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Universitat Autònoma de Barcelona

DEPARTAMENT DE L'EMPRESA

INTERNATIONAL DOCTORATE IN ENTREPRENEURSHIP AND MANAGEMENT

HOSPITAL EFFICIENCY ANALYSIS IN MÉXICO

DOCTORAL DISSERTATION

by

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*To my wife and my son,
who always have been by my side,
granting me their unconditional love,
support and comprehension.*

Thesis Abstract

This thesis is concerned about the efficiency analysis of public and private hospitals in México health system for the assessment and monitoring of performance. Based on empirical analysis, it aims to promote and support the development of public policies, as well as private management, necessary to strengthen healthcare by identifying potential areas for improvement.

The thesis includes three main research topics. The first topic analyzes whether the different financing schemes currently in the health system have an impact over hospital efficiency, as an important part of universal health coverage. The second topic analyzes the presence of economies of scale and scope in private hospitals that allows to improve their performance and decision making. The last topic as a continuation of the previous one, evaluates if private hospitals are more technical efficient and had better capacity utilization when they belongs to a strategic hospital alliance in Mexican healthcare context.

Results obtained for the first topic indicate that financing schemes affects technical efficiency indicating the importance of managing financial resources to achieve universal health coverage. Second topic results indicate a marginal presence of economies of scale and scope in private hospitals and the importance of the best mix health services to achieve economies of scope. And results for the last topic, show a slightly greater efficiency for hospitals belonging to a strategic alliance and a higher capacity utilization.

Overall, this thesis contributes to the development of models to assess and promote the better use of scarce resources in Mexico health system.

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Acronyms and Abbreviations

ABR	Activity-Based Reimbursement
AHA	American Hospital Association
AMIS	<i>Asociación Mexicana de Instituciones de Seguros</i>
BACON	Adaptive Computationally Efficient Outlier Blocked Nominators
CMH	<i>Consorcio Mexicano de Hospitales, A.C.</i>
CRS	Constant Returns of Scale
CSNF	<i>Comisión Nacional de Seguros y Fianzas</i>
DEA	Data Envelopment Analysis
DGIS	<i>Dirección General de Información en Salud</i>
DMU	Decision Making Unit
GDP	Gross Domestic Product
HCU	Hospital Capacity Utilization
HMO	Health Maintenance Organization
IFAI	<i>Instituto Nacional de Transparencia, Acceso a la Información y Protección de Datos</i>
IMSS	<i>Instituto Mexicano del Seguro Social</i>
IMSS-O	Instituto Mexicano del Seguro Social – Oportunidades
INEGI	<i>Instituto Nacional de Estadística y Geografía</i>
ISSFAM	<i>Instituto de Seguridad Social para las Fuerzas Armadas Mexicanas</i>
ISSSTE	<i>Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado</i>
LA	Latin America
NPM	New Public Management

OECD	Organization for Economic Cooperation and Development
OOP	Out-Of-Pocket
PMU	Private Medical Unit
PPP	Public-Private Partnerships
RDT	Resource Dependence Theory
SA	Strategic Alliance
SDG	Sustainable Development Goals
SESA	<i>Secretarías Estatales de Salud</i>
SFA	Stochastic Frontier Analysis
SHA	Strategic Hospital Alliance
SP	<i>Seguro Popular</i>
SSA	<i>Secretaría de Salud</i>
TCE	Transaction Cost Economics
<i>TE</i>	Technical Efficiency
<i>TGR</i>	Technological Gap Ratio
THE	Total Health Expenditure
UHC	Universal Health Coverage
UN	United Nations
VRS	Variable Returns of Scale
WB	World Bank
WHO	World Health Organization
WMW	Wilcoxon-Mann-Whitney

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I. Introduction

Health economics is a relatively new area of specialization in the field of economics but is rapidly expanding due to its importance for society's well-being. References to health economics can be traced as far back as the 1960s and it was to be another decade before a readily identifiable group of practitioners, academics and a coherent programmed work was to emerge (Mannion and Small, 1999). A seminal paper by Arrow (1963) establishes the foundations of health economics as a discipline, defining the basic characteristics of this industry, product uncertainty, pricing practices, supply conditions and insurance policies, among other issues.

Arrow central proposition about healthcare is that, given the uncertainty about the occurrence of diseases, effectiveness of treatments and healthcare participants, the market does not guarantee an efficient allocation of resources, as in the economy of most products and services. Moreover, the solutions arising from certain institutional arrangements or social efforts to overcome the sub-optimality, as is the defense of medical practice under the assumption of being inspired by the welfare patient, reinforce or prevent difficulties in trying to get efficient solutions. That is why the contribution of Arrow leads to demarcate market possibilities and the State participation, with the main objective of extending the efficiency and welfare (Restrepo and Rojas, 2016).

Stiglitz (1999) confirms the ideas of Arrow, recognizing that the healthcare industry is different from any other sector of the economy, especially due to the nature of the risks that individuals face as a result of the presence of failures of asymmetric information, which leads to agency problems. Consequently, these markets function imperfectly and the governments is not left out of this phenomenon; so, in many locations the institutional innovations go beyond the markets and government itself, seeking alternative mechanisms based on community welfare to promote the efficient use of limited resources available.

Efficiency measurement, whether at the level of the individual physician, the hospital or the healthcare system as a whole, is a topic of long-term interest in the health economics literature, with an extensive discussion about the appropriate efficiency concept and measurements. In fact, the feasibility of efficiency estimation is in itself the subject of debate. Newhouse (1994) argues that there are so many problems with current attempts to measure efficiency accurately that efficiency scores have virtually no practical policy value. Nevertheless, the ability to measure efficiency continues to be of interest to analysts and decision makers at all levels of government who are in charge of the responsibility to allocate scarce healthcare resources across competing needs (Liu, Laporte and Ferguson, 2008).

Sola and Prior (2001) defined efficiency as a “representation of the maximum level of output with the minimum level of inputs consumed. Efficiency depends not only on the quality of inputs, but also on the capacity of the managers to organize the production process”. Health efficiency refers to the production of health services at the lowest possible social cost. It further argues that efficiency is measured by the relationship among the results and the value of resources used or simply as far as the consequences of a health project are desirable or not from an economical point of view. As for the results that are part of this ratio (results/resources) it states that there for efficiency, it is only natural that there is no specific way to define them. First, this because the decision about these results is not only in the hands of doctors and other professionals involved in this discipline but health is an aspiration of all people. Second, health is a concept with implications for the social environment and would correspond to society as a whole with the responsibility of defining the result to be achieved (Jimenez, 2004).

There are diverse contemporary approaches in the literature about which method is best used for healthcare efficiency evaluation, among them are the parametric approach (stochastic frontier analysis or SFA) and the non-parametric approach (data envelopment analysis or DEA). The first SFA was proposed independently by Aigner, Lovell and Schmidt, (1977), and by Meeusen and Van Den Broeck, (1977).

The SFA model assumes that departures from the best practice frontier may be stochastic or deterministic, which crumbles the term of the residual error into an inefficient and random error. This is done by assuming that the inefficiency and random error components of the residual have different distributions. The random error component, which can be interpreted as random events outside the control of the organization, are assumed to be distributed in a normal way, while the inefficiency component is usually assumed to follow a regular asymmetric mean distribution. Like regression analysis, models with both multiple inputs and outputs are usually combined into a simple cost function (Jacobs, Smith and Street, 2006).

The first SFA study on an health care organization was published by Wagstaff (1989), who examined 49 Spanish hospitals. The models estimated a deterministic cost frontier, a cross section stochastic cost frontier in which inefficiency is assumed to follow a half normal distribution and a panel data. This paper compares the estimates of average inefficiency obtained from the frontier models and the implied rankings of hospitals in terms of their “costlines”. Zuckerman, Hadley and Iezzoni, (1994), used a stochastic frontier multiproduct cost function to derive hospital-specific inefficiency measures. They conclude that inefficiency accounts to 13.6% of the hospitals total costs. The estimate is robust with respect to model specification and approaches to pooling data across distinct groups of hospitals. Rosko (2001) examined the impact of management care and other environmental factors on hospital inefficiency in 1,631 US hospitals between the periods of 1990-1996. A panel, stochastic frontier regression model was used to estimate inefficiency parameters and inefficiency scores. Results suggest that mean estimated inefficiency decreased by about 28% during the study period. Inefficiency was negatively associated with health maintenance organization (HMO) penetration and industry concentration. Rosko and Mutter, (2008), reviewed twenty stochastic frontier analysis (SFA) studies of hospital inefficiency in the United States to ascertain the robustness of SFA. The results indicate a relative insensitivity to several model variations including structures of costs and distribution of the error

term, inclusion of quality measures and use of simultaneous and two-stage estimation techniques.

Farrell (1957) was the first researcher to carry out a frontier method to estimate the efficiency of a decision-making unit (DMU) with the distance between the DMU's observed level of outputs and inputs and the best practice production frontier (Rosko, 2001). This measure was later formulated into a DEA model that uses linear programming to locate the best practice production frontier introduced by Charnes, Cooper and Rhodes, (1978). The first health care application of DEA was published in 1984, and from then to 2016, over 150 DEA studies of health care organizations have been published (Hollingsworth, 2008). In a study by Emrouznejad, Parker and Tavares, (2008), an evaluation of the research on efficiency and productivity through the DEA was presented, and it was concluded that the technique has become a significant and essential tool for research within the broad field of management science.

DEA provides a mathematical programming method for estimating production frontiers and for evaluating the relative efficiency of different DMUs (Bogetoft, 1994); it allows handling multiple inputs and outputs easily while showing the added advantage of requiring no assumptions either on the functional form of the production frontier or the behavior of actors (Arocena and Garcia-Prado, 2007). Each DMU can select input and output weighting to show the best possible efficiency score, subject to the condition that the corresponding ratio of each DMU will be less than or equal to the unit (Charnes, Cooper and Rhodes, 1978). The DMUs under analysis must be comparable, using the same inputs to produce the same outputs. Similarly, the DMUs must operate in similar environments, otherwise differences in the operating environment should be considered. Also, units which are relatively more and less efficient should be distinguished and inefficiency compared to measured units efficient. Therefore the DEA measures efficiency relative to best practices rather than a central average or trend that incorporates both efficient and inefficient DMUs (Sherman, 1984).

Hollingsworth (2008) study used databases from United States, Europe and Asia countries like China, Taiwan and India. A few DEA studies are on Latin America countries like Argentina (Jayasuriya R and Wodon, 2007), Brazil (Lobo *et al.*, 2010), Chile (Castro, 2004), Colombia (Nupia and Sánchez 2001; Navarro, Maza and Viana, 2011) and Costa Rica (Arocena and García-Prado, 2007). There are two efficiency models applied to healthcare in México: the first published by García-Rodríguez *et al.*, (2011) their objective was to develop an algorithm for measuring the efficiency at a healthcare institution in México and Cuba, in order to identify the units with better productive practice; and to impel the productive efficiency by means of the incorporation in the management processes of benchmarking. The second was published by Salinas-Martínez *et al.*, (2009). Their main objective were to quantify the technical efficiency for diabetes care in family practice settings, characterize the provision of services and health results, and recognize potential sources of variation. They used DEA as well as a Tobit regression models with inputs and outputs for diabetes care from 47 family units within a social security agency in Nuevo León. The DEA methodology was used for evaluating hospital efficiency in México for this thesis.

The following sections explain the motivation for this dissertation, general and specific research objectives, as well as the importance of measuring efficiency in healthcare systems for public policy and private decision making in México hospitals. The content of each chapter is outlined.

1.1. Motivation

Health care industry is one of the largest industries and the fastest growing in the world. It represents a consumption of about 10% of the gross domestic product (GDP) of the countries in the world. In the case of the United States this sector accounts for about 15% of its GDP and México 5% according to the report of the World Health Organization (WHO) and the Organization for Economic Cooperation and Development (OECD) in its 2010 report. Since the mid-70s, the average health expenditure as percentage of GDP has risen from 6.3% to 8.9% among OECD

countries¹. With a relatively low proportion of GDP spent on healthcare in México, it is required that these limited resources are used effectively (OECD, 2016). The increasing burden of healthcare consumption on the countries' limited resources has brought about a clear policy implication: the aim to maximize the value of investments in health care.

Currently the annual global health spending is about 6.5 trillion dollars according to WHO (2012). The total health expenditure is the sum of public and private spending on health as a proportion of the total population. The provision of health services include (both preventive and curative), family planning activities, nutrition activities and emergency aid for health, but do not include aspects like water supply and sanitation. In many countries, hospital care absorbs more than half and up to two thirds of total government spending is on health, with (often excessive) inpatient admissions and length of stay being significant categories of outlay. Another source of inefficiency is the inappropriate size of some facilities and the range of services they offer. While it might make economic sense to enlarge the size and scope of a hospital to fully exploit available expertise, infrastructure and equipment, there is a point at which efficiency starts to decline.

The health sector is undoubtedly a strategic sector for any societal development. To improve efficiency in this sector is to provide real opportunities and life expectancy to a greater number of people. Health systems require sufficient physical and human resources to be able to meet the demands imposed by the epidemiological profile of the population being served, but it also requires adequate and sustainable financing sources.

¹ Health spending is defined by OECD as the final consumption of health goods and services. It includes spending by both public and private sources (including households) on curative, rehabilitative and long-term care as well as medical goods such as pharmaceuticals. It also covers spending on public health and prevention programs, and on administration. This indicator is presented as a total and per financing agent (public, private and out-of-pocket expenditure) and is measured in percentage of GDP, in percentage of total expenditure on health, and in USD per capita (using PPP).

Many countries are reforming the way they finance health care as they move towards universal health coverage (UHC). As a result in September 2015, the United Nations General Assembly adopted the new development agenda: Transforming our world, which is the 2030 agenda for sustainable development, comprising 17 Sustainable Development Goals (SDGs). This Agenda integrates all three dimensions of sustainable development (economic, social and environmental) around people, planet prosperity, peace and partnership. Health is centrally positioned within the 2030 Agenda, with one comprehensive goal – SDG 3: Ensure healthy lives and promote the well-being for all at all ages – and explicit links to many of the other goals. It includes 13 targets covering all major health priorities; especially target 3.8 is about UHC including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all. At the same time, in most cases it is a constitutional obligation for governments to provide UHC, but the reality is that many has failed to fulfill this mandate. México faces significant resource problems and the proper distribution of them. That is why measuring the efficiency of these resources becomes a central hub for improving the sector as part of the political and national agenda to provide health coverage for all.

The hospital industry differs from other industries in at least two ways that can impact decision-making in relation to efficiency: (1) the organizational structure of the hospital consists of two separate entities, on the one hand the experts and medical advisers, on the other hospital administrators who seek to provide services that require doctors to treat patients (Harris, 1977). This creates tension between doctors, who prefer the acquisition of the latest medical technology, and administrators, who prefer to acquire capital for administrative purposes; (2) The environment is highly regulated. The government legislation determines the amount and method of hospital reimbursement in the case of public hospitals, for a large part of patient care and therefore affects the economic performance of hospitals-minimizing costs and maximizing income (Sloan, Morrissey and Valvona, 1988).

The increasing demand for health services has led México to take innovative steps to improve the performance of its healthcare system. Over recent decades, the country has experienced remarkable improvements in life expectancy and a steady decline in infant mortality rates. However, life expectancy remains the fourth lowest among OECD countries. To advance into the country's health services, it is required to address the problems of accessibility in rural areas and poorer States. In 2015, 84% of the total populations have access to health services (although not with the same coverage related to health services and diseases), 16% of the population or a total of 18.7 million Mexican people are unprotected (González and Martínez, 2015).

Healthcare system in México is currently fragmented across the vertical sub-systems, and different sub-systems have quite significantly different levels of resources. This constitutes a real problem of inequitable access. Most deprived socioeconomic groups and deprived States can expect to have access to much more limited services. Mexican healthcare have three different schemes to finance these sub-systems: a global budget mainly for public hospitals approved annually; capitation payment design to protect poor people who do not have access to health services through a program called *Seguro Popular (SP)* in order to comply with international resolutions of UHC; and direct payments made by families and individuals, which make up a quite significant proportion on health spending (constitutes 45% of health system revenue and 4.0% of household expenditure), risk being a significant financial burden per Mexican citizens, especially those unable able to pay (OECD, 2016).

México healthcare displays higher ratios for private to public hospitals (70%) compared to OECD member countries (53%), thus complementing public services offered (OECD, 2016). Therefore, the importance of analyzing the behavior of efficiency in the private hospitals is to determine if they maximize their actual investment (economies of scale), and at the same time if they achieve the optimal mix of health services (economies of scope).

Like many industries, an alternative to private hospitals that seek to comply with demands imposed by market forces, competition, regulators and patients, is the formation of strategic alliances. These healthcare alliances have been well studied in United States and European countries, whose common goal is to increase efficiency through the exchange of services, knowledge and good practices (medical or administrative). Also, to promote capacity utilization among its partners as a short-term agreement consequence. Strategic alliances in Mexico are relatively new, and it is in the managers' interest to determine by a quantitative analysis the benefits of entering into an agreement of this nature.

The Mexican health system needs to advance in the proper direction to find additional funding mechanisms, set collaboration schemes between health institutions (private and public), improve the efficiency of the supply side in the public health sector, and to encourage private investment and alliances supporting the UHC.

1.2. Research objectives and theoretical framework

Lots of hospital efficiency studies have been performed, mainly in developed countries, and few in a Latin America context. However, explanatory and quantitative research is practically non-existent in the area of hospital efficiency that integrates the healthcare system in México. This dissertation aims to establish an empirical research into hospital efficiency for public and private decision-making to improve the limited healthcare resources for the benefit of Mexican society.

The structure of the dissertation analyzes the hospital efficiency from a general perspective of the health system in México based on the financing schemes, to a specific analysis of private hospitals decisions on the use of economies of scale and scope, alliances and capacity management.

The above aim will be accomplished by fulfilling the following specific research objectives:

1o. To identify and evaluate the impact of healthcare financing systems received by Mexican hospitals over technical efficiency, to also identify a sustainable public financing policy supporting UHC.

The objective is to identify and evaluate the impact of healthcare financing systems over Mexican hospitals efficiency. Actual changes in México healthcare policies have incorporate private practices known as the New Public Management (NPM) impacting the financing mechanisms. The results will provide useful information for healthcare policy makers to evaluate the appropriate financing procedure to ensure a higher hospital efficiency and UHC access for all Mexicans.

2º. To evaluate technical efficiency and potential presence of scale and scope economies in Mexican private medical units (PMU) that will improve management decisions.

This objective focuses on the potential of private hospitals to foster economies of scale and scope with actual resources, as a result of a greater efficiency shown in previous objective. Economic theory is used as a framework that supports economies of scale and scope. Results will contribute to the literature by showing a presence of scale and scope economies, allowing managers to incorporate strategies that expand the size of private medical units through mergers, acquisitions, strategic alliances or using organic growth, but most importantly importance to incorporate more health services.

3o. To investigate efficiency implications of belonging to a strategic hospital alliance (SHA) and measuring the effects over capacity utilization of such agreements in México healthcare context.

This objective is to investigate if a private hospital will increase efficiency and capacity through participation in a strategic hospital alliance. Resource dependence theory and transaction cost economics support the formation of alliances; and hospital capacity utilization on economic theory. Results will indicate if efficiency is

better at hospitals that belongs to an alliance and if it also shows an improvement of capacity management in México healthcare environment.

1.3. Thesis summary

The thesis is structured in three chapters, which are briefly described in this section:

Chapter II presents a literature review on actual financing schemes in several countries, and is compared to the current health system in México mainly integrated by global budget, capitation and direct payments. A metafrontier approach is used to identify efficiency among hospitals under different technologies according to their financing scheme, relative to the potential technology available to all healthcare system.

As part of the efficiency results previously obtained for private hospitals, Chapter III evaluates technical efficiency and potential presence of scale and scope economies to improve management decisions, based in the production function, scale and scope economies theories. Non-parametric methodology is used to calculate efficiency scores for scale economies valuation. Then a two-staged model for diversified and specialized hospitals was used to calculate the scope economies valuation. This chapter has been accepted and published in the journal *Salud Pública en México* (year 2014, volume 56, number 4, pages 348-354).

Chapter IV evaluates a strategic hospital alliance by using a metafrontier concept to compare the efficiency between Mexican hospital alliance members and a control group. Hospital capacity utilization ratios are used as the maximum rate of output possible from fixed inputs in a frontier setting, using directional distance functions.

Finally, Chapter V presents the conclusions and main contributions of the thesis, and suggestions for future research. Table 1.1 indicates a summary of the main elements described earlier in each chapter.

Table 1.1. Summary of the main elements for each chapter.

