Do healthcare financing systems influence hospital efficiency? A metafrontier approach for the case of Mexico

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Abstract

The objective of this article is to discuss the impact of healthcare financing systems on the efficiency of Mexican hospitals. The Mexican healthcare system is undergoing a process of transformation to establish conditions for allocating limited health resources in order to achieve efficiency and transparency; in this line, there is a concern about the implications of different funding options. In terms of financing arrangements, the Mexican health system is divided into three categories (one private and two public). In the framework of New Public Management theory, non-parametric metafrontier methods are used to estimate differences in efficiency of hospitals under different financing schemes, and in relation to the potential technology available in the healthcare system. Empirical evidence suggests that: 1) an out-of-pocket funding system, on average, incentivizes more efficient behavior; and 2) public funding seems to be the best option for complex and high-technology hospitals, and capitation appears to be the most appropriate way of negotiating their funding.

Keywords: Healthcare, Public Health Insurance, Regulation, Health Insurance, Public Expenditure, Policy Making

JEL codes: I18, I13, H51

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1. Introduction

The relationship between health financing schemes and hospital efficiency has attracted considerable research interest (Ozcan, Luke & Haksever, 1992; Bannick & Ozcan, 1995). In the last decades, many European countries have implemented market-based reforms through alternative systems of hospital financing (Leidl, 1998). As a consequence, several studies have measured the potential changes in technical efficiency over time due to new financing systems (Lopez-Valcarcel & Perez, 1996; Maniadakis, Hollingsworth & Thanassoulis, 1999; McCallion, Glass, Jackson, Kerr & McKillop, 2000; Sommersguter-Reichmann, 2000; Hofmarcher, Paterson & Riedel, 2002; Biorn, Hagen, Iversen & Magnussen, 2003; Blank & Eggink, 2014).

Parallel to the European experience, many countries in Latin America have also reformed their health care financing and delivery structures in an effort to improve equity and efficiency (Montenegro, Levcovitz, Holder, Ruales & Suárez, 2010). These reforms, as a basic principle, generally called for better resource allocation through market mechanisms (Vazquez, Vargas, Unger, Mogollón, Ferreira & De Paepe, 2009). This has driven governments to focus on the issue of evaluation and improvement of healthcare services, and to adapt new hospital management models (such as different forms of public-private partnerships) to develop appropriate policies. New Public Management (NPM) theory contains heterogeneous axioms that include some elements of new institutional economics (Buchanan, 1986; Williamson, 1981), agency theory (Jensen & Meckling, 1976), and property rights theory (Demsetz, 1967) and serves to evaluate such policies. Policymakers and theorists suggest that NPM-related policies may enhance efficiency by introducing criteria and methods from private sector management into traditional methods of public administration (Andrews & Van de Walle, 2013; Mayston, 1999). However, the real benefits of NPM in healthcare delivery have been inconclusive (Acerete, Stafford & Stapleton, 2012; Pollitt & Dan, 2013; Barlow, Roehrich & Wright, 2013; Alonso, Clifton & Díaz-Fuentes, 2015).

Mexico has also made significant progress in updating its public healthcare system through policy changes and has advanced significantly in terms of universal health coverage (UHC) as a result of the 2003 health reform. Mexican healthcare policies have helped to increase social protection for a greater number of citizens by incorporating NPM-type measures to improve the efficiency and quality of financing, as well as financial protection for households (Knaul & Frenk, 2005), but subsequent analyses have only been theoretical and descriptive, not quantitative (Knaul & Frenk, 2005; Knaul, Arreola-Ornelas, Méndez-Carniado & Miranda-Muñoz, 2006; Frenk, 2006; Frenk, González-Pier, Gómez-Dantés, Lezana & Knaul, 2006; Frenk, González-Pier, Gómez-Dantés, Lezana & Knaul, 2007). Despite this reform, growing healthcare system expenditure on hospitals and low healthcare productivity have triggered debate in Mexico about which strategies are needed to finance the health system and improve efficiency in delivery, while ensuring access to quality care. The central aim of the present study is to disentangle whether the different ways of financing Mexican hospitals, through health policies that incorporate basic characteristics of NPM, have an impact on their efficiency.

