA (52%). When using censable 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 it is still a better usage for SHA (85%) against non-SHA (70%). WMW test¹ was applied to these results obtaining there is a 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 México, when using any of the two defined fixed inputs, ensuring the robustness of the results.

CONCLUSIONS

Changes facing the health system in México 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 private hospitals to foster *TE* by a DEA-metafrontier model construction proposed from O'Donnell, Rao and Battese (2008) and capacity utilization using Johansen (1968) definition. Total database is integrated by 79 hospitals of which 29 are in a hospital alliance *Consortio Mexicano de Hospitales A.C. (CMH)* and the rest are considered part of a control group for year 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, legal, among others), and reductions of operating costs. Formally, *CMH* is an equity joint venture since each hospital member has pool resources to create a separate legal entity and all benefit from the services and programs delivered. *CMH* has sought new ways for its affiliated hospitals to be more attractive for middle class market that does not have the ability to pay large private hospital chains and do not want to be treated in public hospitals by a lower perceived quality and attention.

Current findings show based on *TGRs*, that *CMH* private hospitals are more efficient than hospitals without an agreement based on results obtained similar to conclusions from Dranove, Durkac and

¹ WMW test results for operating rooms as fixed inputs is $z= 2.349$, $p = 0.018$; and for censable beds is $z=3.354$, $p = 0.000$

Shanley, (1996), Bazzoli *et al.*, (2000), Rosko and Proenca (2005); Carey (2003); Granderson (2011); Chu and Chiang (2013); and, Roh, Moon and Jung (2013); and it is also supported by the theoretical framework of RDT and TCE. These results may help hospitals 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 healthcare system management.

Additionally, estimation of capacity utilization for hospitals alliance is made, providing valuable information relevant to managers to evaluate short and long-term investments measured by operating rooms and censable beds. Results on the model employed indicate that capacity utilization is best used by a hospital alliance confirming what is indicated by Li and Benton (2003), Jack and Powers (2009) and Rachel, Tsai and Liu (2011). As part of a better use of installed capacity, *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 in the hospitals members of the alliance. By purchasing this insurance, the beneficiary becomes entitled to discounts on services such as laboratory, X-ray, ultrasound, emergency and hospitalization as well as preferential prices in general clinics, emergency departments and specialists at any alliance hospital.

SHA will become more common and critical for hospitals, staff physicians, employers, and payers. Long-term relationships and enhanced cost-quality combinations will be sought by all participants. Hospitals join alliances to achieve strategic objectives, but whether hospitals improve efficiency and capacity, as well as other factors such profitability, market share or indicators of performance after joining a SA in different health systems is still a research opportunity not only for México but for many other countries and regions.

REFERENCES

American Hospital Association. 1990. American Hospital Association Guide to the Health Care Field 1989 edition, Chicago: AHA.

- Bachouch B, Guinet A, Hajri-Gabouj S. 2012. An integer linear model for hospital bed planning, *International Journal of Production Economics*, **140**(2): 833-843.
- Barringer B, Harrison J. 2000. Walking a tightrope: Creating value through interorganizational relationships, *Journal of Management*, **26**(3):367-403.
- Bates L, Mukherjee K, Santerre R. 2006. Market structure and technical efficiency in the hospital services industry: A DEA approach, *Medical Care Research and Review*, **63**(4): 499-524.
- Battese G, Rao D. 2002. Technology gap, efficiency and a stochastic metafrontier function, *International Journal of Business and Economics*, **1**(2): 87-93.
- Battese G, Rao D, O'Donnell C. 2004. A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies, *Journal of Productivity Analysis*, **21**: 91-103.
- Bazzoli G, Chan B, Shortell S, D'Aunno T. 2000. The financial performance of hospitals belonging to health networks and systems, *Inquiry*, **37**(3): 234-252.
- Bazzoli G, Brewster L, Liu G, Kuo S. 2003. Does U.S. hospital capacity need to be expanded? *Health Affairs*, **22**(6): 40-54.
- Bazzoli G, Brester L, May J, Kuo S. 2006. The transition from excess capacity to strained capacity in U.S. hospitals, *The Milbank Quarterly*, **84**(2): 273-304.
- Benoit J, Krishna V. 1987. Dynamic Duopoly: Prices and Quantities, *Review of Economic Studies*, **54**:23-35.
- Bernardo M, Valls J, Casadesus M. 2012. Strategic alliances: An analysis of Catalan hospitals, *Revista Panamericana de Salud Pública*, **31**(1): 40-47.
- Büchner V, Hinz V, Schreyögg, J. 2016. Health systems: changes in hospital efficiency and profitability, *Health Care Management Science*, **19**(2): 130-143.
- Cardoen B, Demeulemeester E, Beliën, J. 2010. Operating room planning and scheduling: A literature review, *European Journal of Operational Research*, **201**(3): 921-932.
- Carey K. 1997. A panel data design for estimation of hospital cost function, *The Review of Economics and Statistics*, **79**(3): 443-453.
- Carey K. 2003. Hospital cost efficiency and system membership, *The Journal of Health Care Organization, Provision, and Financing*, **40**(1): 25-38.
- Charnes A, Cooper W, Rhodes E. 1978. Measuring the efficiency of decision making units, *European Journal of Operational Research*, **2**(6): 429-444.