Chapter	Objective	Metodology	Study Year	Database	Theories
II	To conduct an efficiency assesment according to financing schemes in a healthcare system.	DEA-Metafrontier	2013	606 public hospitals from <i>IMSS</i> , <i>ISSSTE</i> , <i>ISSFAM</i> , <i>IFAI</i> and <i>DGIS</i> databases; and, 182 private hospitals from <i>INEGI</i> database.	New Public Management
III	To asses economies of scale and scope.	DEA	2010	2,105 private hospitas from <i>INEGI</i> database.	Production theory: economies of scale and scope.
IV	To asses the efficiency of strategic hospital alliances and capacity utilization.	DEA-Metafrontier; DEA-Capacity utilization	2014	29 private hospitals from an alliance- <i>CMH</i> ; and, 47 private hospitals from <i>INEGI</i> database.	For alliances: Resource dependence theory and transaction cost economics. For capacity: Economic theory

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II. Do healthcare financing systems have an effect over hospital efficiency? A metafrontier approach

Abstract

The main objective of the chapter is to discuss the impact of healthcare financing systems on the efficiency of Mexican hospitals. Based on New Public Management theory, México healthcare system is in a transformation process to establish allocation conditions of limited health resources in order to achieve efficiency and transparency. Nowadays, México health system has three categories based on how it is financed: the first group includes public hospitals funded by an annual budget authorized by Congress; the second is also a public system but is funded according to the number of individuals enrolled to a program called *Seguro Popular (SP)*; and, the third group is a private health system where the patient makes the payment or is covered by private insurance. A metafrontier analysis is proposed to estimate technological gaps for hospitals under different technologies according to their financing scheme, and relative to the potential technology available on the healthcare system. The analysis was performed for 2013 database with 606 public and 182 private hospitals, using Data Envelopment Analysis (DEA) for efficiency measurement and metafrontier evaluation. Empirical evidence supports that private hospitals have the ability to succeed if changes in financing healthcare mechanisms occur in México toward universal health coverage. Public hospitals could have difficulties in competing for finances based on the analysis of technological gap ratios.

Keywords: Healthcare financing, efficiency, New Public Management, metafrontiers, DEA

2.1. Introduction

The General Assembly of the United Nations (UN) in 2015 establish 17 Sustainable Development Goals (SDGs) of the 2030 Agenda, which integrate three dimensions of sustainable development (economic, social and environmental) recognizing that “eradicating poverty and inequality, creating inclusive economic growth and preserving the planet are inextricably linked” (UN, 2015). Health is centrally positioned within the 2030 Agenda, with one comprehensive SDG which indicates “ensure healthy lives and promote well-being for all at all ages” and its 13 targets covering all major health priorities (WHO, 2016).

Health systems’ strengthening is a core focus of the SDGs. This is reflected by the fact that universal health coverage (UHC)² is central to the overall health goal as set out in the SDG declaration, and is assigned a specific target (3.8). In order to move towards a UHC, countries need financing systems that enable people use all types of health services -promotion, prevention, treatment and rehabilitation –without incurring financial hardship (WHO, 2010).

Statistics on health financing show that total health expenditure (THE) per capita has increased at a rate of 130% over a period of 20 years (1995-2014) according to the World Bank (WB) database (WB, 2016). Most developing countries spend less than 8% of their gross domestic product (GDP) on health, and many less than 5%. Positive trends are discernible. However, per capita government health expenditure globally increased by about 40% in real terms between 2000 and 2013, with major increases in all regions. This may simply reflect economic growth, but in several countries it is also the result of an increased prioritization for health in government budget allocations. On the average, across countries, global out-of-pocket (OOP)³

² Universal health coverage is defined by WHO (2010) as the access to key promotive, preventive, curative and rehabilitative health interventions for all at an affordable cost, thereby achieving equity in access of care does not put people at risk of financial catastrophe. A related objective of health-financing policy is equity in financing: households contribute to the health system on the basis of ability to pay.

³ According to the WHO (2010) definition, out-of- pocket expenditure is any direct outlay by households, including gratuities and in-kind payments, to health practitioners and suppliers of pharmaceuticals, therapeutic appliances, and other goods and services whose primary intent is to

health spending is down slightly (from 35% of THE in 2000–2004 to 31% in 2010–2013), which suggests an improvement in financial protection. However, average levels in low-income countries remain high (42%) (WHO, 2016). It is important for countries, especially developing and low-income ones, to continue with health system reforms that will help increase the quality of medical services and move even closer to UHC, and maintaining an adequate balance in relation to THE.

Since the 80s, many countries like United Kingdom, Scandinavia, and Netherlands (Dent, 2005; Jakobsen, 2010; Blank and Eggink, 2014), redefined their national health systems by introducing health policies based on business concepts and practices or what is known as the New Public Management (NPM) theory in response to shifting demographics, epidemiological and technological trends, as well as inefficient health service, and the depletion of public funds to finance health operations (De Vries and Nemec, 2013). Financing and payment mechanisms represent one of the fundamental building blocks of any health system, introducing powerful incentives for actors in the system and fierce technical design complexities (Busse, Schreyögg and Smith, 2006; Wendt, Frisina and Rothgang, 2009; WHO, 2010).

The relationship between financing health schemes and hospitals efficiently has been a topic of research. In 1990, many European countries implemented market-based reforms through alternative system of hospital financing (Leidl, 1998). Several studies have measure the potential changes in technical efficiency over time, as a result of new financing systems in European countries (Lopez-Valcarcel and Perez, 1996; Maniadakis, Hollingsworth and Thanassoulis, 1999; McCallion *et al.*, 2000; Sommersguter-Reichmann, 2000; Hofmarcher, Paterson and Riedel, 2002; Biorn *et al.*, 2003; Blank and Eggink, 2014).

contribute to the restoration or enhancement of the health status of individuals or population groups. It is a part of private health expenditure.

Duckett (1995) evaluated public Australian hospital funding reform which represents an economic incentive by linking payment to the number and case complexity of patients treated. Such a change reduces hospital costs but do not necessarily lead to an improvement in system efficiency. Bossert (2000), made a comparative study where it evaluates the implementation of decentralization of health system in three Latin American (LA) countries: Chile, Bolivia and Colombia. He found that municipalities in Chile with more rural populations, those who registered beneficiaries, and those with less vulnerable populations are more technically efficient; in Bolivia he found that technical efficiency was related to the mayor's respect for the law, his initiative, a positive relationship between the mayor and local doctor, and a well-functioning local health directorates; and in Colombia, found that a higher spending of external resources and higher levels of personal source resources was associated with lower efficiency, unless management made significant changes in human resources and services. La Forgia and Harding (2009) relate the public-private partnerships (PPP) reforms in public hospitals in Sao Paulo State in Brazil. Results obtained indicate that PPP are significantly more efficient than directly managed public hospitals. The PPP model altered governance and financing arrangements in ways that generated the key changes in human resources, financial and procurement management. Sahin, Ozcan and Ozgen (2011) explore the operational performance of general public hospitals following a health transformation program in Turkey. They find a positive productivity development along with its two components of efficiency and technology during the years covered in all regions of the country.

Many countries in LA have been carrying out reforms on their health care financing and delivery structures, supposedly to improve equity and efficiency (Montenegro *et al.*, 2010). These reforms, as a basic principle, generally called for better resource allocation through market mechanisms. They also have included strengthening the capacity of health systems through decentralization and different types of reorganization, including introduction of the purchaser/provider split as well as private insurance organizations, private providers, and health care network

(Vázquez *et al.*, 2009). Neoliberal policies underpinned the reform agendas but were presented as “new paradigms” for the restructuring of health systems (Homedes and Ugalde, 2005). This obliged governments to focus on the issue of evaluation and improvement of healthcare services, as well as the adaptation of new hospital management models (such as different forms of public-private partnerships) to develop appropriate policies as part of NPM theory.

Hospital financing and provision of care are fragmented in México among several institutional systems: *Instituto Mexicano del Seguro Social (IMSS)*, *Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE)*, *Instituto de Seguridad Social para las Fuerzas Armadas (ISSFAM)*, *Secretarías Estatales de Salud (SESA)*, and direct payments to private healthcare providers. México has made significant progress to reduce its huge backlog in public health through policy changes. In 2004, the Mexican Congress passed a health care reform, creating *Seguro Popular (SP)* which aims to provide protection to half of its population, low-income families who do not have jobs or are self-employed most of them poor (around 57 million Mexicans), excluded from formal social and private insurance (Presidencia de la República, 2015). A pending challenge for *SP* is to implement the purchaser–provider split within states. The initial reform design envisioned a more efficient arrangement for health-care delivery whereby states would develop the purchasing function of basic hospital and primary care (Knaut *et al.*, 2012).

Despite this reform, there is still a growing healthcare system hospital expenditures, changes in chronic diseases and low healthcare productivity have led to a debate in México about which strategies are needed to finance the health system and improve efficiency in delivery, while ensuring access to quality care. Policy-makers and theorists suggest that NPM-related policies may enhance the efficiency of public service delivery, such as healthcare, by introducing criteria from private sector management into traditional methods of public administration (Mayston, 1999; Andrews and Van de Walle, 2013). However, the real benefits of NPM in healthcare delivery have been inconclusive, thereby forming an international perspective

(Acerete, Stafford and Stapleton, 2012; Pollit and Dan, 2013; Barlow, Roehrich and Wrigth, 2013; Alonso, Clifton and Díaz-Fuentes, 2015). México healthcare policies have helped to increase social protection to a greater number of citizens by incorporating NPM-measures. But the analysis made have only been theoretical and descriptive and not quantitative (Knaul *et al.*, 2005; Knaul *et al.*, 2006; Frenk, 2006; Frenk *et al.*, 2006; Frenk *et al.*, 2007).

The central aim of the present study is to analyze efficiency in Mexican hospitals based on how they are financed, as a result of health policies incorporating basic characteristics of the NPM. The methodological approach to be used requires two steps: first, to evaluate efficiency of hospitals based on the actual funding scheme defined as a global budget (includes *IMSS*, *ISSSTE* and *ISSFAM* hospitals), capitation (*SESA* hospitals) and OOP payments (private hospitals) using Data Envelopment Analysis (DEA); second, to compare efficiency levels based on a common frontier by pooling the data set of all Mexican hospitals defined as a metafrontier, the boundary of an unrestricted technology set (Battese and Rao, 2002), and with each of the above groups, operating with different technologies sets based on their funding scheme. The results presented here are relevant in the Mexican context, but may be of interest beyond the local context.

The remainder of the chapter is structured as follows. Section 2 is an overview of the relevant literature applied to NPM-theory and healthcare financing; section 3 briefly explores the actual healthcare system in México; section 4, clarifies methodologies used in the paper to evaluate efficiency through a DEA metafrontier, description of databases, information structure and variables collected; section 5 shows the results obtained and section 6 conclusions and policy implications based on our results for policy makers.

2.2. Literature review

2.2.1. New Public Management in healthcare

The traditional Weberian model of public administration held that services should be provided only through public agencies, in the belief that this type of bureaucracy would achieve higher levels of efficiency and rationality in pursuing its goals, resulting from unified management and the predictability and uniformity of the routines and processes carried out (Niskanen, 1968; Weber, 1992; Du Gay, 2000; Jørgensen, 2011). However, problems with this model of administration began to appear in the early 1980s under which centralized bureaucracies were viewed as monopolistic and inefficient by nature, suffering problems of coordination and control arising from their excessive size and lack of flexibility, impacted by major economic events worldwide (Ostrom, 1973; Dahl and Tufte, 1974; Simonet, 2015). NPM is a group of heterogeneous axioms as the public choice theory that include (Buchanan, 1986), some elements of new institutional economics (Williamson, 1981), agency theory (Jensen and Meckling, 1976) and property right theory (Demsetz, 1967). NPM adoption signaled a victory of the liberal market economics approach (*i.e.*, a coordination of activities primarily through competitive biddings, market forces, and contracts where the State still plays an active, albeit much reduced roles and where labor relations have become much more market reliant), over the coordinated market economies approach that gives a central role to long-term, non-market relations and stable cooperation between stakeholders (*e.g.* trade unions and local governments) (Amable, 2003).

Contemporary health reforms aim at changing the regulation of healthcare by introducing contracting, competition and marketization based on NPM theory (Hood, 1995; Christensen and Laegreid, 2001; Burau and Vrangbaek, 2008; Van Essen, 2009). NPM used to be a “new” approach superseding traditional “old” public administration. It has shifted to a new logic with specific values and recently to a combination of market-based philosophy and managerial thinking in contrast to the professional bureaucracy (Hood and Peters, 2004). NPM is defined according to Hood (1995) and Van Essen (2009), as lessening or removing differences between

the public and private sector and shifting the emphasis from process accountability towards greater accountability in terms of outcomes. NPM policies have been introduced into public healthcare across most OECD countries since 1980s, in response to concerns about the rising healthcare expenditures, medical and technological advances in health treatment, as well as an aging population (Simonet, 2013). It is important to clarify that NPM is neither universal nor homogeneous with significant variations across countries mainly influenced by political, social, economic and governance structural factors (Bourgon, 2007; Brinkerhoff, 2008; De Vries and Nemec, 2013; Lapsley, 2010; Robinson, 2015).

Although there are several analysis of the impact of NPM in health systems in different countries like United Kingdom (Thatcher reforms of the early 1980s in the public sector), European members and United States (Anessi-Pessina and Cantú, 2006; Correia, 2011; Donnan and Katz, 2015; Mattei, 2006; Maynard, 1994; Moresi-Izzo, Bankauskaite and Gericke, 2010), a few studies has been done to test whether NPM actually led to technical efficiency in hospitals, since most have focused on evaluating health systems.

Ferrari (2006) analyze the effectiveness of a competitive mechanism in the provision of hospitals services, assuming that competition would have led hospitals to increase efficiency in the use of their resources; the changes in technical efficiency of a panel of 52 acute Scottish hospitals observed from 1991 to 1997 was measured. The sample contains a different mix of both trusts and non-trusts, where the former embed the proper working of the reform. The results show a structural break, after which hospitals change not only the way they to provide their services, but also the kind of services they provide, this favors the quicker treatment of patients on a day basis. No significant improvement in technical efficiency is detected instead over time, and no significant difference in efficiency between trusts and non-trusts.

Jakobsen (2010) systematically describes and compares 12 studies with their results to determine whether research supports if activity-based reimbursement (ABR)

would improve efficiency in the Scandinavian hospital sector. The article has two main conclusions: first, studies with positive and non-positive results are approximately equal in number, even when the quality of research designs is taken into account; and second, it is quite likely that this is caused mainly by the low credibility of the new ABR schemes, which has undermined the incentives for greater efficiency that the new schemes should provide.

Alonso, Clifton and Diaz-Fuentes (2015) evaluated NPM with Madrid's public hospitals using a bootstrapped DEA to compare efficiency scores in traditionally managed hospitals and those operating with new management formulas. They did not find evidence that NPM hospitals are more efficient than traditionally managed ones. Moreover, their results suggest that what actually matters is the management itself, rather than the management model.

Reforms in the hospital sector in México have been made due to the need to find financing alternatives that allow stable public finances. In the current health system, the first steps have been taken to incorporate private administrative financing practices (such *SP*), which the final objective should allow for greater coverage of medical care, increase health services quality and efficiency of resources. Therefore the aim for this chapter is to determine if current hospital efficiency is determined by the financing mechanism used to carry out its operations. Healthcare providers in México are grouped based on a specific financing scheme: global budget, capitation and OOP. A metafrontier concept is used in order to compare hospitals operating with different characteristics and technologies. The expected outcome should support the policies implemented in public health hospitals are at least as efficient as private based in NPM.

2.2.2. International healthcare financing

In line with a World Health Assembly resolution in 2005, UHC is considered to be a crucial aim of health financing systems. Whether a health financing system can

achieve this depends on the way in which funds are raised (revenue collection), pooled, and then used to provide or purchase health services.

The first health financing functions, revenue collection, is the process by which the health system receives money from households, organizations, companies, etc. Revenues can be collected in various ways, including general taxation, mandatory social health insurance contributions, voluntary private health insurance contributions, out-of-pocket payments, and donations. Pooling of risks and revenues is the accumulation and management of these revenues, with a vision to share. The risk of the costs of health care is the second function. Finally, the third function is the process by which the revenues collected by private or public agencies are used to provide or purchase services (Cavagnero, 2008).

The way in which health systems are financed as well as the consequences of this financing is a highly debated policy issue, because there is no single way to develop a financing system to achieve UHC. All countries must make choices and trade-offs, particularly in the way that pooled funds are used. It is a constant challenge to policy makers to balance priorities: funds are inadequate, there is continued pressure for services from the demand side and the technologies for improving health are constantly expanding. There is a vast literature related to health financing systems across different countries motivated mainly by measuring the effect of financial reforms that impact healthcare in countries such as Argentina (Bertranou, 1999; Cavagnero, 2008; Cavegnero and Bilger, 2010), Brazil (La Forgia and Harding, 2009), Chile, (Bertranou, 1999), Colombia (Bertranou, 1999), France (Bellanger and Mossé, 2005), Germany (Böhm, 2009), Japan (Besstremyannaya, 2013), Netherlands (Blank and Eggink, 2014), Spain (Antonanzas, 2013), Sweden (Dahlgren, 2014), Switzerland (Widmer, 2015; Zweifel and Tai-Seale, 2009), United Kingdom (Simonet, 2015), United States (Brousseau and Chang, 2013; Zweifel and Tai-Seale, 2009) as well as regions like Europe (O'Reilly *et al.*, 2012; Schneider, 2007; Smith, 2004), LA (Iriart, Merhy and Waitzkin, 2001; Lodoño and Frenk, 1997), Asia (Tangcharoensathien *et al.*, 2011); and international comparisons from different

healthcare systems (McPake and Mills, 2000; Preker *et al.*, 2004; Wranik, 2012) among others.

Most of the countries setting out on the path to UHC begin by targeting the formal sector because these groups are more easily identified, but policy makers must not exclude those who cannot contribute, by subsidizing their health insurance premiums or by not imposing direct payments. In LA and Caribbean region a two-tier public system of healthcare is maintained: one for those employed in the formal sector and another delivered through ministries of health, for the poor and uninsured (Baeza and Packard, 2006; Atun *et al.*, 2015). México is no exception from this kind of policy.

The inefficiencies and inequities of the LA health systems have been known for many decades, but by the late 1970s and early 1980s LA political leaders, users, providers, and researchers were all well aware that some changes were needed to reverse the increasing users' dissatisfaction and decreasing quality of care, and improve the equity and efficiency of the systems (Homedes and Ugalde, 2005).

Health systems are financed mainly through three mechanisms: 1) monies gathered by the state via specific and general taxes; 2) contributions to social security via deductions or taxes; and, 3) private payments, which can be either out-of-pocket (OOP) or from private insurance. The mix of financing among these three categories tends to vary substantially between countries. General taxation and payroll taxes are pre-paid and progressive, and involve a substantial degree of risk pooling. Still, these government-financed and social insurance schemes can, but often do not, protect all citizens from catastrophic and impoverishing health expenditures. Some groups are excluded—typically the poor and dependent, and non-salaried workers (Knaul *et al.*, 2006).

2.2.3. Hospitals payment theory

Economic theory posits that by reimbursing hospitals on the basis of a fixed rate per unit of activity (adjusted for complexity), activity-based funding should provide a financial incentive to increase activity that is absent under the global budgets. Compared with retrospective fee-for-service systems, improved efficiency (through minimizing costs and input use) would also be encouraged (Aas, 1995; Busse *et al.*, 2011; Ellis, 1998; Jegers *et al.*, 2002; Kutzin, 2001; Langenbrunner and Wiley, 2002; Langenbrunner *et al.*, 2005; Newhouse, 1996). If left unchecked, pure activity-based funding could lead to unintended adverse consequences, such as patient selection, inappropriate treatment and quality skimping (Aas, 1995; Ellis, 1998; Jegers *et al.*, 2002; O'Reilly *et al.*, 2012).

In principle, public hospitals do not have any incentive to keep costs under control, given the demonstrated propensity of the national government to bail out their debts. This situation, alongside a real necessity to increase the amount and quality of health services provided to the population, could significantly contribute to decrease efficiency of hospitals and to increase public spending. On the other side, private hospitals had a clear incentive to boost the average length of stay in order to raise their revenues; at the same time, they were encouraged to keep costs under control in order to raise profits. These incentives could result in high public costs and high private profits (Barbetta, Turati and Zago, 2007).

Ownership has a relevant role in explaining economic performance; in fact, different ownership structures create different incentives to economic factors. In general, private ownership characterized by the presence of residual claimants should represent a powerful incentive to economic efficiency and cost reduction; on the contrary, public ownership and/or the absence of any claimant of residual earnings (because of the presence of a non-distribution constraint) may induce shirking and could decrease endeavors, consequently reducing efficiency (Alchian and Demsetz, 1972).

An immense amount of literature deals with empirical analysis of technical efficiency and ownership structure in the hospital sector, but in general this evidence is inconclusive. Indeed, 'overall, the empirical evidence demonstrates no systematic differences in efficiency between for-profit and not for profit hospitals' (Sloan, 2000). Wilson and Jadow (1982), using a linear programming technique to estimate parameters for the Cobb-Douglas specification of both deterministic and probabilistic production frontiers, found that nonprofit hospitals are less efficient than profit hospitals but more efficient than public ones. Using stochastic frontier regressions, Vitaliano and Toren (1996) could not find any relevant difference in efficiency between hospitals with different ownership structures. Gruca and Nath (2001) found no significant differences in efficiency across ownership types (government, religious or secular non-profit) in Canadian hospitals.