2. New Public Management theory and hospital efficiency

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 (Langenbrunner, Cashin & O'Dougherty, 2009; Niskanen, 1968; Weber, 1992; Du Gay, 2000; Jørgensen, 2011). However, problems with this model of administration began to appear in the early 1980s when centralized bureaucracies were viewed as monopolistic and inefficient by nature, suffering from problems of coordination and control arising from their excessive size and lack of flexibility (Ostrom, 1973; Dahl & Tufte, 1974; Simonet, 2015). To combat these problems, NPM policies have been introduced into public healthcare systems in most OECD countries in response to concerns about rising healthcare expenditures, medical and technological advances in health treatment, and an aging population (Simonet, 2013).

Although several studies have examined the impact of NPM on health systems in Europe and the United States (Anessi-Pessina & Cantú, 2006; Correia, 2011; Donnan & Katz, 2015; Mattei, 2006; Maynard, 1994; Moresi-Izzo, Bankauskaite & Gericke, 2010) few studies have explored the question of whether NPM leads to technical efficiency in hospitals. Ferrari (2006) analyzed the effectiveness of a competitive mechanism in the provision of hospital services, considering that competition would raise efficiency in hospitals. Jakobsen (2010) reviewed 12 studies to determine whether there is evidence that activity-based reimbursement improves efficiency in the Scandinavian hospital sector, finding the number of studies with positive and non-positive results to be approximately the same. Alonso, Clifton and Díaz-Fuentes (2015) evaluated NPM in a study of Madrid's public hospitals to compare efficiency in traditionally managed hospitals and those operating with new management formulas. They found no evidence that NPM hospitals were more efficient.

Table 1. Main characteristics of provider payment alternatives

Payment Method	**Retrospective or Prospective Cashin et al., (2005)**	**Payment based on**	**Payment steered by Kutzin (2001)**	**Main incentives created Maceira (1998)**	**Main Advantages Barnum, Kutzin and Saxenian (1995)**	**Main Disadvantages Barnum, Kutzin and Saxenian (1995)**	**Measures to Minimize Disadvantages Barnum, Kutzin and Saxenian (1995)**
Global Budget	Prospective	Inputs or outputs	Various criteria, e.g., negotiated contracts, patient 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.	· Predictable expenses for fund holder; low administrative costs. · Unified budget permits resources to be used efficiently.	· No direct incentives for efficiency. · Provider may under-provide services.	· 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.	· Predictable expenses for the fund holder. · Provider has incentive to operate efficiently. · Eliminates supplier-induced demand. · Moderate administrative costs.	· Financial risk may bankrupt provider. Provider may seek to minimize risk by "cream skimming"- accepting low-risk patients. · Provider may under-provide services.	· To minimize excessive provider risk consider capitation "carve outs" and adjusting capitated payments to reflect the underlying risks of the registered population. · Enforce contracts to ensure service provision.
Out-Of-Pocket	Retrospective	Inputs	Patient choice of provider; negotiation between provider and patient.	Incentives to increase units of service.	Strong incentives to operate efficiently.	· Unpredictable expenses for fund holder. · Cost escalating: strong incentives for supplier-induced demand. · High administrative costs.	

Source: The authors

Referring now to the potential impact of the financing scheme on levels of efficiency, and based on Barnum, Kutzin and Saxenian (1995), Maceira (1988), Kutzin (2001) and Cashin et al. (2005), Table 1 shows the characteristics of the three methods of financing in Mexican hospitals, the expected effect on efficiency, and the most important measures to reduce the disadvantages of each scheme.