- Chu H, Chiang C. 2013. The effects of strategic hospital alliances on hospital efficiency, *The Service Industries Journal*, **33**(6): 624-635.
- Clement J, McCue M, Luke R, Bramble J, Rossiter L, Ozcan Y, Pai C. 1997. Strategic hospital alliances: Impact on financial performance, *Health Affairs*, **16**(6): 193-203.
- Coddington D, Moore D. 1987. *Market-Driven Strategies in Health Care*. Jossey-Bass Publishers, San Francisco, CA.
- Coelli T, Rao D, O'Donnell C, Battese G. 2005. *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.
- Conrad D, Shortell S. 1996. Integrated health systems: Promise and performance, *Frontiers of Health Services Management*, **13**: 3-40.
- Cseh A, Koford B, Phelps R. 2015. Hospital utilization and universal health insurance coverage: evidence from the Massachusetts health care reform act, *Applied Health Economics and Health Policy*, **13**(6): 627-635.
- Dexter F, Epstein R. 2005. Operating room efficiency and scheduling, *Current Opinion in Anesthesiology*, **18**(2), 195-198.
- Dranove D, Durkac A, Shanley M. 1996. Are multihospital systems more efficient? *Health Affairs*, **15**(1): 100-104
- Färe R, Grosskopf S. 2000. Theory and Application of directional distance functions, *Journal of Productivity Analysis*, **13**(2): 93-103
- Färe R, Grosskopf S, Kokkelenberg E. 1989. Measuring plant capacity, utilization and technical change: A nonparametric approach, *International Economic Review*, **30**(3): 655-666.
- Färe R, Grosskopf S, Lovell C. 1994. *Production frontiers*, Cambridge University Press.
- Färe R, Grosskopf S, Kirkley J. 2000. Multi-output capacity measures and their relevance for productivity, *Bulletin of Economic Research*, **52**(2): 101-112.
- Färe R, Grosskopf S, Valdmanis V. 1989. Capacity, competition and efficiency in hospitals: A nonparametric approach, *Journal of Productivity Analysis*, **1**(2): 123-138.
- Ferrier G, Leleu H, Valdmanis V. 2009. Hospital capacity in large urban areas: is there enough in times of need? *Journal of Productivity Analysis*, **32**(2): 103-117.
- Fisher E, Wennberg J, Stukel T, Skinner J, Sharp S, Freeman J, Gittelsohn A. 2000. Associations among hospital capacity, utilization, and mortality of US Medicare beneficiaries, controlling for sociodemographic factors, *Health Services Research*, **34**(6): 1351-1362.

- Gnanlet A, Gilland W. 2009. Sequential and simultaneous decisions making for optimizing health care resource flexibilities, *Decision Sciences*, **40**(2): 295-326
- Granderson G. 2011. The impacts of hospital alliance membership, alliance size, and repealing certificate of need regulation, on the cost efficiency of non-profit hospitals, *Managerial and Decision Economics*, **32**: 159-173.
- Grant R, Baden-Fuller C. 2004. A knowledge accessing theory of strategic alliances, *Journal of Management Studies*, **41**(1): 61-84.
- Green L. 2002. How many hospital beds? *The Journal of Health Care Organization, Provision, and Financing*, **39**(4): 400-412.
- Hayami Y, Ruttan V. 1971. Agricultural development: an international perspective. Baltimore, Md/London: The Johns Hopkins Press.
- Hennart J, 1988. A transaction costs theory of equity joint ventures, *Strategic Management Journal*, **9**: 261-274.
- Jack E, Powers T. 2009. A review and synthesis of demand management, capacity management and performance in health-care services, *International Journal of Management Reviews*, **11**(2): 149-174.
- Jeang A., Chiang A. 2012. Economic and quality scheduling for effective utilization of operating rooms, *Journal of Medical Systems*, **36**(3): 1205-1222.
- Johansen L. 1968. Production functions and the concept of capacity. Recherches Récentes sur la Fonction de Production, Collection *Economie Mathématique et Économétrie*, **2**.
- Judge W, Dooley R. 2006. Strategic alliance outcomes: A transaction-cost economics perspective, *British Journal of Management*, **17**: 23-37.
- Kang S, Kim M. 2015. Short-Run Cost Minimization and Capacity Utilization of Regional Public Hospitals in South Korea, *Modern Economy*, **6**(01): 21-29.
- Kaluzny A, Zuckerman H, Ricketts H. 2002. Partners: Forming strategic alliances in health care, Beard Books Chapel Hill, NC.
- Kuntz L, Scholtes S, Vera A. 2007. Incorporating efficiency in hospital-capacity planning in Germany, *The European Journal of Health Economics*, **8**(3): 213-223.
- Li L, Benton W. 2003. Hospital capacity management decisions: Emphasis on cost control and quality enhancement, *European Journal of Operational Research*, **146**(3): 596-614.