On the contrary, Puig-Junoy (1998) found public and nonprofit hospital more efficient than for-profit ones. Duggan (2000) compared public with private nonprofit and private for-profit hospitals in the United States, and found that the main difference between the three types of producers is the soft budget⁴ constraint characterizing the public ones. In his analysis, Duggan (2000) found that nonprofit and for-profit hospitals were equally responsive to changes in financial incentives (represented by an increase in state funding for services provided to indigent patients) and significantly more responsive than public hospitals. Helmig and Lapsley (2001) concludes that public and welfare hospitals in Germany appear to use relatively fewer resources than private hospitals due to excess capacity generated by selling the most inefficient clinics to private enterprises. On a later study, Herr (2008) based in empirical results for the years, 2001 to 2003 indicate that private and non-profit hospitals are on average less cost efficient and less technically efficient than publicly

⁴ Kornai, Maskin and Roland (2003) define soft budgets in the standard way, by assuming that the government (sponsor) with some probability will bail out the hospital ex-post if it runs a deficit. This bailout probability is a measure of budget "softness". It also allow for the possibility that the surplus in the low-demand state is confiscated. Duggan (2000) argues that public hospitals enjoying soft budgets face the issue that their surpluses in good times might be expropriated by the government.

owned hospitals. Public hospitals that are directly managed by government perform poorly in many developing countries (La Forgia and Harding, 2009).

The design and operation of a country's health system will be conditioned mainly by its social, cultural, political and economic structures, defining the mechanisms and operation of financing activities. No health system is identical, yet it can maintain the main features by turning financing into an important component for its classification. Health financing is much more than a matter of raising money for health. It is also a matter of who is asked to pay, when they pay, and how the money raised is spent (WHO, 2010). Healthcare provider payment has a crucial impact on the behavior of the system and its efficiency.

Hospital financing refers to the “function of a health system concerned with the mobilization, accumulation and allocations of money to cover the health needs of the people, individually and collectively, in the health system... the purpose of health financing is to make funding available, as well as to set the right financial incentives to providers, to ensure that all individuals have access to effective public health and personal health care” (WHO, 2005). However, the insufficient financing of the hospital sector is seen as obstructing the success of the main objectives of the health care system: quality, access and financial sustainability.

Cashin *et al.*, (2005) opine that provider payment method may be categorized according to three main characteristics. The first parameter that characterizes a provider payment method is whether payment rates for a set of services are determined prior to services being delivered (prospectively), or after services are provided (retrospectively). Payment rates may be set prospectively through fee schedules, regulations, or negotiation between providers and payers. Payment rates are set retrospectively if the provider is simply reimbursed the amount that is billed. If payment rates are set retrospectively and the reimbursement rates reflect the cost of providing the services, the purchaser bears all of the financial risk. If payment rates are set prospectively, and services are bundled into a package reimbursed at

a fixed payment rate, some financial risk is transferred from the payer to the provider of services.

The second parameter is whether payment to the provider is made before or after services are delivered. If payment rates are set, payment may then be made to providers either prospectively or retrospectively. For example, in a per capita payment system, the price paid to providers to deliver a complete package of services for each individual is set prospectively, and the payment is also made prospectively. The provider receives an advance lump-sum payment for each individual covered or enrolled. In a case-based hospital payment system, however, the payment rate for each type of hospital case is set in advance, but the provider is paid after the services are delivered based on the price per case and the number of cases treated. So, the payment rate is set prospectively, but payment is made retrospectively.

The third parameter that characterizes a provider payment method is whether or not the payment that is made to providers is based on inputs used to provide services (*i.e.* the recurrent costs of providing services are financed) or outputs produced, such as cases treated, bed-days completed, or individual services provided. For example, if a provider is paid according to a budget to cover operating costs, that is an input-based payment method. The payment rates in input-based payment systems may be set prospectively or retrospectively, and similarly, payment may be made to providers prospectively or retrospectively. For example, in a line-item budget system, the payment to providers is both determined and made prospectively, but the basis of the budget is a projected input use, which may be determined by past patterns of input use or regulations on the level and composition of inputs used (Mason *et al.*, 2009).

Literature review indicates that there a variety of payment methods in healthcare systems (Langenbrunner, Cashin and O'Dougherty, 2009). The current health system of México payment can be characterized into three different financing

systems: global budgets, capitation and OOP. Other methods that are not considered in this analysis are case-based payment, wages, per diem, fee-for-service (according to a fee schedule) and mixed payments.

Global budgets

Global budgets for hospitals are aggregate one-line payments fixed in advance to cover expenditures for specified services during a fixed period of time, usually for one year. Global budgets constrain the growth in the price and quantity of services while allowing flexibility in the use of resources within budget limits.

Hospital deficits and government-sponsored bailouts are frequently observed in many countries. Brekke, Siciliani and Straume (2015) studied the incentives for quality provision and cost efficiency for hospitals with soft budgets, where the payer can cover deficits or confiscate surpluses. While a higher bailout probability reduces cost efficiency, the effect on quality is ambiguous. Profit confiscation reduces both quality and cost efficiency. First best is achieved by a strict no-bailout and no-profit-confiscation policy when the regulated price is optimally set. However, for sub optimal prices, a more lenient bailout policy can be welfare improving. When heterogeneity in costs and qualities is allowed, we also show that a softer budget can raise quality for high-cost patients. In practice, though the pricing schemes used for hospitals are generally not maximizing social welfare, they are often cost-based.

Soft budgets are typically explained as the outcome of a dynamic commitment problem in the context of asymmetric information between the government (sponsor) and the firm (typically, but not always, a state-owned firm). Shen and Eggleston (2009) based on a model predicts that hospitals facing softer budget constraints will be associated with less aggressive cost control, and their quality may be better or worse, depending on the scope for damage to quality from non-contractible aspects of cost control.

Capitation

At its simplest, per capita payment is used to provide (i) a specified package of health care services for (ii) a specified population for (iii) a fixed fee per person for (iv) a fixed period of time (for example, 1 year). Per capita payments can be used at a variety of levels in the health sector: to determine regional budgets, to determine budgets for intermediary fund holders within a region or to distribute funds from the payer to a specific health institution or group of institutions. At the facility level, the capitation amount depends on the types of services included in the benefit package, and the membership group of enrollees must be clearly specified. A fund holder and health institution may choose to provide only some services under a capitation payment (for example, hospital services at a single facility) or all services for an integrated system of facilities (for example, a hospital and its associated polyclinic) (Langenbrunner and Wiley, 2002).

In a system of list patient capitation, providers receive a periodical (mostly annual) lump sum per patient under their supervision during a certain period (mostly a year). The total income for a provider is a function of the number of patients enrolled on the list, irrespective of the number of performed activities and contacts. Reimbursement per capita is used in particular for the settlement of general practitioners if patients are to be enrolled on a list. Capitation involves incentives to reduce costs for profit maximizing physicians in a different way than e.g. fee-for-service or case payments. If a patient seeks care several times during a period, the provider is not additionally rewarded, whereas providers in a case-based system are remunerated.

OOP payments

OOP have serious repercussions for health. Making people pay at the point of delivery discourages them from using services (particularly health promotion and prevention), and encourages them to postpone health checks. This means they do not receive treatment early, when the prospects for cure are greatest. A WHO and WB report launched shows that 400 million people do not have access to essential

health services and 6% of people in low- and middle-income countries are tipped into or pushed further into extreme poverty because of health expenses.(WHO, 2015). They risk being pushed into poverty, or further into poverty, because they are too ill to work.

OOP is considered the most inefficient and inequitable means of financing a health system. In OOP-financed systems there is little room for risk pooling, competition among providers is reduced and patients pay more than they would with a prepayment scheme because of the fragmentation of risk and the urgency of treatment (WHO, 2010).

OOP also damage household finances. Many people who do seek treatment, and have to pay for it at the point of delivery, suffer severe financial difficulties accordingly (Baeza and Packard, 2006; Doorslaer *et al.*, 2007).The unfair distribution of risk and financing in OOP-based systems places a great burden on the family. The proportion of households facing financial catastrophic⁵ payments from OOP health expenses varied widely between countries. Catastrophic and potentially impoverishing, expenditures arise, or necessary care is forgone, if the cost of care exceeds the ability to pay at the time of service. Families are often forced to choose between satisfying other basic needs such as education, food, and housing, or purchasing health care and saving loved ones from illness, suffering, and shortened life spans. Catastrophic spending rates are high in some countries in transition, and in certain LA countries. Three key preconditions for catastrophic payments were identified: the availability of health services requiring payment, low capacity to pay, and the lack of prepayment or health insurance (Xu *et al.*, 2003).

Estimates of the number of people who suffer financial catastrophe are available for 89 countries, covering nearly 90% of the world's population. In some countries, up to 11% of people suffer this type of severe financial hardship each year and up to

⁵ Financial catastrophe is defined as paying more than 40% of household income directly on health care after basic needs have been met (WHO, 2010).

5% are forced into poverty because they must pay for health services at the time they receive them (Xu *et al.*, 2007). Catastrophic health spending is not necessarily caused by high-cost medical procedures or one single expensive event. For many households, relatively small payments can also result in financial catastrophe. A steady drip of medical bills can force people with chronic disease or disabilities into poverty (Knaul *et al.*, 2006). Not only do OOP payments deter people from using health services and cause financial stress, especially for low-income families (Ruger and Kim, 2007; Galárraga *et al.*, 2010; WHO, 2010, Grigorakis *et al.*, 2016), they also cause inefficiency and inequity in the way resources are used from a healthcare system view. They encourage overuse by people who can pay and underuse by those who cannot (Carrin *et al.*, 2005). Considering the efficiency of private hospitals receiving OOP payments, results over this are mixed. The citizens perception of private hospitals performance are better than public (Hvidman and Andersen, 2016). Tiemann and Schreyögg (2009) showed that public German hospitals performed significantly better than their private for-profit and non-profit counterparts. Chang, Cheng and Das (2004) indicate that by 9% of difference, Taiwan public hospitals are less efficient than private hospitals for both regional and district hospitals. Masiye (2007) reported a significantly positive effect of private ownership on efficiency in Zambian hospitals. Farsi and Filippini (2005) found that Swiss hospitals' efficiency levels were not predisposed towards inefficiency by type of ownership. Additionally, there is evidence in the literature that German hospitals that changed ownership from public to private, have improved in their efficiency (Tiemann and Schreyögg, 2012; Lindlbauer, Winter and Schreyögg, 2016).

Among the strategies that have gained attention are provider payment reforms that set financial incentives to providers for improving access to care, while at the same time promoting cost containment through the effective and efficient use of resources. The effects of provider payment mechanisms on the health care system vary widely depending on contextual factors, including the level of resources available for health care, the degree of choice, and the opportunities and constraints facing providers to respond to incentives (Cashin *et al.*, 2005). In addition, provider payment may lead

to unintended incentives, such as increasing the number of services provided beyond what is necessary; reducing input used to provide care, “gaming” the system, cost shifting, and increased paperwork for providers (Ellis, 1998).

No single payment model is clearly superior or timeless in its relative utility to achieve sector objectives. The choice for a particular health system will be influenced by a wide range of temporal factors, including the priorities and organization of the health and hospital system, available data and techniques together with the level of development throughout the hospital system. Given the dynamic nature of health systems and the continuing pressure on resources, it would be expected that hospital payment models will be subjected to ongoing developments to take account of advances in technology and in information and analytical systems (Langenbrunner and Wiley, 2002).

Based on Barnum, Kutzin and Saxenian (1995), Maceira (1998), Kutzin (2001) and Cashin *et al.*, (2005), they establish the different characteristics of the methods of payment received by the provider based on the groups defined for this chapter, the effect over efficiency and the most important measures to reduce the disadvantages that occur in each scheme (Table 2.1.).

2.3. México healthcare system: A general overview

México, a middle-income country characterized by social inequalities and a complex epidemiological transition, has supported a fragmented and unequal health system since the 1940s like most in LA. The insured populations received health care from well financed, vertically-integrated federal institutions, whereas the uninsured relied on underfunded, state-decentralized institutions. Every public institution is responsible for stewardship, financing and service delivery only for its particular population. At the same time, many families relied on the poorly regulated, costly private sector. Households –even those with social security- paid for a substantial

Table 2.1. Provider payment alternatives main characteristics

Retrospective or Prospective		Payment Method	Payment based on	Payment steered by.	Main incentives created.	Main Advantages.	Main Disadvantages.	Measures to Minimize Disadvantages.
Cashin <i>et al.</i> , (2005)				Kutzin (2001)	Maceira (1998)	Barnum, Kutzin and Saxenian (1995)	Barnum, Kutzin and Saxenian (1995)	Barnum, Kutzin and Saxenian (1995)
Global Budget	Prospective	Inputs or outputs	Various criteria, e.g., negotiated contracts, patiente-volume, physical capacity, among others.		Spending artificially set rather than through market forces, not always linked to performance indicators, cost-shifting possible if global budget covers limited services, rationing may occur.	<ul style="list-style-type: none"> Predictable expenses for fund holder, low administrative costs. Unified budget permits resources to be used efficiently. 	<ul style="list-style-type: none"> No direct incentives for efficiency Provider may under provide services 	<ul style="list-style-type: none"> Monitor performance. Provide performance based incentives (link global budget to performance, bonuses)
Capitation	Prospective	Outputs	Consumer choice or size of population in catchment area		Incentives to undersupply, strong incentives to improve efficiency that may cause providers to sacrifice quality, rationing may occur, improves continuity of care	<ul style="list-style-type: none"> Predictable expenses for the fund holder Provider has incentive to operate efficiently Eliminates supplier-induced demand Moderate administrative costs 	<ul style="list-style-type: none"> Financial risk may bankrupt provider. Provider may seek to minimize risk by "cream skimming"--enrolling low-risk patients. Provider may under provide services. 	<ul style="list-style-type: none"> To minimize excessive provider risk consider capitation "carve outs" and adjusting capitated payments to reflect the underlying risks of population enrolled Enforce contracts to ensure services provided
Out-Of-Pocket	Retrospective	Inputs	Patient choice of provider; negotiation between provider and patient		Incentives to increase units of service	<ul style="list-style-type: none"> Strong incentives to operate efficiently 	<ul style="list-style-type: none"> Unpredictable expenses for fund holder Cost escalating: strong incentives for supplier-induced demand High administrative costs. 	

Source: Own elaboration

proportion of their health care directly at the point of service and this can expose families to impoverished expenditures (Knaul and Frenk, 2005).

Mexican territorial organization divided is into 32 States with differences between them in terms of health needs and the contribution to health care, particularly for the uninsured illustrating inequity of this system. Pressures on the original, segmented model are becoming more intense as the health system concomitantly battles the diseases of underdevelopment -concentrated in the poorest Southern States- and meets the challenges and upward pressure on health expenditure associated with chronic disease and aging that affects all parts of the country (Frenk *et al.*, 2003; Knaul and Frenk, 2005).

México has advanced significantly for UHC—particularly on the first two stages— as a result of the 2003 health reform that legislated *Sistema de Protección Social en Salud* known as *SP* and Constitutional reform implemented in 1983. The third stage, quality of care, is a continuous challenge for all countries and México is no exception. The 2003 structural reform of the Mexican health system was designed to increase financial protection by offering subsidized, publicly provided health insurance to 57 million Mexicans who are not covered by social security and are concentrated among the poor. The reconfiguration of the sources and allocation of funds via the reform seeks to increase the efficiency and equity of financing, as well as financial protection for households (Knaul and Frenk, 2005).

Nowadays, Mexican health system has great strengths but also weaknesses to successfully fulfill its mission. Without having solved the problems of social gap, the population suffers the brunt of health risks and emerging health problems, as well as enjoys some health problem solutions that are considered controlled.

Gómez *et al.*, (2011), describe the structure of México healthcare system, which is comprise public and private sectors. The public sector includes social security institutions: *IMSS*, *ISSSTE*, *PEMEX*, *ISSFAM*, and institutions that protect or provide

services to the population without social security, among which are included the *SP*, *Secretaría de Salud (SSA)*, *Secretarías Estatales de Salud (SESA)* and *Programa IMSS-Oportunidades (IMSS-O)*. Figure 2.1. describes the current healthcare system in México.

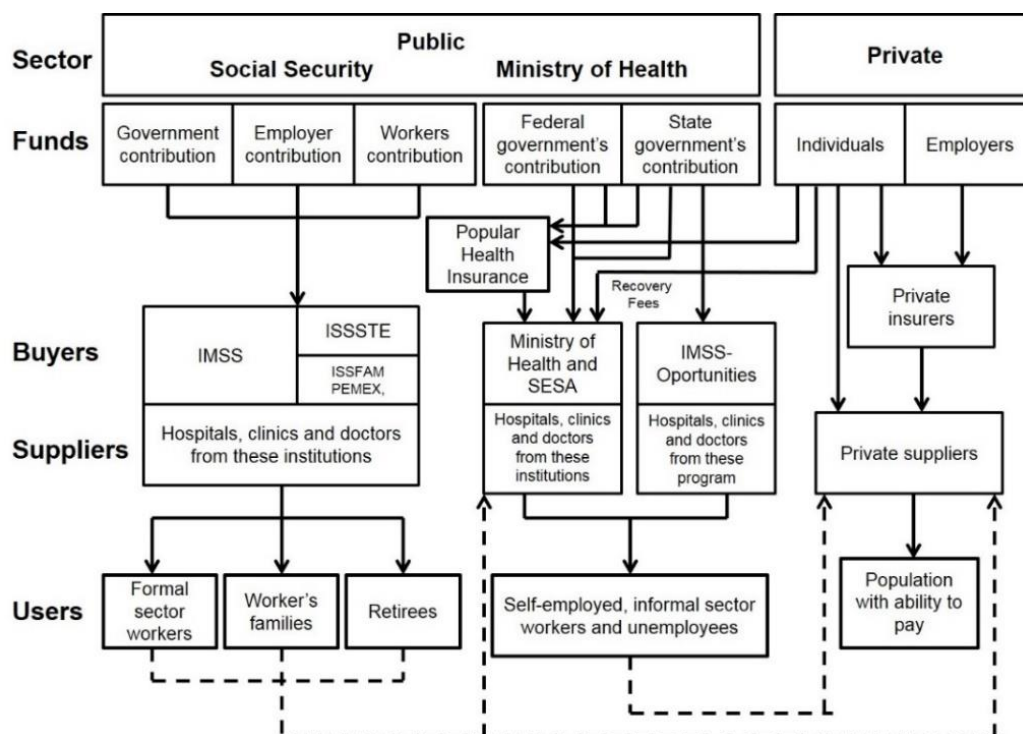


Figure 2.1. Current healthcare systems in Mexico (Gómez *et al.*, 2011)

As shown in Table 2.2. the financing of social security institutions comes from three sources: government, employer and employee contributions (*IMSS*, *ISSSTE*, *PEMEX* and *ISSFAM*). Both the *SSA* and the *SESA* are funded from federal and state governments, plus a small contribution that users pay to receive care (recovery fees) *IMSS-O* is funded by federal resources, managed by *IMSS*. Allocations of funds to hospitals (suppliers) within each of the subsystems described above would be considered in the previous definition of global budget group.

On the other hand, *SP* is funded by Federal and States based on the number of families and individuals enrolled in the program (Gómez and Ortiz, 2004). Additionally, the *SP* evaluates the socio-economic situation of each family based on

the application for the program to determine the annual fee that the family should cover based on their income. Low income family's members are exempt from this payment. With these resources, *SP* buys services from *SESA* for its hospital affiliates. This type of resource allocations is considered in the analysis as a capitation payment.

Table 2.2. Financial architecture of the public health in Mexico (Frenk *et al.*, 2007)

Healthcare public system	Contributions		
	Government (social quota)	Employer (employer's quota)	Worker/Employee (employee quota)
IMSS (Instituto Mexicano de Seguro Social)	13.9% of the minimum wage in Mexico City	- 13.9% of the minimum wage in Mexico City - 6% of the difference between the base salary of contribution and three times the minimum wage in Mexico City	- 13.9% of the minimum wage in Mexico City - 6% of the difference between the base salary of contribution and three times the minimum wage in Mexico City
ISSSTE (Instituto de Seguridad y Servicios Sociales para los Trabajadores del Estado)	13.9% of the minimum wage in Mexico City	7.375% of base salary	2.75% of base salary
ISSFAM (Instituto de Seguridad Social para las Fuerzas Armadas)	15% of base salary	None	None
SESA (State Health Services by the each State Ministry of Health. <i>SP</i> buys services from them)	3.92% of the minimum wage in Mexico City	State Government / Federal Government - solidarity Federal contribution (1.5 times social quota) - solidarity State contribution (0.5 times social quota)	Individual (fee per individual proportional to their socioeconomic status, being zero if located in I and II decil)

The financial protection coverage amounts to 84% of the population in Mexico, considering corrected and unduplicated figures. Social security covers 44% and *SP* up to 40% of the total population. September 2016 statistics, according to *Comisión Nacional de Seguros y Fianzas (CNSF)*, indicates that private insurance policies cover 10.8 million Mexicans, equivalent to 8.8% of total population (CNSF, 2016). However, this figure cannot be added to the total financial protection due to the duplication that exists, particularly on the subject of social security (González and Martínez, 2015).

In 2013, according to *Dirección General de Información de Salud (DGIS)* from SSA (2015), total health expenditure per capita was \$8,485⁶, indicating an increase 2.3

⁶ Expressed in Mexican Pesos

times in real terms since 1995, and 1.8 times since 2000. Spending per capita in the target population of social security it was \$5,419 and the population covered by SSA, including the *SP*, \$3,560. In 2000, spending assigned to these two populations was \$4,256 and \$1,461 respectively. The public gap spending between insured and uninsured got closed considerably, going from a 2.91 ratio of expenses in 2000, to 1.52 in 2013. The per capita amount pooled fund by the *SP* for this year was \$2,631. The per capita spending on private insurance, considering the covered population 2013 was \$4,777, indicating a decrease of 11.1% over 2003 levels per capita of private insurance and social security expenditure are very similar, although the former is more exposed to fluctuations associated with the economic cycle. The fall in per capita spending was observed, in effect, from the economic crisis of 2009 (González and Martínez, 2015).