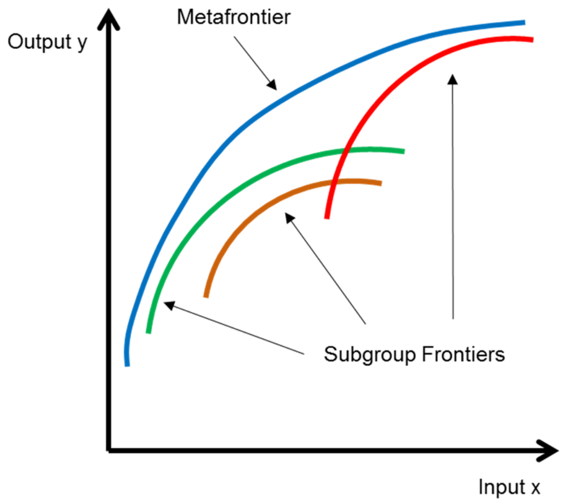
International experience shows that mixed financing systems are often combined, as in the case of Mexico. Joumard et al. (2010) propose a taxonomy of health systems based on the percentages of public and private participation. In some countries basic coverage is essentially private, as in the case of Germany, the Netherlands, Slovak Republic, the United States of America and Switzerland. Other countries, such as Australia, Belgium, Canada, France and, to a greater extent, Austria, Czech Republic, Greece, Japan, South Korea and Luxembourg, have some limited public participation in basic coverage. Finally, in other countries public participation in basic coverage is more developed; some examples are Iceland, Sweden, Turkey, Denmark, Finland, Mexico, Portugal, Spain, Hungary, Ireland, Italy, New Zealand, Norway, Poland and the United Kingdom. In this last group, some experiences are noteworthy. For example, Spain started with a global budget financing system, but has moved towards a capitation system due to the incentives it generates to improve costs and efficiency.

3. Methods

To analyze whether the different ways of financing Mexican hospitals impact on their efficiency we use the concept of metafrontier analysis introduced by Battese and Rao (2002), which ensures that heterogeneous hospitals are compared in a single homogenous group (Mitropoulus, Talias & Mitropoulus, 2015).

A metafrontier can be described as a function that envelops separate groups, each having their own technological characteristics (O'Donnell C, Rao D, Battese G. 2008). Efficiency is then calculated relative to both the metafrontier and the local subgroup. The ratio of these two efficiency scores is referred to as the technology gap ratio (TGR) (see Figure 1). This ratio measures the distance between the subgroup frontier and the metafrontier (Asmild, 2015).

Figure 1. Graphical representation of subgroup frontiers and metafrontier



Source: The authors

Let y and x be nonnegative real output and input vectors (of dimensions O and I, respectively). The meta-technology set contains all input and output combinations that are technologically feasible. Formally:

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

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

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

This is the boundary of this output set as the output metafrontier. It is assumed the output set satisfies the standard regularity properties listed in Färe and Primont (1995). Since the objective of this article is to measure efficiency, it is useful to represent the technology using the output meta-distance function, defined as:

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

Let us assume that the total number of hospitals in a healthcare system can be divided into K 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 meta-technology set, T. The input-output combinations available to hospitals in the *k-th* group area contained in the group-specific technology set are:

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

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

$$P^k(x) = \{ y: (x, y) \in T^k \}, \qquad k = 1, 2, \dots, K \tag{5}$$

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

The boundaries of the group-specific output are set by the group frontier. 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 technology gap ratio measures how close a group frontier is to its metafrontier and represents the restrictive nature of the production environment (Battese, Rao & O'Donnell, 2004). Let TE_r^k be the technical efficiency of a production unit *r* relative to its technology (frontier) k, and TE_r^M the technical efficiency of the same unit with respect to the metafrontier *M*. Therefore, the technology gap ratio (TGR_r) for unit *r* is computed as in Mitropoulus, Talias and Mitropoulus (2015):

$$TGR_r = \frac{TE_r^M}{TE_r^k} \tag{7}$$

TGR_r takes a value between zero and one and measures the ratio of the output for the frontier production function for the k group relative to the potential output defined by the metafrontier function, given the observed inputs. Therefore, the higher the TGR_r score, the higher the efficiency in operations that can be achieved.