- Lowensberg D. 2010. A “new” view on “traditional” strategic alliances formation paradigms, *Management Decision*, **48**(7): 1090-1102.
- McSweeney-Feld M, Discenza S, De Feis G. 2010. Strategic alliances and customer impact: A case study of community hospitals, *Journal of Business and Economics Research*, **8**(9): 13-21.
- Nelson R. 1989. On the measurement of capacity utilization, *The Journal of Industrial Economics*, 273-286.
- Nguyen J, Six P, Antonioli D, Glemain P, Potel G, Lombrail P, Le Beux P. 2005. A simple method to optimize hospital beds capacity, *International Journal of Medical Informatics*, **74**(1): 39-49.
- O'Donnell C, Rao D, Battese G. 2008. Metafrontier frameworks for the study of firm-level efficiencies and technology ratios, *Empirical Economics*, **34**: 231-255.
- Ouellette P, Vierstraete V. 2004. Technological change and efficiency in the presence of quasi-fixed inputs: A DEA application to the hospital sector, *European Journal of Operational Research*, **154**(3): 755-763.
- Presada R, O'Donnell C, Battese G. 2003. Metafrontier functions for the study of inter-group productivity differences, Working Paper No. 01/2003, Centre for Efficiency and Productivity Analysis, School of Economics, The University of Queensland, Australia.
- Rachel J, Tsai T, Liu S. 2011. Building a Hospital Alliance—Taiwan Landseed Medical Alliance, *Asian Case Research Journal*, **15**(1): 123-148.
- Rego G, Nunes R, Costa, J. 2010. The challenge of corporatisation: the experience of Portuguese public hospitals, *The European Journal of Health Economics*, **11**(4): 367-381.
- Roh C, Moon M, Jung K. 2013. Efficiency disparities among community hospitals in Tennessee: Do size, location, ownership, and network matter? *Journal of Health Care for the Poor and Underserved*, **24**: 1816-1835.
- Rosko M, Proenca J. 2005. Impact of Network and System Use on Hospital X-Inefficiency, *Health Care Management Review*, **30**(1): 69-70.
- Rosko M, Proenca J, Zinn J, Bazzoli G. 2007. Hospital inefficiency: What is the impact of membership in different types of systems? *Inquiry*, **44**(3): 335-349.
- Smet M. 2004. Multi-product costs and standby capacity derived from queuing theory: The case of Belgian hospital, *Applied Economics*, **36**(3): 1475-1487.

- Utley M, Gallivan S, Davis K, Daniel P, Reeves P, Worrall J. 2003. Estimating bed requirements for an intermediate care facility, *European Journal of Operational Research*, **150**(1): 92-100.
- Valdamis V, Bernet P, Moises J. 2010. Hospital capacity, capability, and emergency preparedness, *European Journal of Operational Research*, **207**(3): 1628-163.
- Valdmanis V, DeNicola A, Bernet P. 2015. Public health capacity in the provision of health care services, *Health Care Management Science*, **18**(4): 475-482.
- Valdmanis V, Kumanarayake L, Lertiendumrong J. 2004. Capacity in Thai public hospitals and the production of care for poor and nonpoor patients, *Health Services Research*, **39**(6): 2117-2134
- Wan T, Ma A, Lin B. 2001. Integration and the performance of health care networks: do integration strategies enhance efficiency, profitability, and image? *International Journal*
- Williamson O. 1985. The economic institutions of capitalism, New York: Free Press.
- Winston G. 1977. Capacity: An integrated micro and macro analysis, *American Economic Review*, **67**(1): 418-422
- World Health Organization. National Health Accounts (NHA) 2013. [Online] Available at: <<http://www.who.int/health-accounts/atlas2013.pdf?ua=1>> [Accessed April 1, 2016].
- Wullink G, Van Houdenhoven M, Hans E, Van Oostrum J, Van der Lans M, Kazemier G. 2007. Closing emergency operating rooms improves efficiency, *Journal of Medical Systems*, **31**(6): 543-546.
- Yi P, George S, Paul J, Lin L. 2010. Hospital capacity planning for disaster emergency management, *Socio-Economic Planning Sciences*, **44**(3): 151-160.
- Zinn J, Proenca J, Rosko M. 1997. Organizational and environmental factors in hospital alliance membership and contract management: A resource-dependence perspective, *Hospital and Health Services Administration*, **42**(1): 67-86.
- Zuckerman H, D'Annunzio T. 1990. Hospital alliances: cooperative strategy in a competitive environment, *Health Care Management Review*, **15**(2): 21-30.
- Zuckerman H, Kaluzny A. 1991. Strategic alliances in health care: The challenges of cooperation, *Frontiers of Health Services Management*, **7**(3): 3-23.