SP affiliation is voluntary and this is an aspect of the reform that differs from the structure of UHC in many countries. In the case of Mexico, this feature of the reform is being converted into an important incentive for improving the quality of health care at the state level. Voluntary affiliation facilitates the process of replacing supply-side with demand-side subsidies so that money follows people. This is because states have the budgetary incentive to achieve UHC and this implies convincing families to enroll by improving the quality of health service delivery.

Although the financial trigger is a demand-side subsidy, the additional funding mobilized by the reform is channeled to strengthen supply (drugs, equipment, and enhancing or building facilities) at the state level. This is done in line with expansion in affiliation to improve the availability of health care services. Combined with the focus on poor families who do not contribute financially, the affiliation process will help prevent problems associated with market failure such as adverse selection (Knaul *et al.*, 2006).

The private sector includes insurance companies and service providers who work in medical offices, clinics and private hospitals, including providers of alternative

medicine. It is financed by OOP through users when they receive care and premiums from private insurance and offers services in clinics, private clinics and hospitals.

2.4. Methodology and data

2.4.1. The Metafrontier

Technical efficiencies of hospitals measured with respect to a given frontier are comparable but cannot apply once they operate under different set of technologies (Mitropoulos, Talias, and Mitropoulos, 2015). In order to solve this situation, the use of a metafrontier technique ensures that heterogeneous hospitals are compared under a single homogenous technology. The concept of metafrontier analysis was introduced by Battese and Rao (2002) using a stochastic metafrontier model by which comparable technical efficiencies can be estimated.

A metafrontier concept can be described as a function that “envelops” separate group frontiers, each having their own technology and environmental factors (O’Donnell, Rao and Battese, 2008). The main idea of metafrontier analysis in DEA is defining a limit enveloping the observations from a number of subgroups. Efficiency is then calculated relative to both the metafrontier and to the frontier of the subgroup the observation belongs to, and the ratio of these two efficiency scores is referred to as the metatechnology ratio (or technology gap ratio or best-practice gap), as show in Figure 2.2. This ratio indicates the distances between the frontier for the subgroup and the metafrontier, from the point of view of the observation under analysis and thus is exactly the same as the program efficiency score of Charnes, Cooper and Rhodes (1981) (Asmild, 2015).

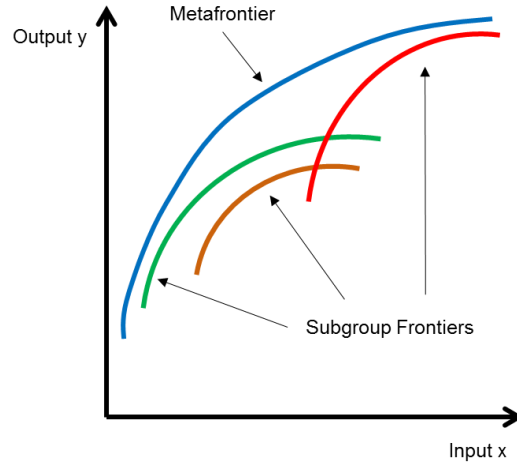


Figure 2.2. Graphical representation of subgroup frontiers and metafrontier

According to O'Donnell *et al.*, (2008), let y and x be nonnegative real output and input vector of dimension $(O \times 1)$ and $(I \times 1)$, respectively. The metatechnology set contains all input and output combinations that are technologically feasible. Formally:

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

Associated with this metatechnology set, are input and output sets. The output set is defined for any input vector, x , as:

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

This is the boundary of this output set as the output metafrontier. It is assume the output set satisfies the standard regularity properties listed in Färe and Primont (1995). Since the objective of this chapter is to measure efficiency, it is convenient to represent the technology using the output metadistance function, defined as:

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

2.4.2. Groups frontiers

The total hospitals in a healthcare system can be divided into $K(>1)$ groups, where resource financing, regulatory or other environmental constraints may prevent

hospitals in certain groups from choosing from the full range of technologically feasible input-output combinations in the metatechnology set, T . The input-output combinations available to hospitals in the k -th group area contained in the group-specific technology set:

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

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.

2.4.3. Metatechnology ratios

Battese *et al.*, (2004), formulated a technology gap ratio. To illustrate this method, the case where there are $K(>1)$ subgroups where each subgroup operates under a specific technology is consider. The technical efficiency (TE) of a production unit r relative to its technology (frontier) k is denoted by TE_r^k . The technical efficiency of the same unit r evaluated at the metafrontier M is denoted by TE_r^M . Therefore the ratio of the frontier scores of a production unit r and the metafrontier represents a technology gap ratio (TGR_r) for that unit r (Mitropoulos, Talias and Mitropoulos, 2015):

$$TGR_r = \frac{TE_r^M}{TE_r^k} \quad (7)$$

This implies that the technical efficiency of a hospital relative to the metafrontier is simply the product of the technical efficiency of that hospital relative to the frontier for a particular group and the technology gap for that group. The metatechnology ratio measures how close a group frontier is to its metafrontier and represents the restrictive nature of the production environment. The TGR_r score takes a value between zero and one, and measures the ratio of the output for the frontier production function for the k group relative the potential output defined by the metafrontier function, given the observed inputs. Therefore, the higher the TGR_r score is the higher the efficiency in operations that can be achieved.

The metafrontier analysis applied to healthcare has been studied. Watcharasriroj and Tang (2004) show that large and small hospitals may have different frontiers. They claim that this effect may be because, at any level of outputs, large hospitals may practice more sophisticated production technology by using advanced medical equipment or experienced specialist. Asmild *et al.*, (2013) investigated the capacity as an exogenous factor and claims that large and small Canadian hospitals have different characteristics in terms of economies of scale, market share and access to advanced technologies. Mitropoulos, Talias and Mitropoulos, (2015) found differences in Greek hospital group's efficiencies scores. Their metafrontier analysis indicates a relatively large gap between efficiency scores for the primary care hospitals, while the secondary and the tertiary hospitals operate with similar technologies according to their results.

2.4.4. DEA model

The distance functions can be obtained by different parametric and non-parametric methodologies. In this chapter, the methodology used for hospital efficiency measurement is Data Envelopment Analysis (DEA), based on O'Donnell, Rao and Battese (2008) for metafrontier concept. This is rooted in the fact that different forms of financing for a specific group of hospitals affect the decisions on the technologies to be used.

DEA is developed by Charnes, Cooper and Rhodes (1978) which was derived from a seminal paper of Farrell (1957). The basic concept of a DEA model is to analyze a set of organizational units with the same objectives in order to identify the efficient ones so they can become benchmarks or peers for the inefficient units in the set and a cooperative system can facilitate sharing best practices (Dyson and Shale, 2010). This methodology has been particularly well-suited to measuring hospitals efficiency because it is able to accommodate multiple heterogeneous inputs and outputs in order to model the complex relationships that exists within them (Arocena and Garcia-Prado, 2007; Hollingsworth, 2008). The DEA estimation procedure consists of solution for each DMU with an optimization problem via linear programming. The efficient frontier is represented by convex combinations of efficient DMUs. The rest of inefficient DMUs are “wrapped” by the efficient frontier considering that deviations from the efficient frontier are due to technical inefficiency (Hollingsworth, Dawson and Maniadakis, 1999).

DEA methodology can examine the efficiency of DMUs using either an input or an output orientation. Input-oriented technical efficiency measures keep output fixed and explore the proportional reduction in input usage which is possible⁷, while output-oriented technical efficiency measures keep input constant and explore the proportional expansion in output quantities that are possible. Actual structure of the public health system in Mexico is such that public managers have no control over the size of the hospitals they run, and therefore of their inputs. For this reason, an output oriented DEA model was used to examine the potential level of outputs a hospital should achieve given the actual level of its inputs.

The DEA model also required if it will use constant returns of scale (CRS) or variable returns of scale (VRS). A CRS models assume a constant rate of substitution between inputs and outputs. Previous research shows that CRS cannot reasonably be assumed in the hospital sector for efficiency analysis, the most common

⁷ An input-oriented model would be inappropriate as the underlying assumption is the desirability to maximize health gains, not hold health gains constant and minimize inputs.

alternative is to assume VRS. This can mean increasing or decreasing returns to scale, such that outputs rise more or less than proportionally relating to changes in inputs used. (Hollingsworth and Street, 2006; Sodani and Madnani, 2008; Asmild, Hollingsworth and Birch, 2013). A VRS model is used for this analysis considering that Mexican hospitals operate in a non-market environment with imperfect competition and budgetary constraints, as well as regulatory constraints that often result in hospitals operating at an inefficient scale size (Jacobs, Smith and Street, 2006).

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

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

Subject to:

$$\begin{aligned} \theta_r^{-1} y_r - y \lambda_r &\leq 0, \\ x \lambda_r - x_r &\leq 0, \\ j' \lambda_r &= 1, \\ \lambda_r &\geq 0. \end{aligned} \tag{8}$$

Where:

y_r is the $(O \times 1)$ vector of output quantities for the r hospital;

x_r is the $(I \times 1)$ vector of input quantities for the r hospital;

y is the $(O \times r^k)$ matrix of outputs for the r^k hospitals belonging to group k ;

x is the $(I \times r^k)$ matrix of inputs for the r^k hospitals belonging to group k ;

j is an $(r^k \times 1)$ vector of ones;

λ_r is an $(r^k \times 1)$ vector of weights;

θ_r is the efficiency distance function for the r hospital.

The model above can also be applied in a metafrontier group by substituting index k with M , where $M = 1, 2, \dots, k, \dots, K$.

The coefficients obtained from the previous model indicate that those hospitals in which the optimal solution are $\theta_r = 1$ are efficient, therefore they are within efficiency frontier. If $\theta_r < 1$ then these hospitals are inefficient.

Till date, there are only two papers on the efficiency model applied to healthcare in Mexico. The first one was published by García-Rodríguez *et al.*, (2011) for hospital efficiency measure in the State of Tabasco, México and Cuba hospitals, in order to identify the units with better productive practice; and to impel the productive efficiency by means of incorporating management processes of benchmarking. The second was prepared by Salinas-Martínez *et al.*, (2009) with the main objective to quantify the technical efficiency of diabetes care in family practice settings, characterize the provision of services and health results, and recognize potential sources of variation. They used DEA with inputs and outputs for diabetes care from 47 family units within a social security agency in Nuevo Leon as well as a Tobit regression models. The authors concluded that performance varied within and among family units; some were efficient at providing services while others at accomplishing health goals. They recommend the inclusion of outputs in the study of efficiency of diabetes care in family practice settings for future research in this topic.

2.4.5. Data

The data required for groups and metafrontiers construction were collected from various electronic public databases available for year 2013: *Instituto Nacional de Estadística y Geografía (INEGI)*, *IMSS*, *ISSSTE*, *ISSFAM* and *DGIS*. Additionally, data bases from public health systems were requested at *Instituto Nacional de Transparencia, Acceso a la Información y Protección de Datos Personales (IFAI)*.

The data obtained were structured using three subgroups based on the different forms of financing that allow the development of a metafrontier model. They are as follows:

Group1: Global budget. This group consists of public health agencies, which by their legal nature as defined in its laws, must draw up a budget based on operational and investment needs to satisfy future economic context, the demographic transition of beneficiaries and the emergence of epidemiological diseases. The budget is sent by Federal Government to Mexican Congress to approve resources dates indicating the laws, which may be subject to change. Originally, the group comprised 250 hospitals that belong to *IMSS*, 110 to *ISSSTE* and 37 to *ISSFAM* for a total of 397 hospitals, but only 369 hospitals were used due to available data⁸.

Group 2: Capitation. This group consists of hospitals which belong to *SESA* at each State in Mexico. Since the reform of December 30, 2009, *SP* is federally funded based on those registered for the program. The main requirement is the lack of any health service previously describe in the first group including self-employed persons, self-employed and those working in the informal economy. The group consists of 237 hospitals located in Mexico⁹.

Group 3: Out-of-pocket (OOP). The group consists of private medical units to provide hospitalization and outpatient services, which the payment is made by patients. These units must have registered beds, space, equipment and personnel for controlling patient's admissions and assesses them to refer them for observation, diagnosis, care or treatment. These hospitals develop a budget which is approved by a board of directors and managers. The group consists of 182 hospitals¹⁰.

⁸ Data obtained from *IMSS* (2015) and *ISSSTE* (2015) websites.

⁹ Data were obtained from *SSA* (2014), *SP* (2015) and *IFAI* (2015) websites.

¹⁰ Data were requested to *INEGI* headquarters, because this information is not available on the public website.

Following the definition of the groups required for analysis, it is necessary to select the inputs and outputs that required the efficiency frontier models described earlier. According to the literature review made by O'Neill *et al.*, (2008), the selection of the input categories refers to the classical production function, where the output is taken to be a function of capital and labor. The common input measures in the hospital sector for labor are full-time equivalents for different staff categories, and beds and material costs for capital, whereas the common output measures are adjusted discharges variables available from the databases. Therefore the outputs and inputs selected were the most common used previously for efficiency calculation.

In addition, this study used the definitions established by the Mexican Official Standard for health, NOM-035-SSA3-2012¹¹, with the aim to establish the criteria to obtain, integrate, organize, process, analyze and disseminate information on health, in terms of population and coverage, resources, services provided, health damage and performance evaluation of the National Health System, and is mandatory throughout Mexico territory for establishments, individuals and corporations, public, social and private sectors, providing services to health care people.

The outputs selected for this chapter are:

y_1 : Surgical medical procedures. Procedure involves to remove, explore, replace, transplant or repair a defect or injury; or to change 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.

y_2 : Total medical consultations. Here a diagnosis is reached after questioning and examining of the patient.

¹¹ Mexican Official Standard (NOM) is the technical regulation of mandatory issued by the competent normalizing agencies through the National Advisory Committee for Standardization, in accordance with Article 40 of *Ley Federal sobre Metrología y Normalización*, which establishes rules, specifications, attributes, guidelines, characteristics or requirements for a product, process, installation, system activity, service or method of production or operation, as well as those concerning terminology, symbols, packaging, marking or labeling and those relating to compliance or application.

y_3 : Days of stay. The number of days since the patient entered the hospital until discharge; it is obtained by subtracting the discharge date from the admission. If a patient goes in and out the same day, it generates one day stay, thereby occupying a registered bed.

y_4 : Hospital discharges. It occurs when a patient is discharge from the hospital emptying a licensed bed. This includes discharge after cure, improvement, transfer to another hospital unit, death, voluntary discharge, or escape. It excludes movements between different services within the same hospital.

The input variables are defined as follows:

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; it does not include those that are in areas of technical and administrative support, research, and teaching.

x_2 : Nurses. These are those who studied how to provide medical assistance to the sick and disabled. Their focus is on maintenance and health care during illness and rehabilitation, as well as assistance to doctors, health diagnosis and treatment of patients.

x_3 : Licensed beds. It's key feature is that it generates a hospital discharge; this bed is at the hospitalization service (for regular use of patients, it must have the necessary space as well as material and personnel resources for patient care). It includes incubators for newborn in pathological state.

x_4 : Operating rooms. There should be hospital area, furniture, equipment and facilities, in order to perform surgical procedures.

The sample means, standard deviation, minimum and maximum of all DEA variables in subgroups and in overall sample of hospitals are presented on Table 2.3. These data exclude outliers. To remove outliers' presence from the database, the following procedures were followed to ensure that it did not have effect on efficiency coefficients. The first step was to review each group database from various sources of information, eliminating all hospitals where a data is blank or had had a "0" (cero). For the analysis requires that all input and output variables contain a positive natural number. The second step was to apply the command called "adaptive computationally efficient outlier blocked nominators" (BACON) algorithm proposed by Billor, Hadi, and Velleman (2000) and analyzed by Weber (2010) with the purpose of identifying multivariate outliers. Finally, super efficiency coefficients were calculated using DEA according to Wilson (1993), hospitals who presented coefficients less than 0.50 should be eliminated.

This validates that hospitals in each group do not have outliers that distort the efficiency coefficients of individual frontier as well as the metafrontier proposed for this analysis.

2.5. Results

The purpose of this chapter is to analyze efficiency in Mexican hospitals based on how they are financed, considering public policies in the health system in function of NPM theory. The first methodological step of this research is to evaluate efficiency levels of Mexican hospitals grouped independently according to their financing scheme in which they operate: global budget, capitation and OOP; the second step is to combine on a common frontier by pooling the data set of all hospitals defined as a metafrontier.

As a result, Table 2.4 compares a key summary statistics obtained for each of the groups and the metafrontier. The average TE_r^k for the group global budget is 0.86 with 93 hospitals among them fully efficient (25% of its frontier). The capitation frontier produced an average score of 0.67 with 34 hospitals being fully efficient

(around 14% of its frontier) and the OOP hospitals produced an average score of 0.89 with 72 hospitals being fully efficient (40% of its frontier).

Table 2.3. Group's descriptive statistics: global budget, capitation, OOP and metafrontier

Budget: IMSS, ISSSTE e ISSFAM (n= 369 DMUs)	Mean	Std. Dev.	Min.	Max.
Outputs				
y ₁ : Surgical medical procedures	4,409.47	4,102.59	12	18,925
y ₂ : Total medical consultations	135,590.69	94,323.33	18,169	645,953
y ₃ : Days of stay	29,845.48	30,183.40	755	196,474
y ₄ : Hospital discharges	6,430.37	5,557.10	279	30,794
Inputs				
x ₁ : Doctors in direct contact with the patient	144.08	137.17	10	787
x ₂ : Nurses	249.81	231.04	19	1,536
x ₃ : Censable beds	107.45	103.76	5	722
x ₄ : Operating rooms	3.73	3.43	1	20
Per Capita Budget: SSa (n= 237 DMUs)	Mean	Std. Dev.	Min.	Max.
Outputs				
y ₁ : Surgical medical procedures	4,632.98	4,949.17	13	30,809
y ₂ : Total medical consultations	50,990.74	56,435.40	1,729	662,396
y ₃ : Days of stay	23,288.06	28,827.63	191	264,498
y ₄ : Hospital discharges	7,102.86	6,835.67	138	47,693
Inputs				
x ₁ : Doctors in direct contact with the patient	119.63	155.35	7	1,215
x ₂ : Nurses	188.35	209.97	8	1,838
x ₃ : Censable beds	72.28	94.43	6	937
x ₄ : Operating rooms	3.54	4.02	1	37
Out Of Pocket: Private hospitals (n= 182 DMUs)	Mean	Std. Dev.	Min.	Max.
Outputs				
y ₁ : Surgical medical procedures	971.37	1,186.62	2	6,205
y ₂ : Total medical consultations	6,424.62	9,946.24	8	54,786
y ₃ : Days of stay	5,188.92	7,510.83	7	51,688
y ₄ : Hospital discharges	1,876.71	2,210.03	7	13,709
Inputs				
x ₁ : Doctors in direct contact with the patient	34.11	70.28	1	651
x ₂ : Nurses	26.07	57.99	1	357
x ₃ : Censable beds	23.43	37.33	1	383
x ₄ : Operating rooms	2.58	2.46	1	17
Metafrontier (n= 788 DMUs)	Mean	Std. Dev.	Min.	Max.
Outputs				
y ₁ : Surgical medical procedures	3,682.61	4,217.89	2	30,809
y ₂ : Total medical consultations	80,313.52	89,985.31	8	662,396
y ₃ : Days of stay	22,178.47	28,002.69	7	264,498
y ₄ : Hospital discharges	5,580.90	5,817.75	7	47,693
Inputs				
x ₁ : Doctors in direct contact with the patient	111.33	138.24	1	1,215
x ₂ : Nurses	179.65	216.35	1	1,838
x ₃ : Censable beds	77.47	95.65	1	937
x ₄ : Operating rooms	3.41	3.46	1	37

Table 2.4. Groups individual efficiency scores¹²

Groups	N	N-Efficient	Mean	Std. Dev.	Min.	Max	q1	q3
Global Budget: IMSS, ISSSTE e ISSFAM	369	93	0.86	0.14	0.50	1.00	0.74	1.00
Capitation: SESA	237	34	0.67	0.16	0.50	1.00	0.57	0.84
Out-Of-Pocket: Private hospitals	182	72	0.89	0.16	0.51	1.00	0.70	1.00

The budget group for this analysis consists of hospitals from *IMSS*, *ISSSTE* and *ISSFAM* public systems and a mean efficiency score of 0.91, 0.71 and 0.88 were obtained respectively. Therefore, *ISSSTE* hospitals had the lowest score with a 0.71 of the maximum output that could be produced by a particular hospital using the input vector, x , and k -group technology was used to determine the type of financing used.

Empirical results also show that the hospitals in the private sector are relatively more efficient than public hospitals. The average efficiency scores show a slightly better performance of private or OOP (89%) than public hospitals operating under a global budget (86%). Even though this difference is small, a Wilcoxon-Mann-Whitney (WMW) test was performed to verify if the difference was statistically significant. Test results indicate the coefficients $z=1.304$ and $p=0.192$, therefore the null hypothesis that both populations are equal cannot be rejected. This evidence shows that these two groups (OOP and global budget) are the same, as regard technical efficiency and how they are financed.