The distance functions can be estimated by using different stochastic parametric methods, which assume the existence of a theoretical production function, such as Cobb-Douglas, translog or another form (Kumbhakar et al., 2015), and require the use of econometric techniques. Another approach would be to use non-parametric methods that build an empirical frontier from the observed data, without assuming any functional form. There are two main non-parametric techniques, depending on the assumptions on the convexity of the technology. The first, the Free Disposal Hull method (Thiry & Tulkens, 1992) does not require the convexity assumption. The second and most widely used, the Data Envelopment Analysis (DEA) methods, assume convexity. In this article, we use DEA methodology (Charnes, Cooper & Rhodes, 1978) since it has been widely used for analyzing the efficiency in the health care industry (Ozcan, 2014). DEA output-oriented technical efficiency scores keep inputs constant and explore the possible proportional expansion in output quantities (Banker, Charnes & Cooper, 1984). Since public health managers have no control over the size of the hospitals they run because investments in public hospitals are made through annual government budgets assigned by Congress, an output-oriented DEA model was selected. Previous research also shows that the most convenient alternative is to assume variable returns to scale (VRS) (Hollingsworth & Street, 2006; Sodani & Madnani, 2008; Asmild, Hollingsworth & Birch, 2013). Consequently, 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 & Street, 2006)[2]. To ensure that our data supported this technological assumption, we carried out a test (see Simar & Wilson, 2002) that confirmed VRS technology as the best technological assumption with a high statistical significance (p value = 0.000). Regarding the orientation, due to the growing demand for health care services, it is widely accepted that the output orientation (which determines the maximum potential increase in the outputs) is the most desirable orientation from the social point of view.

Therefore, for the group k consisting of data on r^k hospitals, the VRS output-oriented DEA problem formulation would be as follows:

$$
\begin{aligned}
& D^k(x,y) = \min_{\theta_r \lambda_r} \theta_r \\
& s.t.: \\
& \theta_r^{-1} y_r - y\lambda_r \leq 0 \\
& x\lambda_r - x_r \leq 0 \\
& j'\lambda_r = 1 \\
& \theta_r, \lambda_r \geq 0
\end{aligned}
\qquad (8)
$$

where:

y_r is the vector of O output quantities for the r hospital;

[2] In Mexico, decisions about investments and size of public hospitals are beyond the control of managers. For this reason, the efficiency of scale related to hospital size is not considered in our estimations.

x_r is the vector of I input quantities for the r hospital;

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

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

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

λ_r is an $(r^k x\ 1)$ activity vector;

θ_r is the distance function for hospital r .

The above model can also be applied for the metafrontier group by substituting the subindex r with M, where $M = 1, 2, \ldots, k, \ldots, K$.

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

4. Data and variables

Data were collected from various public databases available for the year 2013: *Instituto Nacional de Estadística y Geografía* (INEGI), *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 Mexicanas* (ISSFAM) and *Dirección General de Información de Salud (DGIS).* Additionally, databases from public health systems were requested from the *Instituto Nacional de Transparencia, Acceso a la Información y Protección de Datos Personales (IFAI).* The groups were structured according to their financing system:

i. *Global budget (G1)*. This group consists of public health agencies, which by law, must draw up a budget based on operational and investment needs to satisfy future economic context, the demographic transition of beneficiaries, and contingencies for epidemics.
ii. *Capitation (G2)*. This group consists of hospitals belonging to *Servicios Estatales de Salud* (SESA) in each state of Mexico. Following the reform of December 30, 2009, they are federally funded based on the number of people registered in the program.

iii. *Out-of-pocket* (*G3*). This group consists of private medical units providing hospitalization and outpatient services paid for by patients themselves.

Following this definition of the groups, the inputs and outputs required for the efficiency frontier models described earlier must now be selected. This selection is based on the literature review carried out by O'Neill et al. (2008).

The outputs are:

i. *Surgical medical procedures* (y_1). These procedures involve the removal, exploration, replacement, transplant, or repair of a defect or injury; or the replacement of tissue, or a damaged or healthy organ.

ii. *Total medical consultations* (y_2). A diagnosis is reached after examining the patient.

iii. *Days of stay* (y_3). The number of days from the patient's admission to their discharge, obtained by subtracting the discharge date from the admission date.

iv. *Hospital discharges* (y_4). A patient is discharged from hospital, emptying a licensed bed, after cure, improvement or transfer to another hospital unit, death, voluntary discharge, or escape.

The inputs selected are:

i. *Doctors in direct contact with the patient* (x_1). Health professionals with a degree and license who practice their profession or specialty providing direct care to patients.

ii. *Nurses* (x_2). Health professionals qualified to provide medical care to the sick and disabled consisting of health care and maintenance during illness and rehabilitation, assisting doctors, health diagnosis and treatment of patients.

iii. *Licensed beds* (x_3). The number of beds in the hospital for regular use by inpatients. The hospital must have the necessary space resources, as well as the material and personnel resources for the patient's medical care.

iv. *Operating rooms* (x_4). Hospital area, furniture, equipment and facilities required to perform surgical procedures.