When comparing efficiency scores between private (89%) and public hospitals operating under a capitation agreements (67%), there is a clear difference in results. WMW test results indicate coefficients $z=7.911$ and $p=0.000$, this reveals that the populations between this groups are not the same, evidence that group's global budgets and capitation are statistically different on their financing scheme was obtained.

¹² Results are expressed as the reciprocal of the distance function, known as the Farrell output measure of technical efficiency (Farrell, 1957).

The second methodological step of this chapter, calculates a metafrontier by pooling all hospitals without considering that there are differences in financing schemes in Mexico health system. On Table 2.5., it is observed at the metafrontier scores that their estimated efficiencies (TE_r^M) varies from 0.25 to 1.00 with 92 of 788 hospitals fully efficient (around 12% of total database). The greater proportion of fully efficient hospitals is found in OOP with 29%, followed by 7% for global budget hospitals and 6% for capitation hospitals. The less efficient group relative to the metafrontier is the capitation frontier. On the whole, hospital efficiency in Mexico had a mean score of 65%, therefore it is possible to increase the output without altering the amounts of inputs currently used by the health system in 35%, which means that it maintains substantial areas of opportunity to improve efficiency.

Once the efficiencies of defined individual groups and the metafrontier have been calculated, it is necessary to determine the TGR_r according to O'Donnell *et al.*, (2008), where it calculates the closeness of each hospital belonging to a specified group frontier to a metafrontier.

Table 2.5. Metafrontier, group frontier and TGR_r

Groups	Mean	Std. Dev	Min.	Max	q1	q3
Metafrontier (N=788)	0.65	0.19	0.25	1.00	0.53	0.81
Global Budget: IMSS, ISSSTE e ISSFAM (N=369)						
Metafrontier (TE_r^M)	0.65	0.17	0.26	1.00	0.64	0.79
Frontier (TE_r^k)	0.86	0.14	0.50	1.00	0.71	1.00
Technological Gap Ratio (TGR_r)	0.81	0.15	0.38	1.00	0.68	0.91
Capitation: SESA (N=237)						
Metafrontier (TE_r^M)	0.58	0.17	0.33	1.00	0.50	0.74
Frontier (TE_r^k)	0.67	0.16	0.50	1.00	0.57	0.84
Technological Gap Ratio (TGR_r)	0.92	0.13	0.47	1.00	0.78	0.99
Out-Of-Pocket: Private hospitals (N=182)						
Metafrontier (TE_r^M)	0.78	0.22	0.25	1.00	0.57	1.00
Frontier (TE_r^k)	0.89	0.16	0.51	1.00	0.70	1.00
Technological Gap Ratio (TGR_r)	1.00	0.19	0.32	1.00	0.76	1.00

WMW test for TGR_r^k between groups had the following results: global budget and capitation technological gap, $z=7.321$ and $p=0.0000$; global budget and OOP technological gap, $z=8.511$ and $p=0.0000$; capitation and OOP technological gap, $z=8.511$ and $p=0.0000$. This reveals that the populations at each group comparison are not the same, thus obtaining evidence that they are statistically different on their financing scheme.

The DEA results reveal that the average metatechnology ratio for global budget, capitation and OOP frontiers are 0.81, 0.92 and 1.00 respectively. That is, the maximum output that could be produced using the inputs of capitation and the technology available in México (unrestricted technology without considering the financing obtained) is about 92% of the maximum output that could be produced using the same inputs and the technology represented by the metafrontier. The other groups are at opposite ends, while hospitals that receive budget financing can produce at 81% of the maximum output related to the metafrontier, hospitals in OOP are in full production of outputs.

It is interesting to note that in all hospital groups were at least partial tangent to the metafrontier¹³. As a result, the metafrontier envelops each group's frontiers with 58% of hospitals on private hospitals frontier which is the highest, 27% from public hospitals with a capitation frontier and 15% from public hospitals with a budget frontier as the lowest. The hospital analysis of tangent to the metafrontier as shown in Table 2.6. indicates that no hospital from Aguascalientes or Campeche is tangent to the metafrontier, although both States have a GDP per capita (2013) above the national average¹⁴. The States of Estado de México, followed by Distrito Federal, Jalisco and Baja California have 26, 17, 16 and 15 hospitals respectively, represents the 59% of 186 hospitals tangent to the metafrontier and 65% from OOP group. These hospitals explain the efficient operations concentrated in the largest

¹³ This is the case when the minimum value of the technological gap ratio equals one in each of the sample hospitals.

¹⁴ Data obtained from *INEGI* (2010) website.

population areas of México with the largest GDP per State (2013). Baja California has been considered in recent years as a medical tourism destination, mainly in Tijuana, Ensenada and Mexicali. Results indicate that Nuevo León (the other State in México with a higher GDP per capita) only have 8 tangent hospitals to the metafrontier.

Table 2.6. Hospitals tangent to the metafrontier by Mexican State

Mexican States	Population (2010)	GDP per Capita (2013)*	Number of Hospitals Tangent to Metafrontier
Aguascalientes	1,184,996	\$ 124,142.02	0
Baja California	3,155,070	\$ 121,139.76	15
Baja California Sur	637,026	\$ 156,891.16	2
Campeche	822,441	\$ 767,299.15	0
Chiapas	4,796,580	\$ 47,845.66	7
Chihuahua	3,406,465	\$ 109,966.75	2
Coahuila de Zaragoza	2,748,391	\$ 159,152.45	4
Colima	650,555	\$ 117,719.49	1
Distrito Federal	8,851,080	\$ 253,379.06	17
Durango	1,632,934	\$ 95,971.06	6
Estado de México	15,175,862	\$ 78,596.30	26
Guanajuato	5,486,372	\$ 95,116.36	13
Guerrero	3,388,768	\$ 55,041.41	4
Hidalgo	2,665,018	\$ 78,447.77	5
Jalisco	7,350,682	\$ 111,824.57	16
Michoacán de Ocampo	4,351,037	\$ 68,925.19	11
Morelos	1,777,227	\$ 87,786.30	2
Nayarit	1,084,979	\$ 77,654.83	1
Nuevo León	4,653,458	\$ 206,887.46	8
Oaxaca	3,801,962	\$ 53,874.55	4
Puebla	5,779,829	\$ 72,780.69	5
Querétaro	1,827,937	\$ 148,209.71	6
Quintana Roo	1,325,578	\$ 155,449.41	3
San Luis Potosí	2,585,518	\$ 98,128.34	3
Sinaloa	2,767,761	\$ 97,132.34	6
Sonora	2,662,480	\$ 148,027.71	3
Tabasco	2,238,603	\$ 189,949.28	3
Tamaulipas	3,268,554	\$ 123,036.08	0
Tlaxcala	1,169,936	\$ 61,112.16	1
Veracruz de Ignacio de la Llave	7,643,194	\$ 88,332.86	9
Yucatán	1,955,577	\$ 97,154.33	2
Zacatecas	1,490,668	\$ 81,507.88	1
Total	112,336,538	\$ 116,769.99	186

* Mexican pesos

On the whole, results show that even in a harmonized single group as budget, it was that observed efficiency levels in hospitals varies substantially. Additionally, Mexican hospitals do not always have access to the same technology, even if hospitals are part of the same healthcare system such *IMSS* or *ISSSTE*, mainly by the location influence where they provide their health services, for example, hospital technology in México City differs from those located in the States with smaller populations. To support this, TGR_r were regrouped into two groups considering the median population by each Federal State¹⁵, based on the population census of 2010 reported by *INEGI*. WMW test results suggest that between this two groups, there is a statistically significant difference between TGR_r with higher and lower population states from the median population, helping explain, in part the size of the population's influence over $TGRs$ ¹⁶.

2.6. Conclusions and policy implications

This chapter performs, through a systematic analysis, a comparison of efficiency levels for Mexican hospitals according to the financing mechanisms they used. currently, the health system in México is structured under three different forms of financing: the first group is based on an annual global budget authorized by the Mexican Congress, which includes the health systems of *IMSS*, *ISSSTE* and *ISSFAM*; the second group considered as capitation payment with hospitals enrolled in the national health program called *Seguro Popular (SP)*, where resources are obtained based on the number of people affiliated to the program for their medical care and it is administered by *Secretarías Estatales de Salud (SESA)*; and finally the group of private hospitals (also known as Out-Of-Pocket or OOP), where patients make direct personal payments to receive medical care. This last type of payment deters people from using health services and cause financial stress to families. They also cause inefficiency and inequity in the way resources are used has a health

¹⁵ Wilcoxon-Mann-Whitney test for two groups with population higher and lower than median of 2,706,704.50 ($z=-2.244$; $p = 0.0248$).

¹⁶ The median of State GDP and State GDP per capita where also used as indicators to establish two groups, but it did not provide enough statistical evidence of his influence.

system. They encourage overuse by people who can pay and underuse by those who cannot (WHO, 2010).

The incorporation of *SP* is one of the first measures with a patient approach that has been introduced to the health system based on the New Public Management theory (NPM) by incorporating business practices into government policies, seeking greater efficiency for the allocation of resources to health sector. The aim of *SP* is to protect around 57 million people who previously did not have any kind of assistance and medical coverage. *SP* as a fund holder would allocate monies through specialized service contracts to a network of public and private providers (including the States' own hospitals and clinics) on the basis of population needs, rewarding both efficient and responsive care. Local provision of public goods and provider regulation would remain part of the stewardship function of state ministries; working with the Federal agency SSA. Yet progress has been slow and uneven due to lack of local capacity compounds with the pressing need to expedite the supply of basic interventions.

The efficiency results were obtained using a DEA model with an output orientation for each group according to the financing that are subject (individual frontier), by using a sample of 788 hospitals located across México, considering that they are operating in an inefficient scale, thus developing a variable returns of scale (VRS) model. The OOP payment method represented the best group evaluated with 89%, followed by the budget frontier with 86%, therefore it seems to indicate that there is no difference between both forms of financing¹⁷; but if private and capitation financing are compared, the latter as a result of 67%, which represents the least efficient. A limitation to the previous results is that there is no reliable standard measure for quality that allows the incorporation of this factor within the model (like readmissions). This variable can have a substantial change since it measures the impact over efficiency scores for public and private hospitals.

¹⁷ Wilcoxon-Mann-Whitney test were performed to evaluate the existence of statistical differences between results of each group.

The concept of metafrontier proposed by Battese *et al.*, (2004) and O'Donnell *et al.*, (2008) is used to measure hospitals based on an environment without restrictions of access to the available technology in México, regardless of their financing scheme. It measures the closeness of the individual groups frontiers to the metafrontier by applying a technological gap ratios (TGR_r) for each group. Results indicate that private hospitals are on average tangent to the metafrontier, obtaining a ratio of 1.00; however, under current financing conditions, budget and capitation hospitals would only reach 81% and 92%.

Chapter empirical analysis indicates that the private hospital model in México has a greater efficiency with the resources that are available to maximize the outputs, given the economic incentive to managers and stockholders. This situation is not present in the public sector, due to managers' limitations from the point of view of restricted financing and the non-discretionary use of resources to maximize output. That is partly reflected in public health funded systems when comparing results by TGR_r , it can be seen that it is less than private, especially budget financing.

UHC requires a solid payment scheme between service providers, and even though there have been advances in the health system of México, funding is a strategic issue that has not yet been defined. NPM as theoretical basis is permitted to establish the conditions under which the portability of health services exist, introduce competition and thus the search for the optimization of resources by public and private hospitals. The previous results allow the establishment of guidelines for the elaboration of public policies that allow efficiency in the allocation of public resources to the health system, and define agreements that allow public-private collaboration to enhance the efficiency of the sector, as defined in the *SP* program.

UHC in México gave the first steps to the exchange of medical services between the public health systems formed by *IMSS*, *ISSSTE* and *SESA*, starting in 2016. The program began with the exchange of 700 medical services (which are the most

common conditions among the Mexican population). In order to take advantage of actual infrastructure and medical equipment, public health costs were reduced.

Given the above results, it is important to México health system to separate the delivery of medical services from specific health financing functions. In order to be efficient, effective and transparent, they should enhance the capacity to objectively assess the performance of medical service providers, grant them greater organizational and financial freedom to manage their budgets and planning systems. This will be subject to the objective scrutiny of their efficiency by the payer, which can easily be measured by patient satisfaction and the introduction of performance agreements.

Although this document does not fully resolve all concerns of hospitals in each group, it provides a starting point for a benchmark in the different access to financing. One limitation to the study is that it is not possible to analyze the behavior of each group frontier over time, due to lack of consistent information. Alternative models considering the changes in the operation and integration of the Mexican health system are clearly desirable in the near future.

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III. Scale and scope economies in Mexican private medical units¹⁸

Abstract

The objective is to evaluate technical efficiency and potential presence of scale and scope economies in Mexican private medical units (PMUs) that will improve management decisions. We used data envelopment analysis (DEA) methods with inputs and outputs for 2,105 Mexican PMUs published in 2010 by the *Instituto Nacional de Estadística y Geografía* from *Estadística de Unidades Médicas Privadas con Servicio de Hospitalización* (PEC-6-20-A) questionnaire. The application of the models used in the paper found that there is a marginal presence of economies of scope and scale in Mexican PMU. The main conclusion indicate that Mexican PMU must focus to deliver their services on a diversified structure to achieve technical efficiency.

Keywords: efficiency; scale economies; scope economies; private medical units; data envelopment analysis (DEA); México

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3.1. Introduction

Public and private hospitals, as well as the healthcare industry, face great pressure to control continuously growing costs, even more when governments have a major stake in this sector, driven primarily by maintaining the population health welfare and the correct allocation of scarce resources.

The increasing demand for health services has led México to take innovative steps to improve its performance. Over recent decades, the country has experienced remarkable improvements in life expectancy and a steady decline in infant mortality rates. However, life expectancy remains the fourth lowest among OECD countries. It is required to find additional funding and improve the efficiency of supply in the public health sector and to encourage private investment (Organization for Economic Cooperation and Development, 2010). From 2000 to 2010, public medical units have grown by 12.6% and by 3.0% on available beds. For the same period, investments in private medical units have grown by 41.0% and 28.6% respectively. At the end of 2010, México had 3,976 hospital units, of which 66.4% were private (*Dirección General de Información en Salud*, 2013). The above information highlights the importance of the private hospital sector in recent years due to the lack of public infrastructure that supports quality public services.

There is a large body of literature on the efficiency and productivity of hospitals which has been summarized by several authors (Hollingsworth, 2003; Worthington, 2004; Hollingsworth, 2008). Most studies focus on the effects of environmental pressures on hospital efficiency, such as payment system and property rights (Farsi and Filippini, 2008; Daidone and D'Amico, 2009; Rego, Nunes and Costa, 2010). Other studies pinpoint their attention on economic phenomena, such as economies of scale, economies of scope, economic behavior, and expense preference (Schneider, Miller, Ohsfeldt, Morrissey, Zelner and Pi, 2008; Blank and Van Hultst, 2009), as well as market structure and competition (Gaynor, 2006; Bloom, Proper, Seiler and Van Reenen, 2010). The main objective of this paper is to measure technical efficiency in two subgroups of medical units: diversified and specialized, in

order to determine the presence of scale and scope economics for managerial purposes based on a conceptual framework.

3.2. Materials and methods

3.2.1. Production Function

Mckay and Deily (2008) present a conceptual framework indicating that the standard economic theory of the firm posits a production function, in which a production process transforms inputs into outputs, and assumes that, for a given set of input prices, the firm chooses the set of inputs that will minimize the cost of producing a given amount of output at a given level of quality. The production process itself is taken as given, with no description of how inputs are transformed into output. In this approach, any inefficiency occurs only temporarily and randomly, as the firm adjusts toward optimization.

Efficiency measurement, whether at the level of the individual physician, the hospital or the health-care system as a whole, is a topic of continuing interest in the health economics literature, with an extensive discussion from the appropriate efficiency concept and measurements. The ability to measure efficiency continues to be of interest to analysts and to decision-makers at all levels of government who are in charge of the responsibility to allocate scarce health-care resources across competing needs (Liu, Laporte and Ferguson, 2008).

Theories of economies of scale and scope are considered part of production theory, therefore their analysis as a framework are important to understand the factors affecting efficiency in the healthcare sector. In general terms, these two economic concepts describe what happens to production or costs when the size and/or the diversification of the firm changes (increases).

3.2.2. Scale Economics

According to Stigler (1958), the theory of the economies of scale is the theory of the relationship between the scale of use of a properly chosen combination of all

productive services and the rate of output of the enterprise. Economies of scale exist if the average costs of producing a product or service decline as the volume of production increases. Scale effects are potentially relevant for hospital efficiency, given the nature of the production process and the substantial size differences between hospitals (Asmild, Hollingsworth and Birch, 2013).

To assess the potential role of scale economies in specialty hospital efficiency, scale economies for specific services in specialty hospitals versus general hospitals would need to be compared. For many specific surgical procedures, the volume of specific services performed at specialty hospitals typically exceeds that performed in general hospitals within the same market area (Cram, Rosenthal and Vaughan-Sarrazin 2005; Mitchell, 2005). Thus, given the higher procedural volume in some services, to the extent economies of scale exist in these specific procedures they are likely to be realized to a greater degree in specialty hospitals compared with general hospitals with lower procedural volume. (Schneider *et al.*, 2008).

3.2.3. Scope Economies

Panzar and Willig (1977, 1981) coined the term “economies of scope” to describe a basic and intuitively appealing property of production: cost savings with result from the scope rather than the scale. There are economies of scope where it is less costly to combine two or more product lines in one firm than to produce them separately. This is often the case when production relies on common resources, such as technology, workers, inputs and general overhead.

The decision to specialize will depend in part of the extent to which a firm’s existing scope of products and services exhibit diseconomies of scope (*i.e.*, where joint production is more costly than separate production). Conversely, the decision to diversify will in part be based on the extent to which joint production costs are less than separate production costs (Schneider *et al.*, 2008).

3.2.4. Methodology

Hospital efficiency analysis is an important issue within the field of health economics. There are two contemporary approaches to measure hospital efficiency: the parametric approach (stochastic frontier analysis) and the non-parametric approach (free disposal hull and data envelopment analysis). Farrell (1957) first operationalized a frontier method to estimate the efficiency of a decision-making unit (DMU) with the distance between the DMU's observed level of outputs and inputs and the best practice production frontier. This measure was later formulated into a data envelopment analysis (DEA) model that uses linear programming to locate the best practice production frontier introduced by Charnes, Cooper and Rhodes, (1978). Each DMU can select his own input and output weights to show the best score of efficiency, subject to the condition that the corresponding ratio of every DMU be less than or equal to unity (Charnes *et al.*, 1978).

DEA could use constant returns of scale (CRS) or variable returns of scale (VRS). If CRS cannot reasonably be assumed in the hospital sector for efficiency analysis, the most common alternative is to assume VRS. This can mean increasing or decreasing returns to scale, such that outputs rise more or less than proportionally with respect to changes in inputs used (Asmild *et al.*, 2012). The main limitations of DEA are the sensitivity to outliers and zero tolerance to data errors. (Cooper, Seiford and Tone, 2007).

This paper use the methodology proposed by Prior and Sola (2000), using the programming model developed by Banker, Charnes and Cooper, (1984) corresponding to the envelopment version in radial input orientation and VRS:

$$\text{Min } \alpha_j \quad [1]$$

Subject to:

$$\begin{aligned} \sum_{i=1}^I z_i \cdot y_{m,i} &\geq y_{m,j}, \quad m = 1, \dots, M, \\ \sum_{i=1}^I z_i \cdot x_{n,i} &\leq \alpha_j \cdot x_{n,j}, \quad n = 1, \dots, N, \\ \sum_{i=1}^I z_i &= 1. \end{aligned}$$

Where:

$y_{m,j}$: quantity of output m obtained by unit j ,

$x_{n,j}$: quantity of input n consumed by unit j ,

I : total number of units,

M : total number of outputs,

N : total number of inputs,

z_i : coefficient of intensity that determines the weights with which the observation "i" is used in determining the frontier corresponding to unit j ,

α_j : radial coefficient of technical efficiency corresponding to unit j .

The units I in model [1] consider simultaneously both specialized and diversified firms. This procedure implies there are cases presenting economies (or diseconomies) of diversification, this factor appears aggregated in α_j and is treated as a component of technical efficiency, without the possibility of separating it from other factors.

The following step is to separate diversified units (D) and specialized units (S) in two separate groups. The notation on model [2] evaluates only diversified units with reference to the diversified frontier:

$$\text{Min } \beta_d \quad [2]$$

Subject to:

$$\begin{aligned} \sum_{i=1}^D z_i \cdot y_{m,i} &\geq y_{m,d}, \quad m = 1, \dots, M, \\ \sum_{i=1}^D z_i \cdot x_{n,i} &\leq \beta_d \cdot x_{n,d}, \quad n = 1, \dots, N, \\ \sum_{i=1}^D z_i &= 1. \end{aligned}$$

Where:

$y_{m,d}$: quantity of output m obtained by the diversified unit d ,

$x_{n,d}$: quantity of input n consumed by the diversified unit d ,

D : total number of diversified units,

β_d : radial coefficient of technical efficiency corresponding to the diversified unit d .

Model [3] evaluates the D diversified units with reference to the specialized frontier (formed with the S specialized DMUs):

$$\text{Min } \gamma_d \quad [3]$$

Subject to:

$$\begin{aligned} \sum_{i=1}^S z_i \cdot y_{m,i} &\geq y_{m,d}, \quad m = 1, \dots, M, \\ \sum_{i=1}^S z_i \cdot x_{n,i} &\leq \gamma_d \cdot x_{n,d}, \quad n = 1, \dots, N, \\ \sum_{i=1}^S z_i &= 1. \end{aligned}$$

Where:

$y_{m,i}$: quantity of output m obtained by the specialized unit s ,

$y_{m,d}$: quantity of output m obtained by the diversified unit d (the DMU under analysis),

$x_{n,i}$: quantity of input n consumed by the specialized unit s ,

$x_{n,d}$: quantity of input n consumed by the diversified unit d (the DMU under analysis),

S : total number of specialized units,

γ_d : radial coefficient of technical efficiency corresponding to the diversified unit d ,

The objective to have two separate models [2] and [3] is to obtain a double frontier reference (the frontier of diversified and specialized units), and compare these frontiers to establish whether diversification economies exists (Figure 3.1.). The coefficient β_d indicates the proportion in inputs ($0 < \beta_d \leq 1$) that unit d requires in order to reach the diversified frontier, and γ_d indicates the proportion in inputs ($0 < \gamma_d \leq 1$) that unit d requires in order to arrive at the specialized frontier, the existing relation between the values of the coefficients β_d and γ_d indicates the presence of diversification economies (when $\beta_d < \gamma_d$), or of diversification diseconomies (when $\beta_d > \gamma_d$) (Prior and Sola, 2000).

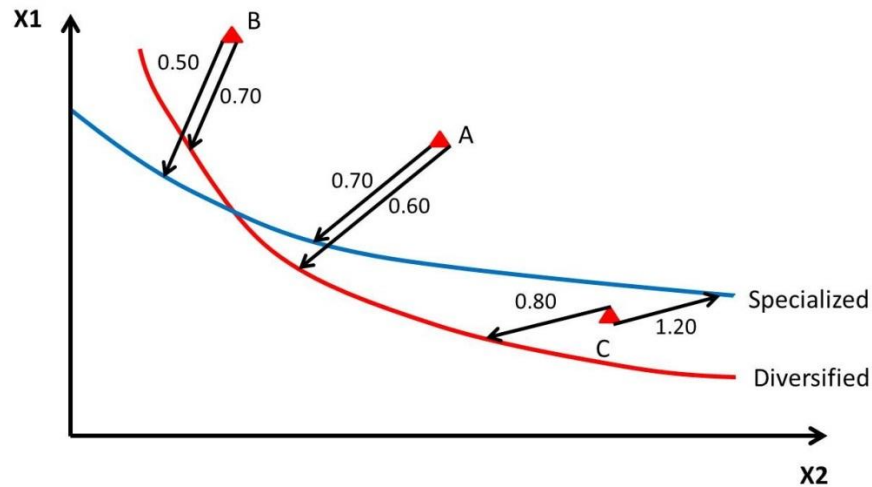


Figure 3.1. Specialized and diversified frontier example

For a specialized unit $d1$, it appears to be diversification economies when the following coefficient, obtained by combining these two frontiers, has the expected value:

$$\frac{\gamma_{d1}}{\beta_{d1}} > 1$$

But otherwise, for another unit $d2$, if the input and output mixes produce a situation of diversification diseconomies, the coefficient shows another value:

$$\frac{\gamma_{d2}}{\beta_{d2}} < 1$$

Managerial implications from the models above can be observed using information of three DMU's: *A*, *B* and *C* (Table 3.1.).

Table 3.1. Specialized and diversified efficiency scores

DMUs	Specialized efficiency scores γ_d	Diversified efficiency scores β_d
<i>A</i>	0.70	0.60
<i>B</i>	0.50	0.70
<i>C</i>	1.20	0.80

Figure I graphically shows the specialized and diversified frontiers. By applying the previous models we can determine that: (1) unit *A* exhibits economies of scope (as $[0.7/0.6]=1.16 > 1$) because in this dimension the diversified frontier is more efficient than the specialized; (2) unit *B* represents a diversified unit exhibiting diseconomies of scope (as $[0.5/0.7]=0.71 < 1$), this situation indicates that, in this dimension, the specialized frontier is more efficient than the diversified frontier; and (3) unit *C*, being in the same sector than *A*, is in the subsample of DMUs exhibiting economies of scope (as $[1.2/0.8]=1.5 > 1$), with the particularity that, being inefficient for the diversified frontier, this unit is characterized as superefficient when compared with the specialized frontier ($\gamma_d > 1$).

The data employed was obtained from a national database created and collected annually by *Instituto Nacional de Estadística y Geografía* in México through a questionnaire called *Estadística de unidades médicas privadas con servicio de hospitalización* (form PEC-6-20-1). The total sample for this study consists of 3,079 private medical units (PMUs) that include general and specialty hospitals, nursing homes, clinics and maternity units with 183 variables for year 2010, limiting the study to one year.

From the original database, it was necessary to eliminate some observations: 13 that corresponded to psychiatric hospitals, 480 due to its lack of medical procedures and 481 due to lack of consistency between surgical procedures and operating rooms. The total PMUs remaining, with an acceptable level of data quality, for this analysis consisted of 2,105 observations: 1,990 diversified and 115 specialized.

The specific definition of outputs variables selected, according to the literature review and variable availability from the database, were:

y₁: carried out on patients with diagnostic or therapeutic purposes and which, by their nature, may be performed within or outside of an operating room.

y₂: Total medical consultations. Attention where by questioning and examination of the patient a diagnosis is reached.

y₃: Days of stay. The number of days since the patient entered the hospital until discharge. The patient going in and out the same day generates one day stay.

Inputs variables were defined as follows:

x₁: Physicians. Lawfully authorized personnel with a professional title, whether general or a specialty or personnel in undergraduate and postgraduate training.

x₂: Staff (physicians and non-physicians). Medical personnel that play technical support work, teaching and administrative staff in the medical units, paramedical, administrative and other staff.

x₃: Hospital beds. Is a bed on service installed for regular use of inpatients.

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

Descriptive statistics are on Table 3.2. for variables considering above, presented in three sections: all PMUs, only diversified units and only specialized units. It can be observed a wide margin in data between minimum and maximum in each output and input which is related to different PMUs sizes on the database used. It is also noteworthy that surgical procedures and operating rooms were considered as long as both have a value of zero, as part of database quality control. Specialized PMUs have a lower value on average against diversified, but this is not maintained on total medical consultations output, due perhaps for demand on specialized treatments that cannot cover a diversified PMUs.

Table 3.2. Descriptive statistics for each group

Diversified and specialized private medical units (2,105 observations)				
Variable	Mean	Std. Dev.	Minimum	Maximum
<u>Outputs</u>				
y ₁ : Surgical medical procedures	216.97	522.89	-	12,668
y ₂ : Total medical consultations	1,806.08	4,797.96	2	142,219
y ₃ : Days of stay	1,015.75	2,966.54	1	60,561
<u>Inputs</u>				
x ₁ : Physicians	32.06	117.06	1	4,718
x ₂ : Staff	21.80	72.67	1	1,986
x ₃ : Hospital beds	9.97	14.39	1	383
x ₄ : Operating rooms	1.45	1.11	-	17
Diversified private medical units (1,990 observations)				
Variable	Mean	Std. Dev.	Minimum	Maximum
<u>Outputs</u>				
y ₁ : Surgical medical procedures	219.66	526.19	-	12,668
y ₂ : Total medical consultations	1,796.90	4,404.40	2	142,219
y ₃ : Days of stay	1,035.73	3,020.41	1	60,561
<u>Inputs</u>				
x ₁ : Physicians	32.63	120.19	1	4,718
x ₂ : Staff	22.07	73.91	1	1,986
x ₃ : Hospital beds	10.07	14.51	1	383
x ₄ : Operating rooms	1.46	1.10	-	17
Specialized private medical units (115 observations)				
Variable	Mean	Std. Dev.	Minimum	Maximum
<u>Outputs</u>				
y ₁ : Surgical medical procedures	170.49	461.63	-	4,281
y ₂ : Total medical consultations	1,964.97	9,294.26	3	89,293
y ₃ : Days of stay	669.97	1,767.19	9	12,919
<u>Inputs</u>				
x ₁ : Physicians	22.20	27.30	2	205
x ₂ : Staff	17.03	46.15	1	346
x ₃ : Hospital beds	8.26	12.09	2	100
x ₄ : Operating rooms	1.31	1.18	-	11

3.3. Results

The first step is to calculate efficiency scores with DEA for all observations in the database determining a first efficiency frontier and evaluating if scale economies are present. On Table 3.3. are the descriptive statistics for the results using the standard DEA in radial input orientation from model [1] by using constant returns of scale (CRS), variable returns of scale (VRS) and a scale efficiency ratio calculation (meaning, dividing the efficiency score of CRS by the efficiency score of VRS).

Table 3.3. Descriptive statistics for standard DEA efficiency measures

	CRS (1)	VRS (2)	Scale Efficiency (1) / (2)
Mean	0.2558	0.3859	0.6345
Standard deviation	0.2129	0.2176	0.2737
Minimum	0.0082	0.0584	0.0123
Maximum	1.0000	1.0000	1.0000
Skewness	1.6398	1.3970	-0.3460
Kurtosis	5.5649	4.5268	1.9379
No. of efficient observations	37	110	37
% of efficient observations	1.76%	5.23%	1.76%

Results obtained using a CRS model indicate 37 efficient PMUs representing 1.76% of the total database, whereas this number increased to 110 efficient PMUs when a VRS model is considered representing a 5.23%. This increase is expected because the VRS model considers any efficient units that are on the edge of the efficient frontier. An economy of scale is obtained by dividing CRS efficiency scores between VRS efficiency scores (Prior and Sola, 2000). The results indicate that only 1.76% of the database used show the presence of economies of scale. Distributions using CRS and VRS are positively skewed, presenting long right tails, and have positive kurtosis, indicating that their distributions have fat tails relative to the normal distributions. Results for scale efficient coefficients exhibit negative skew and positive kurtosis.

In order to corroborate whether there are important differences between efficiency scale scores for diversified and specialized PMUs groups, it was necessary to perform a Mann–Whitney U test. The results suggest that there is a statistically significant difference between efficiency scores for diversified units and specialized units ($z = 3.8777$; $p = 0.001$). The sum of the diversified efficiency scores ranks was higher while the sum of the specialized efficiency scores ranks was lower.

To determine economies of scope, Table 3.4. contains the results using the two-stage model from models [2] and [3]. On average, the coefficient of diversification is 0.6399 with a presence of diversification economies at 1.80% of them. The distributions are negatively skewed, presenting long left tails, and have positive kurtosis, indicating that their distributions have fat tails relative to the normal distributions.

Table 3.4. Summary statistics for the two-staged model

	Diversification Coefficients
Mean	0.6399
Standard deviation	0.2733
Minimum	0.1239
Maximum	1.0000
Skewness	-0.3696
Kurtosis	1.9579
No. of efficient observations	36
% of efficient observations	1.80%

Considering the observations available, managerial implications from above indicate that most Mexican PMUs have improvement areas to move to efficiency. On average, there is 36.01% ($1 - 0.6399$) opportunity to increase in input consumption to reach for technical efficiency. The results show lack of economies of scope in Mexican PMUs.

3.4. Conclusions

Efficiency has been a major concern in healthcare industry for governments but also for private managers, due to pressures from general public and investors respectively. The private sector has increased their investment in healthcare in recent years in México, as an opportunity to provide quality health services with respect to the public sector, influenced by an increase of population and government budget constraints.

Considering the impact of scale and scope economics over technical efficiency in Mexican private medical units (PMUs), results show that there is a large variability in the efficiency scores among PMUs from 0.0584 to 1 using a VRS model. The efficiency results indicate that within Mexican PMUs there is a marginal presence of scale and scope economics (with only 1.76% and 1.80% respectively). We did not find any similar study in México and internationally comparison is limited due to differences in variables and methods selected. We recommend the convenience to expand the size of Mexican PMUs through mergers, acquisitions, strategic partnerships or using organic growth will be important in the near future to achieve technical efficiency, and also incorporate more health services.

The growing need for medical services in México allows an important opportunity for academic research with managerial implications within the public and private healthcare in México. Future research suggested should include: 1) allocative efficiency using economic data: revenues and costs; 2) comparison between private and public units using cross-sectional data; and, 3) to perform efficiency analysis in specific regions of México (like Estado de México and Distrito Federal) where the presence of PMUs are important.

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IV. Strategic alliances effects over hospital efficiency and capacity utilization in México

Abstract

This chapter 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.

4.1. 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'Annunzio, 1990; Zuckerman and Kaluzny, 1991). Much of the related literature has examined the comparative performance of system hospitals prior to and in the years immediately following the introduction of Medicare's prospective payment system in 1983 (Carey, 2003).

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).

According to Pan American Health Organization 2010, "health systems in Latin-America are characterized by high levels of fragmentation of their health services". The decades shows that excessive fragmentation of health services generates difficulties in access to services, the provision of low technical quality, irrational and

inefficient use of available resources, an unnecessary increase in costs production, and low citizen satisfaction with services received.¹⁹

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 Mexico*. 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)²⁰ and only 4% corresponds to pay private health insurance premiums²¹. Likewise, Mexican Association of Insurance Institutions (AMIS)²² 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).

¹⁹ México actual healthcare system structure was described in chapter #2.

²⁰ Out-of-pocket payments characteristics and implications were analyzed in chapter #2.

²¹ Information provided by *Instituto Nacional de Estadística y Geografía (INEGI)*.

²² The main objective of AMIS is to promote the development of the insurance industry in México, represent their interests to the public, private and social authorities, as well as providing technical support to its partners.

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; Valdmánis, DeNicola and Bernet, 2015); and future constraints events such as natural disasters, terrorism and epidemics (Ferrier, Leleu and Valdmánis, 2009; Valdamis, 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.

Literature has analyzed the hospital alliances from the perspective of economies of scale. Cardwell and Bolon, (1996) point out that one specific objective when a SHA is formed is to improve economies of scale by using resources among affiliated members and economies in marketing a large organization rather than several smaller firms to increase patient flow (McCue, Clement and Luke, 1999; Rosko *et al.*, 2007; Granderson, 2011). However an economy of scale has effect on hospital size in a short or long term (Given, 1996; Wholey *et al.*, 1996; Prior and Sola, 2000; Preyra and Pink, 2006); this means that hospitals in an alliance would need to focus on how to increase their actual capacity at their current size.

This is research gap on private hospitals performance due to the lack of quantitative evidence in México, particularly over efficiency and capacity utilization. A general perception is that private hospitals carry excess of capacity and require attracting patients; therefore a SHA should increase hospitals affiliates' efficiency and capacity.

This research chapter 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*).

The chapter's structure has the following content. On section 2, it describes a theoretical framework of general alliances and specifically applied to general hospitals; section 3, clarifies a DEA metafrontier methodology to evaluate efficiency between groups, the procedure for calculating *HCU* is defined, description of databases, information structure and variables collected; section 4, shows the *TGR* and capacity utilization ratios results; and, section 6 discusses managerial implications based on previous results for private Mexican hospitals in a SA.

4.2. Literature review

4.2.1. 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 has been defined by different authors. Das and Teng (2000) broadly define it as a voluntary cooperative inter-firm agreements aimed at achieving competitive advantage for the partners; to Gulati (1998), it is voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies, or services. They can occur as a result of a wide range of motives and goals, take a variety of forms, and occur across vertical and horizontal boundaries.

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). To distinguish more long-term substantial collaboration from other casual cooperative arrangements between firms, the term SA has been used to refer to agreements characterized by the commitment of two or more firms to reach a common goal which entails the pooling of their resources and activities (Teece, 1992). On Figure 4.1., it provides an overview of the range of interfirm relationships that can be categorized as strategic alliances arising from contractual or equity agreements (Yoshino and Rangan, 1995; Kale and Singh, 2009).

Organizations seek to maintain existing internal resources and obtain new resources externally, and they will participate in partnership strategies to achieve this goal (Yarborough and Powers, 2006). In this view, SA are the manifestation of highly cooperative (and not competitive) strategies in organizations, that enables the harnessing of the specific resources and skills of each organization in order to achieve greater common goals for the dyad or triad, as well as goals specific to the individual partners (Varadarajan and Cunningham, 1995).

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. There is a key difference between alliances and multihospital systems. Multihospital systems are generally controlled through a corporate office; an alliance is controlled and/or owned by the member institutions (American Hospital Associations, 1990). 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.

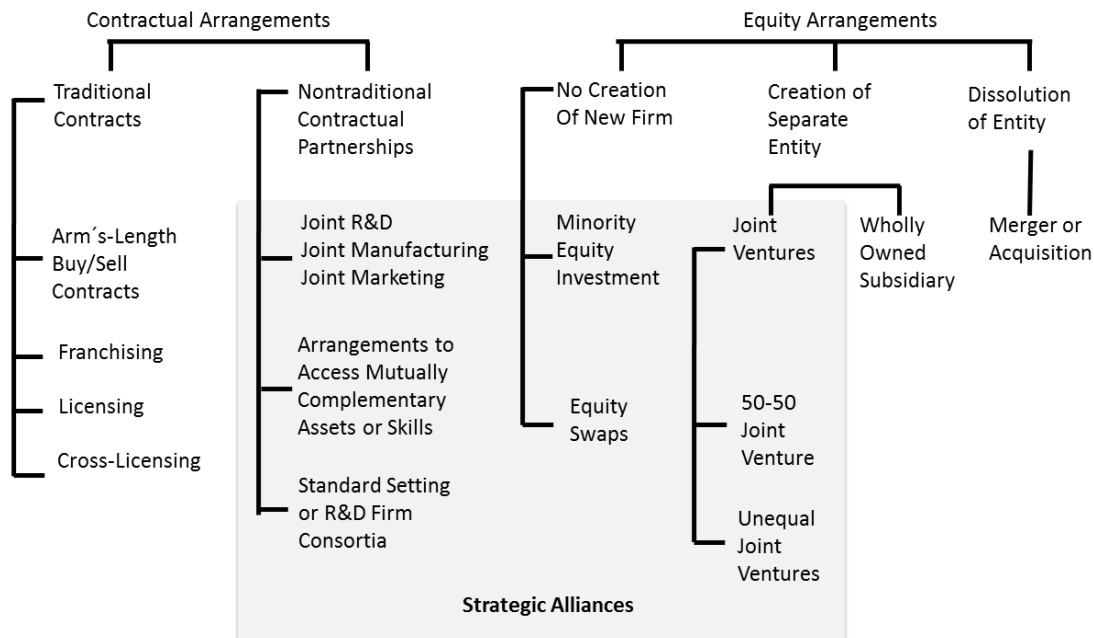


Figure 4.1. Scope of inter-firm relationships (Adapted from Yoshiro and Rangan, 1995; Kale and Singh, 2009)

SHA exhibit considerable diversity in meeting the needs of their stakeholders, differing in stated purpose, membership criteria, organizational structure, geographical location, financing and general economy state. Among the services provided by most, not all hospital alliances, are group purchasing (medicines and medical equipment), insurance writing, continuing education, sharing best medical and administrative practices, access to capital and sources of financing, technology assessment, consulting and marketing and revenue-generating opportunities (Zinn, Proenca and Rosko, 1997).

Bazzoli *et al.*, (1999) identified three fundamental components underlying meaningful differences among health care organizations: the level at which services are organized and provided (centralization); the selection of category and scope of services to offer (differentiation); and the choice of whether to offer services through direct ownership or through contractual relationships (integration). These dimensions form the conceptual framework for taxonomy of health networks and systems.

Based on these components, the difference between health networks and health systems is defined. Health networks are those organizations tracked by the AHA that are strategic alliances or contractual affiliations of hospitals and other health organizations (e.g. home health agencies, nursing homes) that provide an array of health services. Health systems also offer an array of services and products but have unified asset ownership of affiliated hospitals and other organizational units. They also recognized that differences among systems may be due to factors more complex than ownership or duration, and they conducted cluster analysis on measures of differentiation, integration and centralization that suggested the existence of five category system taxonomy defined as centralized systems, centralized physician/insurance systems, moderately centralized systems, decentralized systems and independent systems.

Previous studies have addressed the association between hospitals network and hospital performance. Some studies found a positive relationship between membership in a network and operational efficiency (Mascia and Di Vincenzo, 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 belong in a health network that have higher centralization of decision making and service delivery generally have better performance, as 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 upon system characteristics when comparing hospitals that were members of centralized health systems, membership in centralized physician/insurance or decentralized systems was associated with decreased inefficiency; membership in 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. B chner, Hinz and Schrey gg (2016), analyzed the potential changes in hospital

performance after health system entry, and found that there is an increase in hospital technical and cost efficiency with permanent effects.

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 chapter, resource dependence theory (Pfeffer and Salancik, 1978) and 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).

4.2.2. Resource dependence theory

Resource dependence theory (RDT) characterized the corporation as an open system, dependent on contingencies in the external environment (Pfeffer and Nowak, 1976; Pfeffer and Salancik, 1978). Murray, Kotabe and Zhou (2005) indicate that resource dependence theory focuses on the effects of environmental factors as to how firms should organize in order to compete in the marketplace. The theory recommends that a firm should reduce its dependence on other firms for critical resources, and adjust its boundaries to manage environmental uncertainties (Pfeffer and Salancik, 1978; Drees and Heugens, 2013). However RDT allow the inclusion of strategic alliances when evaluating firms' recourses (Ulrich and Barney, 1984).

According to Ulrich and Barney (1984), RDT is based on three assumptions: 1) organizations comprise of social exchanges that result in the formation of both internal and external coalitions with the intention of influencing and controlling

behavior; 2) environments are uncertain and have limited resources that are valued by the organization and are essential for the firm's survival; and 3) organizations contend for power through the attainment of resources which reduces their dependence on other organizations and maximizes the dependency of other organizations on them. In this view, organizational success is defined as the maximization of organizational power, while the connections among organizations are viewed as a set of power relations based on the exchange of resources (Hayek *et al.*, 2014).

Resource dependence theorists have suggested that managers make strategic choices within constraints (Pfeffer and Salancik, 1978; Hrebiniak and Joyce, 1985). Although managers do not have unbridled strategic choice, they do have discretion over how to structure organizational relationships to manage uncertainties in order to increase their performance (Oliver, 1990; Greening and Gray, 1994, Dias and Magriço, 2011).

Other alliance relationships are expected when resource flows are particularly problematic and environmental uncertainty is high (Pfeffer and Salanick, 1978). Resource flows are problematic if resources are scarce, widely disperse and the survival of firms is mutually dependent so that resource exchanges occur frequently, in this situation strategic alliances may be more actively adopted. Organizational capabilities for managing problematic resource also affect the dependence of a hospital on alliances. If a hospital is self-sufficient, it is less dependent on external resources, and therefore has less need for managing dependence and strategic alliances (Song, 1995).

Analyzing healthcare alliance in regards to the resource contributions of each party involved is consistent with research on strategic alliances. Ozcan and Eisenhardt (2009) showed that not only do firms rely on each other through interdependence, but firms can also create a vision of interdependence. Lomi and Patterson (2006) suggested that dependencies extend across multiple networks, forming a

“multiplicity” of interdependencies and exchange relationships. Zinn *et al.*, (1997) analyzed that hospitals with greater resources and more favorable payer mix are more likely to join alliances.

Rosko and Proenca (2005) indicates that the argument on 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 needed resources and knowledge, it create scale and scope economies, share costs, and gain leverage. RDT suggests that hospitals should be able to provide services at lower cost and with greater efficiency by collaborating on service delivery with other institutions as part of a network or a system. Prior 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 overhead, and to lower 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).

4.2.3. 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). Judge and Dooley (2006) indicates that there are three general forms of governance mechanism within TCE: first, “market” governance where prices govern; second, “intermediate” governance where complex contract and strategic alliances govern; and third, “hierarchical” governance within the boundaries of the firm (Barney, 1999). For the purpose of this chapter, focus is on intermediate governance, according to the nature of the hospital alliance under this analysis.

TCE can be applied to interchanges between collaborating organizations as well as the intra-organizational workings of firms (Williamson, 1991). A fundamental principle of TCE is that organizations incur cost as a result of planning, implementing and enforcing exchanges with other organizations. Costs can include contract negotiations, monitoring adherence to contractual terms, providing financial incentives or penalties and losses resulting from suppliers’ non-compliance (Rosko *et al.*, 2007). Among the services provided by most, but not all alliances, are group purchasing, insurance writing, continuing education, access to capital, technology assessment, consulting and marketing and revenue generating opportunities (Zinn *et al.*, 1997). SA is the results of the business world moving from competitiveness to cooperativeness where alliances allow organizations to take advantage of economies of scale and scope (Williamson, 1985). 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 seeking selfish and opportunistic openings (Hutt *et al.*, 2000).

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.

4.2.4. 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).

A hospital might be considered as a production system, in which the scarce resources are used to support the patient flow. Then, the demand side of a hospital consists of many patients with different pathologies that enter the hospital according to their own time pattern, while the supply side consists of one hand of the available personnel (e.g. surgeons, nursing staff) and on the other hand of the material resources (e.g. beds, operating rooms). The objective of a hospital is to match its supply and demand side in the best possible way, resulting in a quick, reliable and efficient service. However, the uncertainty exists in the health care system will play a destructive role on the efficiency of the health service delivery (Ma and Demeulemeester, 2013). Research in healthcare has concentrated on the distinct characteristics of health operations that make capacity measurement challenging (Li and Benton, 2003; Utley *et al.*, 2003; Li and Markowski, 2006; Cardoen, Demeulemeester and Beliën, 2010; Ayvaz and Huh, 2010). Some studies have also focused on determining hospital capacity levels as part of emergency preparedness for extraordinary events such as acts of terrorism, increasingly violent weather (Valdmanis, Bernet and Moises, 2010), financial stress (Kim *et al.*, 2004), consolidation of operations following a merger or any other planned or unplanned changes in hospital capacity may cause a “shock” in the supply of hospital services (Ferrier, Leleu and Valdmanis, 2009).

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.

4.3. 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.

4.3.1. 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 4.2. 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 .

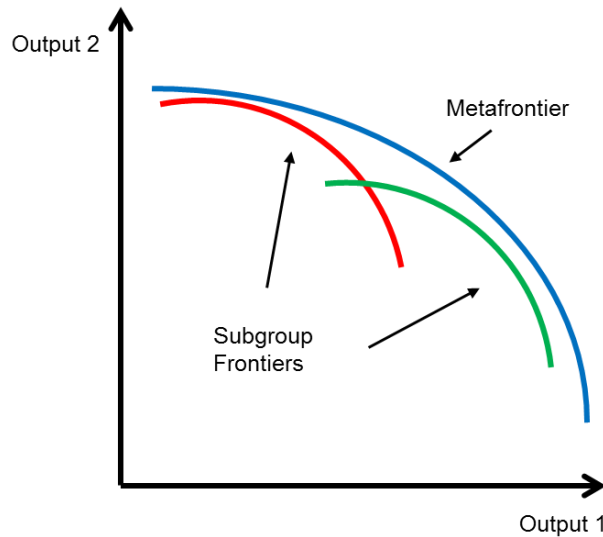


Figure 4.2. Metafrontier and group frontiers with two outputs

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:

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

4.3.2. Groups frontiers

The hospitals used in this chapter 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:

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

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:

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

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

4.3.3. $TGR's$

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 4.3. assumes two outputs, hospital r with respect to metafrontier (M) is the distance of $0r/0M$, and the same hospital r with respect to his group frontier (k) is denoted as $0r/0k$. It is possible to calculate the ratio as follows:

$$TGR_r = \frac{D(x,y)}{D^k(x,y)} = \frac{0r/0M}{0r/0k} = \frac{0k}{0M} \quad (9)$$

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.

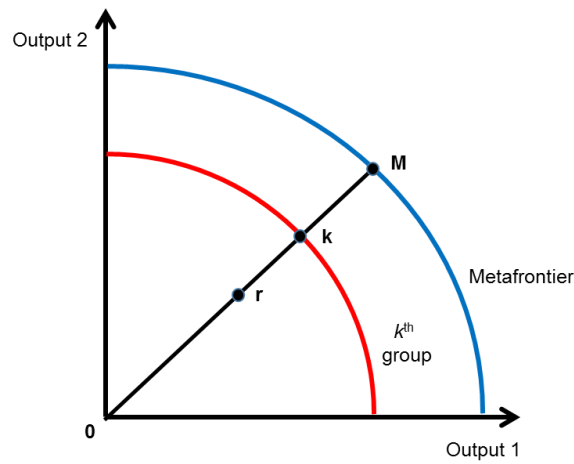


Figure 4.3. $TGRs$ Representation with two outputs

An empirical efficiency analysis and metatechnology ratio requires an empirical description of the methodology used. There are different techniques assessing hospital efficiency indicators, including 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 chapter uses DEA methodology.

4.3.4. 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 strengths of DEA are related to the fact that this method allows multiple inputs and outputs to be used simultaneously in a linear programming model that develops a single score of efficiency for each observation that is used to measure E , scale efficiency, allocative efficiency, congestion efficiency and technical change. This point is important in analyzing the hospital sector, in which the production process is multiple-input and multiple-output, and from which price information is difficult to obtain.

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 chapter, 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 chapter, 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 censure 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 chapter 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 $M = 1, 2, \dots, k, \dots, K$.

4.3.5. DEA capacity measurement

This chapter 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).

Healthcare capacity is usually measured in terms of resources or inputs in order to deal with a variety of the patient/service mix (Bamford and Chatziaslan, 2009). The capacity units privileged under these circumstances are operating rooms and beds (Kim *et al.*, 2000; Santerre and Adams, 2002; Moore 2003; Li and Benton, 2003; Bamford and Chatziaslan, 2009; Gnanlet and Gilland, 2009; Cardoena, Demeulemeester and Beliën, 2010; Yiet *al.*, 2010). To study the capacity of alliance hospitals, this chapter employs linear programming models that treat fixed (censable beds and operating rooms) and variable inputs (medics, nurses) asymmetrically, while accounting for multiple outputs. It is important to gauge plant capacity and capability in the context of cost minimization (even though cost minimization is not explicitly specified in the econometric sense) due to the context of cost containment objectives.

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:

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

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 , $\widehat{Do} [(x^f, x^v), y; g^y] \geq 0$; 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:

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

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:

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

Subject to:

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

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

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

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

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

$$\beta_r \geq 0 \quad (14)$$

Where:

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

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

x_{i1n}^f is the i_1 fixed input quantities corresponding to hospital n ;

x_{i1r}^f is the i_1 fixed input quantities corresponding to hospital r under assessment;

x_{i2n}^v is the i_2 variables input quantities corresponding to hospital n ;

x_{i2r}^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:

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

Subject to:

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

$$\sum_{n=1}^N z_n \cdot x_{ni1}^f \leq x_{i1r}^f, \quad i_1 = 1, \dots, I_1$$

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

$$z_n \geq 0, \quad n = 1, \dots, N \quad (15)$$

Where:

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

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

x_{i1n}^f is the i_1 fixed input quantities corresponding to hospital n ;

x_{i1r}^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:

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

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).

4.3.6. 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. *CMH* has its origins in the need for Mexican medium-sized general hospitals to remain competitive in service quality and cost/price ratio, due to the presence of foreign hospitals and large hospital corporations. It began operations in 2007 with 22 private hospitals that saw the need for a common front in negotiating the purchase with the pharmaceutical industry and medical equipment as their first objective.

The *CMH*²³ has expanded its membership to include 36 private general hospitals located in 35 cities across México. it now 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

²³ Information published in *CMH* website at <http://www.cmh.mx>

private medical units with hospitalization service" (form PEC-6-20-A)²⁴ 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 census²⁵ 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.

Literature review of hospital *TE* and *HCU* indicates that the inputs and outputs selected are appropriate for the purpose of this chapter (Hollingsworth, 2008; O'Neill *et al.*, 2008; Valdmanis, Kumanarayake and Lertiendumrong, 2004; Valdamis, Bernet and Moises, 2010; Büchner, Hinz and Schreyögg, 2016). On table 4.1., a review of the most relevant articles was carried out from 2000 to 2017 to determine the main variables that have been used as inputs and outputs.

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 chapter collected from the databases and their current definitions are described by Mexican Official Norm²⁶, are describe in Table 4.2.

²⁴ Data were requested to *INEGI* headquarters, because this information is not available on the website.

²⁵ Number of people living in urban, semi-urban and rural localities, defined by population ranges according to *INEGI*

²⁶ Mexican Official Norm (NOM-035-SSA3-2012) published November 30, 2012 in *Diario Oficial de la Federación* (Official journal of Federal Mexican government).

Table 4.1. Overview of inputs and outputs used previously

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Puig-Junoy J.	2000	DEA	94 hospitals	1990	(1) Full time equivalent (FTE) physicians, including residents; (2) FTE nurses and equivalents; (3) FTE other nonsanitary personnel; (4) In-patient beds	(1) Case-mix adjusted discharged patients; (2) In-patient days in acute care medicine services; (3) In-patient days in intensive care units; (4) In-patient days in long-term and other services; (5) Surgical interventions; (6) Hospital daycare services; (7) Ambulatory visits; (8) Resident physicians	Spain, Cataluña
Chirikos T, Sear A.	2000	DEA and SFA	186 hospitals	1982-1983 (longitudinal)	NA	NA	United States. Florida
Jacobs R.	2001	Data Envelopment Analysis y Stochastic Frontier Analysis	232 hospitals	1995-1996	(1) Cost Index; (2) Total cost incurred for inpatient; (2) Number of inpatient; (3) Healthcare Resource Group case mix; (4) Average HRG case mix index; (5) Total number of inpatient; (6) Total first outpatient attendances; (7) Total cost of outpatient attendances for all studies; (8) Total first A&E attendances; (9) Total cost A&E; (10) Total first A&E attendances.	(1) Transfers in per spell; (2) 1 minus transfer out per spell; (3) Emergencies per spell; (4) Specialty finishehd consultant episode per spell; (5) Outpatient attendees per spell; (6) Emergency index/unpredictability of emergencies; (7) Episodes per spell; (8) HRG weight, case mix index; (9) Proportion of patients under 15 years; (10) Proportion of patients over 60 years; (11) Proportion of female patients; (12) Student whole-time equivalents per spell; (13) Proportion of revenue spent on research; (14) Market forces factor; (15) Heated volume per bed; (16) Number of sites with more than 50 beds; (17) Scope/specialization index	United Kingdom
Sola M, Prior D.	2001	DEA and Malmquist Productivity Index	33 general hospitals	1990 and 1993	(1) Healthstaff: health care staff. This is made up of full-time medical and nursing personnel; (2) Otherstaff: other non-health care staff, also full-time; (3) Beds: number of beds assigned for the continuous care of patients admitted; (4) Materials: total value of current purchases in Spanish pesetas.	(1) Acute; (2) Longstay; (3) Intensive; (4) Visits; (5) Infections.	Spain, Cataluña

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Olesen O, Petersen N.	2002	DEA	70 hospitals	NA	NA	483 outputs in combination with a set of probabilistic assurance regions defined by the cost distributions for each output.	Denmark
Hofmarcher M, Peterson I, Riedel M.	2002	DEA	93 hospitals	1994-1996	(1) LDF-points; (2) Medical staff; (3) Para-medical staff; (4) Administrative staff; (5) Number of beds; (6) Number of wards	(1) Patient days; (2) Number of discharges	Australia
Biom E, Hagen T, Iversen T, Magnussen J.	2003	DEA	48 hospitals	1992-2000 (longitudinal)	(1) Physician full time equivalents (FTEs); (2) Other labour FTEs; (3) Medical expenses; (4) Total running expenses	(1) Inpatient care; (2) Outpatient care	Norway
Harrison J, Coppola M, Wakefield M.	2004	DEA	525 federal hospitals	1998 and 2001	(1) Operating expenses; (2) Hospital beds; (3) full time employees (FTEs); (4) Service complexity	(1) Admissions; (2) Outpatient visits	United States
Oullette P, Vierstraete V.	2004	DEA and Malmquist Productivity Index	Emergency rooms from 15 hospitals	1997-1998 1998-1999	(1) Non-physician hours worked; (2) Expenditure on furniture and equipment; (2) Number of stretchers; (3) Full-time equivalent number of physicians	(1) Number of cases	Canada
Wei C.	2006	DEA and Malmquist Productivity Index	110 hospitals	2000-2004 (longitudinal)	(1) Beds; (2) Physicians; (3) Paramedical personnel; (4) Registered nurses; (5) Staff	(1) Number of patient days; (2) Patients for operations; (3) Outpatient services	Taiwan
Balakrishnan R, Soderstrom	2006	SFA	311 general hospitals	1997-2001	(1) For-Profit hospitals; (2) Government hospitals; (3) System hospitals; (4) Teaching hospitals; (5) Licensed Beds; (6) Casemix Index; (7) LOS; (8) %Medicare; (9) %MediCal; (10) %Inpatient; (11) %ICU Days	(1) Raw utilization; (2) Scaled by average utilization; (3) Scaled by maximum utilization	United States. California
Cylus J, Dickensheets B.	2007	Measure multifactor productivity (MFP)	ND	1990-2005 1981-2005	(1) Operating expenses (payroll, fringe benefits, total labor, depreciation, rent, total capital, intermediate inputs)	(1) Paid Patient Care Net Revenue; (2) Unpaid Patient Care Revenues; (3) Non-Patient Care Operating Net Revenues; (4) Non-Patient Care Non-Operating Net Revenues.	United States
Barros C, Menezes A, Peypoch N, Solonandrasana B, Vieira J.	2007	Luenberger, Malmquist Productivity Index	51 hospitals	1997-2004	(1) Number of beds; (2) Full-time equivalent personnel; (3) Total variable costs	(1) Case flows (number of persons that leave the hospital); (2) Length of stay; (3) Number of consultations; (4) Number of emergency cases	Portugal

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
O'Neill L, Rauner M, Heidenberger K, Kraus M.	2008	DEA	79 studies	1984-2004	(1) Beds; (2) Clinical staff; (3) Non-clinical staff; (4) Working hours; (5) Services offered; (6) Costs; (7) Atypical and specific input categories	(1) Medical visits, cases, patients, and surgeries; (2) Inpatient days; (3) Admissions, discharges, and services; (4) Atypical, teaching, and specific output categories	12 countries: United States, Spain, Canada, Turkey, Kenya, Norway, Austria; Greece, Finland, United Kingdom, Taiwan, Sweden
Gannon B.	2008	DEA and Malmquist Productivity Index	6 regional hospitals, 8 general hospitals and 22 national hospitals	1995-1998	(1) Number of beds; (2) Full-time equivalent (FTE) people employed	(1) Number of discharges and deaths; (2) Outpatient attendance; (3) Day cases	Ireland
Ng Y.	2008	DEA and Malmquist Productivity Index	12 coast hospitals / 17 interior hospitals	2002-2005	(1) Number of physicians and nurses, (2) Other health staff; (3) Beds	(1) Number of outpatient visits; (2) Number of inpatient stays	China
Kirigia J, Emrouznejad A, Cassoma B, Asbu, E, Barry S.	2008	DEA and Malmquist Productivity Index	28 municipal hospitals	2000-2002	(1) Number of physicians plus nurses; (2) Number of beds; (3) Expenditure on pharmaceutical and non-pharmaceutical supplies	(1) Number of OPD visits; (2) Inpatient admissions	Angola
Nayar P, Ozcan Y.	2009	DEA	53 non-federal hospitals	2003	(1) Beds; (2) Operational expenses, not including payroll, capital or depreciation expenses; (3) Total full-time and part-time staff; (4) Total assets.	(1) Adjusted discharges; (2) Total outpatient visits; (3) Training full-time equivalents (FTEs).	United States. Virginia
Weng S, Wu T, Blackhurst J, Macklulak G.	2009	DEA and Malmquist Productivity Index	116 hospitals	2001-2005	(1) Number of beds available to serve patients; (2) Number of staff members in the hospital	(1) Average speed of treatment of acute care service; (2) Average speed of treatment of swing bed service; (3) Admission of acute care patients; (4) Admission of swing bed patients.	United States. Iowa
Simões P, Marques R.	2009	DEA	68 hospitals	2005	(1) Capital expenses; (2) Number of full-time employees (Staff); (3) Other operational expenses.	(1) Number of patients treated at hospital services; (2) Number of emergency visits; (3) Number of outpatients' visits.	Portugal

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Dash, U.	2009	DEA and Malmquist Productivity Index	29 districts head quarter hospitals	2002-2007	(1) Number of beds; (2) Number of nursing staff; (3) Number of physicians (surgeons)	(1) Number of inpatients; (2) Number of outpatients; (3) Number of surgeries undertaken; (4) Emergency cases handled; (5) Medical legal cases; (6) Deliveries	India
Salinas-Martínez A, Amaya-Alemán M, Arteaga-García J, Núñez-Rocha G, Garza-Elizondo M.	2009	DEA	47 family units	2004	(1) Percentage of man-doctor hours in care for patients with diabetes; (2) Percentage of family physicians using nutritionist support; (3) Percentage of family physicians using support.	(1) Percentage of patients with fasting glucose ≤ 130 mg / dL; (2) Percentage of patients with cholesterol < 200 mg / dL in the last laboratory report; (3) Percentage of patients with blood pressure $< 130/80$ mmHg at the time of the survey; (4) Percentage of patients considered to have received the care they were expecting from the family physician at the last control visit.	Mexico
Karagiannis R, Velenizas K.	2010	DEA and Malmquist Productivity Index	8 public hospitals	2002-2007	(1) Number of beds; (2) Number of doctors; (3) Number of nursing and other personnel	(1) Number of inpatient days	Greece
Lobo M, Ozcan Y, Silva A, Lins M, Fiszman R.	2010	DEA and Malmquist Productivity Index	30 hospitals	2003-2006	(1) Labor force (physicians and full time equivalent non-physicians); (2) Operational expenses; (3) Beds; (4) Service-mix	(1) Number of admissions; (2) Inpatient surgeries; (3) Outpatient visits	Brazil
Kristensen T, Bogetoft P, Pedersen K.	2010	DEA	36 public hospitals	2004	(1) Adjusted operational expenses	(1) DRG-value inpatients; (2) DRG-value grey zone patients; (3) DRG-value outpatients	Denmark
Biørn E, Hagen T, Iversen T, Magnussen J	2010	DEA	47 hospitals	1992-2001	(1) Physician FTEs (full-time equivalents); (2) Other labor FTEs; (3) Medical expenses; (4) Operating expenses To determine efficiency 1 (EF-1): (1) Costs with in-patient hospital services; (2) Costs with outpatients visits; (3) Costs with emergency services; (4) Costs with hospital day care services; (5) No. of beds; To determine efficiency 2 (EF-2): (1) No. of doctors; (2) No. of nurses; (3) No. of other personnel; (4) No. of beds.	(1) Inpatient care; (2) Outpatient care	Norway
Rego G, Nunes R, Costa J.	2010	DEA	83 hospitals	2002-2004		(1) No. of inpatient days; (2) No. of patients discharged; (3) Total no. of outpatient visits; (4) Total no. of emergencies; (5) No. of sessions in hospital day care services; (6) No. of surgeries.	Portugal

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Sahin I, Ozcan Y, Ozgen H.	2011	DEA and Malmquist Productivity Index	352 general hospitals	2005-2008	(1) Beds; (2) Physicians; (3) Nurses; (4) Other personnel; (5) Operational expenses	(1) Outpatients; (2) Inpatients; (3) Surgeries	Turkey
Chang S, Hsiao H, Huang L, Chang H.	2011	DEA and Malmquist Productivity Index	31 regional hospitals	1998-2002 1998-2004	(1) Number of physicians; (2) Nurses; (3) Supporting ancillary services personnel; (4) Patient beds	(1) Number of outpatient visits; (2) Number of ambulatory visits; (3) Number of emergency room visits; (4) Patient day; (5) Net inpatient mortalities	Taiwan
García-Rodríguez J, García-Fariñas A, Rodríguez-León G, Chaviano-Moreno M, Gálvez-González A.	2011	DEA	México: 37 medical units; Cuba: 20 medical units	2006	(1) Doctors; (2) Nurses; (3) Family practice clinics; (4) Non-censable beds;	(1) External consultations; (2) Reproductive health consultations; (3) Vaccines applied; (4) Chronic-degenerative detections; (5) Chronic patients in control; (6) Oral health activities; (7) Health promotion.	México, Cuba
Chua C, Palangkaraya A, Yong J.	2011	DEA	123 hospitals	1996/1997 - 2003/2004	(1) Full-time equivalent (FTE) doctors; (2) FTE nurses; (3) FTE registered and other nursing staff; (4) FTE administrative, domestic and other staff; (5) Expenditures on drug, medical and surgical supplies; (6) Number of beds	(1) Total weighted inlier equivalent separations; (2) Quality	Australia
Dimas G, Goula A, Soulis S.	2012	DEA and Malmquist Productivity Index	22 general hospitals	2003-2005	(1) Number of beds; (2) Total personnel salary; (3) Total expenditure on medicines, supplies, and other materials.	(1) Number of patient-days; (2) Number of patients in the outpatient department; (3) Number of emergency cases	Greece
Hu H, Qi Q, Yang C.	2012	DEA	31 province level hospitals	2002-2008	(1) Doctor; (2) Technician; (3) Staff; (4) Beds; (5) Fixed Capital	(1) Total number of outpatient and emergency room visits; (2) Total number of inpatient days; (3) Patient mortality; (4) Adjusted patient mortality	China
Tiemam O, Schreyögg J,	2012	DEA	99 for-profit hospitals; 33 non-profit hospitals; 133 control hospitals.	1997 through 2008	(1) Supplies; (2) Full-time equivalents; (3) Physicians; (4) Nursing staff; (5) Other clinical staff; (6) Administrative staff; (7) Nonclinical staff members	(1) Inpatient cases; (2) Number 1 minus the average in-hospital mortality rate.	Germany
Sulky S.	2012	DEA and Malmquist Productivity Index	81 hospitals	2001 to 2005	(1) Beds, (2) Specialist; (3) General practitioners.	(1) Outpatient visits; (2) Inpatient cases case-mix adjusted; (3) Total number of surgery; (4) Hospital mortality rate; (5) Bed occupation rate; (6) Average length of stay	Turkey

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Guerra M, Artur de Souza A, Rafael D.	2012	DEA	25 hospitals	2008	(1) Days of stay; (2) Occupancy rates; (3) Occupied beds; (4) Full-time equivalent; (5) Full-time equivalent to occupied beds	(1) Operating margin; (2) Return on assets; (3) Total asset turnover	Brazil
Nedelea I, Fannin J.	2012	DEA	36 rural hospitals	2005-2006	(1) Full time equivalent (FTE) facility personnel (labor input); (2) Total staffed and licensed hospital beds (a proxy for capital); (3) Input prices	(1) Outpatient visits; (2) Admissions; (3) Post-admission days; (4) Emergency room visits; (5) Outpatient surgeries and births. All hospitals: (1) Surgical inpatients; (2) Medical inpatients; (3) Surgical day patients; (4) Medical day patients DRGs; (5) Other DRGs; (6) Outpatients visits University hospitals: (1) DRG-adjusted surgical hospital cases; (2) DRG-adjusted medical hospital cases; Surgical day patients (3) DRGs Outpatients visits; (4) DRGs Postgraduate medical students: (5) Doctors under supervision; (6) No. of citations; (7) CWTS field normalised citation score; (8) Share of top 5% publications (1) Risk-adjusted predicted and observed mortality rates for AMI; (2) Congestive heart failure; (3) Pneumonia; (4) Risk-adjusted predicted and observed complication rates for cholecystectomy surgery (gall-bladder removal)	United States
Rehnborg C, Häkkinen U.	2012	DEA	Denmark: 64 hospitals; Finland: 245 hospitals; Norway: 290 hospitals; Sweden: 209 hospitals	Denmark (2002) Finland (1999-2004) Norway (1999-2004) Sweden (2001-2004)	(1) Operating costs in real value; (2) Teaching and research costs		Denmark, Finland, Norway and Sweden
Ferrier G, Trivitt J.	2013	DEA	1,074 hospitals	2005	(1) Hospital beds, (2) Full-time equivalent; (3) Registered nurses; (4) FTE licensed practical nurses; (5) FTE other labor, and medical residents.		United States
Mitropoulos P, Mitropoulos I, Sissouras A.	2013	DEA	96 general hospitals	2005	Economic model: (1) Expenses for HR; (2) Expenses for supplies; (3) Operational cost Production model: (1) Number of doctors; (2) Number of laboratory doctors; (3) Number of nurses; (4) Number of administrative staff	Both models: (1) Introduction in pathologic clinic; (2) Introduction in surgical clinic; (3) Number of surgeries; (4) Number of outpatient visits; (5) Laboratory examinations	Greece
Du J, Wang J, Chen Y, Chou S, Zhu J.	2014	DEA	119 acute-care hospitals	2006	(1) Beds; (2) Doctors; (3) Nurses; (4) TOE	(1) TOR; (2) Cases; (3) Survival rate	United States. Pennsylvania

Table 4.1. Overview of inputs and outputs used previously (cont.)

Author (s)	Publication Year	Methodology	DMU	Research Period	Inputs	Outputs	Country
Araujo C, Barros C, Wanke P.	2014	DEA	20 private for profit hospitals		(1) Hospital area (m ²); (2) Number of ICU beds; (3) Number of emergency beds; (4) Total number of hospital beds; (5) Total number of staff; (6) Number of doctors; (7) Number of nurses; (8) Number of doctor's offices in the hospital; (9) Number of surgical rooms	(1) Number of ordinary inpatients; (2) Number of ICU inpatients; (3) Number of emergency inpatients; (4) Total number of outpatient treatments; (5) Number of surgeries.	Brazil
Karagiannis R.	2015	DEA	53 public hospitals	1993 and 2002	(1) Number of beds; (2) Number of doctors; (3) Number of nursing personnel; (4) Number of administrative and other personnel.	(1) Inpatient days; (2) Number of laboratory tests.	Greece
Vadmanis V, DeNicola A, Bernet P.	2015	DEA	67 county health departments of Florida	NA	(1) Treatment expenditures; (2) Health services expenditures; (3) Treatment; (4) Health services FTE	(1) Number of clients treatment; (2) Number of clients health services	United States. Florida
Kang S, Kim M.	2015	DEA	34 regional public hospitals	2007 to 2010	(1) Number of doctors and nurses; (2) beds; (3) capital stock; (4) Tanbille fixed assets	(1) Adjusted number of paties; (2) Value added variables	South Korea
Chowdhury H, Zelenyuk	2016	DEA	113 acute-care hospitals	2003 and 2006	(1) Administrative staff hours; (2) Nursing hours; (3) Staffed beds; (4) Medical-surgical supplies costs; (5) Non-medical supplies costs; (6) Equipment expenses	(1) Ambulatory visits; (2) Case-mix weighted inpatient days	Canada. Ontario
Atlgan E.	2016	SFA	459 acute-care hospitals	2013	(1) Total Number of Physicians; (2) Total Number of Ancillary Medical Staff; (3) The total number of other employees; (4) Administrative and technical staff, including the contracting out personnel; (5) Total Number of Beds	(1) Total number of discharges; (2) Total number of patient days	Turkey
Fontalvo T, De la Hoz G	2016	DEA	44 hospitals	2010	(1) Inventory; (2) Assets; (3) Property and equipment.	(1) Net income	Colombia
van Ineveld M, van Oostrum J, Vermeulen R, Steenhoek A, van de Klundert, J	2016	DEA and Malmquist Productivity Index	65 hospitals	2005-2010	(1) Number of beds; (2) Operational expenses; (3) FTE (full time equivalent) physicians; (4) FTE non-physicians.	(1) Number of (inpatient) admissions; (2) Number of primary outpatient visits; (3) Day care treatment	Netherlands
Arfa C, Leleu H, Goaid M, van Mosseveld C.	2017	DEA	101 public district hospitals; 94 public district hospitals	2000 and 2010	(1) No. of physicians; (2) No. of surgical dentist; (3) No. of midwives; (4) No. of nurses and equivalents; (5) No. of beds; (6) Operating budget	(1) Outpatient visits in stomatology ward; (2) Outpatient visits in emergency ward; (3) Outpatient visits in external wards; (4) No. of admissions; (5) No. admissions in maternity wards	Tunisia

Table 4.2. Chapter's variables description

<i>Outputs</i>	<i>Inputs</i>
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; it does not include those that are in areas of technical and administrative support, research, and teaching.
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 (for regular use of patients, it must have the necessary space as well as material and personnel resources for patient care).
	x_4 : 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 4.3.

Table 4.3. Group's basic descriptive statistics: SHA hospitals and Non-SHA hospitals

SHA: CMH (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: INEGI (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

4.4. Results

4.4.1. 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 chapter, SHA are expected to improve efficiency. Results obtained for a DEA metafrontier model are presented in Table 4.4.

Table 4.4. *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 chapter 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.

4.4.2. 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 chapter, 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 4.5.

Table 4.5. 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 test²⁷ was applied to this results obtaining there is a significant statistical evidence between this 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.

4.5. 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 chapter 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.

Chapter's current findings show based on *TGRs*, that *CMH* private hospitals are more efficient than hospitals without an agreement based on results obtained similar

²⁷ WMW test results for operating rooms as fixed inputs is $z=2.349$, $p=0.018$; and for censable beds is $z=3.354$, $p=0.000$

to conclusions from Dranove, Durkac and 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.

This chapter has limitations to consider as well as future research extensions. The first limitation is that the information is provided by alliance members, although the alliance was formed in 2007 and has 36 hospitals currently, there are areas of opportunity to integrate and systematize the information under the same alliance policies to make a more objective comparison based on economic efficiency scores (*i.e.* accounting policies to recognize drugs sales in a surgical procedure, in some hospitals it is considered as part of the surgery, while in another it as a direct pharmacy sale). A second limitation is the inability to make comparison between efficiency and capacity utilization, due to lack of sharing information culture for analysis purposes between alliance members over time. The group control also has this obstacle because *INEGI* did not properly identify medical units over the years. A third limitation is the selection of control group that was carried out with basic descriptive techniques considering the assumptions of location and hospital type (general hospitals only). It is advisable to use sophisticated methods such as propensity score matching, observing statistical adjustments required.

4.6. References

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V. Conclusions

Universal health coverage is a fundamental purpose to reduce barriers in accessing health services. However population growth, especially in middle and low-income countries, increase in life expectancy which requires specialized treatments by healthcare providers, changes in epidemiological profiles arising from changes in lifestyles, financing schemes and payment services for public and private systems, as well as changes in health regulation to meet standards of quality and patient care, have a direct effect on public and private decision-makers, who need to measure and monitor the current efficiency of the hospital system for a better allocation of scarce resources.

The Mexican health reform has been an adequate policy to incorporate the non-salaried population through legislated access to a comprehensive package of health services (which gradually incorporates a greater number of diseases and medical procedures), which accounts around 57 million people that did not have access to any health system. The current government has made significant changes to continue the provision of hospital services through a public policy that seeks the coordination of resources between public health systems that were previously independent (*i.e.* *IMSS* and *ISSSTE*); extension of basic health coverage to every student enrolled in a public university; and maximizing the use of *IMSS* operating rooms. Although there are agreements by law for healthcare public-private partnerships, in practice very little have been done, due to lack of clarity in the operative and payment mechanisms, with almost no information available.

The major problems in healthcare system in México remain as the cluster of distinct sub-systems coexist, each offering different levels of care to different groups, with different outcomes, prices and financing mechanisms (OECD, 2016). Despite the fact that public health expenditure from 2000 to 2013 has increased by 269% (*Dirección General de Información en Salud*, 2016), México allocates fewer of its national resources to health than any other OECD country and evidence from

national health statistics indicators suggest that the money that is spent is not always used efficiently to achieve health gains (OECD, 2016).

Private hospitals have increased their presence in México healthcare system. From 2000 to 2010, public hospitals have grown by 12.6% and by 3.0% on censable beds; for the same period, private hospitals investments have grown by 41.0% and 28.6% respectively. At the end of 2013, México had 4,407 hospital units, of which 70% were private (*Dirección General de Información en Salud*, 2016). One reason for such happening may be dissatisfaction with quality or accessibility of services proved by public institutions to which individuals are affiliated, leading them to seek care from private health providers who have seen the potential of healthcare market. Middle and upper-class families acquire private health insurance policies, even when they are entitled to public healthcare, increasing the cost of overall system.

Literature review shows the existence of hospital efficiency studies mainly in industrialized countries (Hollingsworth, 2003, 2008), but also there have been detected studies in middle-income countries, particularly in Latin America (Lodoño and Frenk, 1997; Bertranou, 1999; Iriarta, Merhy and Waitzkin, 2001; Cavagnero, 2008; La Forgia and Harding, 2009; Cavegnero and Bilger, 2010). Research for México has focused on the qualitative assessment of the reforms implemented since 2003 (Knaul *et al.*, 2012), but there is only two quantitative research to measure hospital efficiency. The first by García-Rodríguez *et al.*, (2011) evaluates efficiency over hospitals located in Tabasco-Mexico and Cuba to identify better productive practices, but without making any comparison between the countries that operate in different environmental conditions. The second, Salinas-Martinez *et al.*, (2009) main objective is to quantify the technical efficiency of diabetes care in family practice settings, characterize the provision of services and health results, and recognize potential sources of variation.

This thesis is an explanatory, structured and quantitative research. Its main objective is to establish an empirical research into hospital efficiency for public and

private decision-making for the improvement of limited healthcare resources for the benefit of Mexican society, through the application of non-parametric frontier techniques. This evaluation aims to contribute to defining better public policies by identifying the best financing schemes as well as encouraging private hospitals participations to support possible initiatives for UHC.

In Chapter II, an efficiency comparison of health financing systems in México is made between global budgets, capitation and OOP payments. Considering that each financing system has its own characteristics, the concept of metafrontier was applied. This measures the closeness of the individual groups frontiers to the metafrontier by applying a technological gap ratios (TGR_r) for each group. From an empirical analysis, there is indication that the private hospital in México has greater efficiency with the resources that are available to maximize the outputs, given the economic incentive to managers and stockholders. This situation is not present in the public sector, due to manager's limitations from the point of view of restricted financing and the non-discretionary use of resources to maximize output. Based on this results, they support that private hospitals have the ability to succeed if changes occur in Mexican healthcare financing schemes if an independent institutional healthcare payer have this role based on hospitals efficiency (non-existent today, but it is within government's short term plans). On the other hand, public hospitals may have difficulties in competing for financing. Additionally, this could lead to public-private partnerships fostering quality care.

Chapter III focuses on the evaluation of Mexican private hospitals efficiency. The aim is to determine the presence of economies of scale by using a non-parametric method and then using a two-stage model for diversified and specialized hospitals for scope economies valuation. Results indicate that in Mexican private hospitals there is a marginal presence of scale and scope economies. It is recommended for managers to expand the size through organic growth, mergers, acquisitions or strategic alliances. Based on the results, it is necessary to analyze which is the best

mix of health services that can be incorporated into the hospital to achieve scope economies.

Chapter IV closes the empirical analysis of the thesis by developing a metafrontier analysis based on a recommendation of Chapter III, which is related to increasing the economies of scale and scope for private hospitals through a strategic hospital alliance (SHA). The objective is to evaluate the convenience for a private hospital to belong to an alliance in order to increase its efficiency. In addition, this chapter incorporates the valuation of the hospital capacity utilization (*HCU*) by hospitals affiliated to the alliance. Both objectives are compared with a control group. The results indicate that there is a favorable difference in efficiency for hospitals that are in a strategic alliance, so an implication from a manager's perspective is to evaluate this kind of agreements in addition to qualitative advantages, mainly by sharing best practices and training in specialized areas of interest. In the capacity analysis, the results showed that there is an improvement in installed capacity for hospitals in a SHA compared to the control group.

The fragmentation of Mexico healthcare system impedes the correct allocations of resources among public institutions creating operational inefficiencies that translate into a lack of patient care and poor quality. Private hospitals have seen this as an opportunity to offer their services to middle class, but the rising costs in health services require operating strategies that allow them to provide quality services in a timely manner without losing their business vision. This document finding reveals important information on opportunity areas to attain efficiency for hospitals and institutions on healthcare system in México. Most specifically, besides providing decisions makers (public and private) with information to help them understand how hospitals actually performs with available resources, it is possible to identify areas of opportunity that support the system design towards an UHC. Each chapter made a contribution to this general objective. A summary of the results can be seen in Table 5.1.

There are several limitations to this study: (1) The lack of consistent and reliable information for technical efficiency measurement for public and private hospitals, even when it is a government official databases (they were detected when comparing databases from different sources); (2) public health information is not available in time and is dispersed among many institutions that collect health information; (3) the inability to analyze an efficiency comparison over time, due to the fact that most decision making units are not well detected over time in databases (Malmquist index); (4) the inability to obtain income and/or expenses information to efficiently analyze allocation (these figures are usually presented by Federal State or global accumulation of the health system, but not at a hospital level); and (5) lack of efficiency analysis in México, do not allow comparison with other similar studies.

Future research for healthcare efficiency in México can take several paths. First, it is recommended to conduct efficiency studies over time incorporating the effect of public and private decision making for several years. Second, research could be done at the family medical units (DMU) from public sector, with quality variables and time of concentration due the impact of attention over population (there are 20,892 units overall in the health system at the end of 2013). Third, hospital efficiency analysis should integrate *Secretarías Estatales de Salud* (SESA) which are subject to the previsions and operational regulations of each State. Forth, hospital or department efficiency based on quality patient attention at each health sub-system. Fifth, analysis of hospital capacity utilization at each public health institutions. Sixth, evaluation of hospital efficiency by sharing resources among public health sub-systems (for example, from 2016 IMSS and ISSSTE have begun to share operating rooms in the care of their affiliates). And seventh, the evaluation of public-private health agreements that support the process of implementing universal health coverage.

Table 5.1. Summary of the main findings of the thesis

Chapter	Objective	Metodology	Study Year	Database	Theories	Main findings
II	To conduct an efficiency assesment according to financing schemes in a healthcare system.	DEA-Metafrontier	2013	606 public hospitals from IMSS, ISSSTE, ISSFAM, IFAI and DGIS databases; and, 182 private hospitals from INEGI database.	New Public Management	Empirical results also show that the hospitals in the private sector are relatively more efficient than public hospitals. The average efficiency scores show a slightly better performance of private or OOP (89%) than public hospitals operating under a global budget (86%).
III	To asses economies of scale and scope	DEA	2010	2,105 private hospitas from INEGI database.	Production theory: economies of scale and scope.	Results of the model employed show that there is a large variability in the efficiency scores among PMUs from 0.0584 to 1. The efficiency results indicate that within Mexican PMUs there is a marginal presence of scale and scope economics with only 1.76% and 1.80% respectively.
IV	To asses the efficiency of strategic hospital alliances and capacity utilization	DEA-Metafrontier; DEA-Capacity utilization	2014	29 private hospitals from an alliance-CMH; and, 47 private hospitals from INEGI database.	For alliances: Resource dependence theory and transaction cost economics. For capacity: Economic theory	Current findings based in TGRs, indicates that CMH private hospitals (97%) are more efficient than hospitals without an agreement (94%). The results on capacity utilization with operating rooms SHA obtain a higher rate (67%) than non-SHA (52%). With censable beds results indicate a better usage for SHA (85%) against non-SHA (70%)

5.1. References

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