Descriptive statistics are presented in Table 2, which reveals significant differences in size among hospitals, depending on the financial system. For instance, the largest hospitals appear under the publicly funded label, 'global budget' being both the predominant group of hospitals and including those with the largest size (the average number of licensed beds is 107). Capitation hospitals (the average number of licensed beds is 72) represent the second largest group; finally, out-of-pocket is the smallest group with the lowest size in terms of beds (23 licensed beds).

Table 2. Descriptive statistics: global budget, capitation, out-of-pocket and metafrontier.

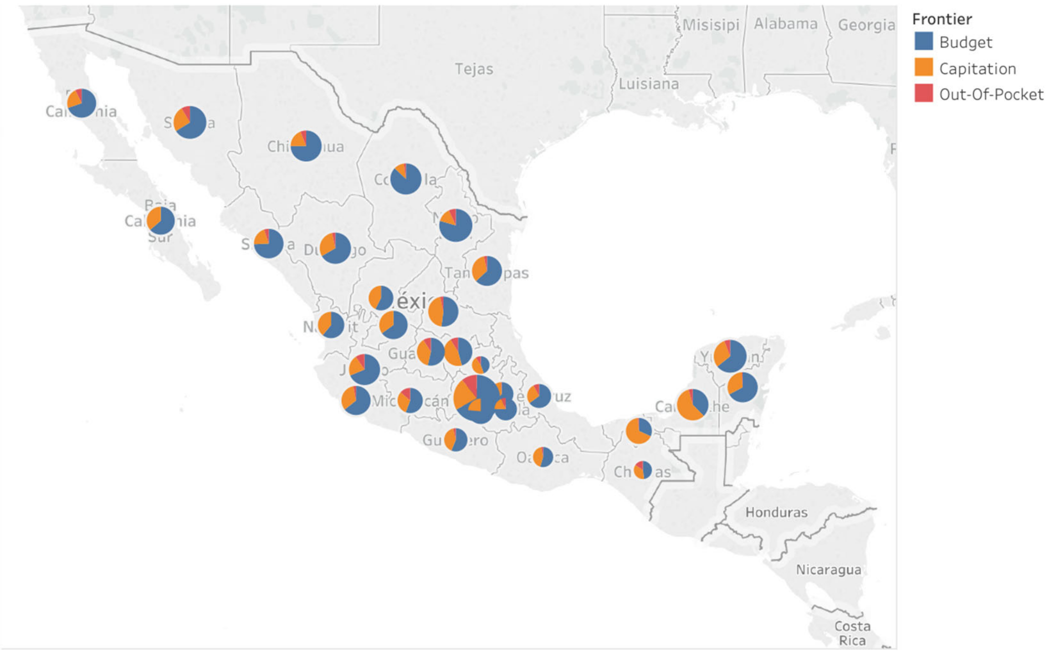
Global budget: ***IMSS, ISSSTE, ISSFAM*** **(n= 369** ***DMUs*****)**	**Mean**	**Std. Dev.**	***q1***	***q2***	***q3***
Outputs					
y1: Surgical medical procedures	4,409	4,103	1,001	3,127	6,659
y2: Total medical consultations	135,591	94,323	64,332	119,479	175,483
y3: Days of stay	29,845	30,183	6,809	19,787	42,701
y4: Hospital discharges	6,430	5,557	2,018	4,930	8,940
Inputs					
x1: Doctors in direct contact with the patient	144	137	45	96	194
x2: Nurses	250	231	70	178	369
x3: Licensed beds	107	104	30	73	149
x4: Operating rooms	4	3	1	3	5
Capitation: ***SESA*** **(n= 237** ***DMUs*****)**	**Mean**	**Std. Dev.**	***q1***	***q2***	***q3***
Outputs					
y1: Surgical medical procedures	4,633	4,949	775	3,469	6,693
y2: Total medical consultations	50,991	56,435	23,693	36,698	56,993
y3: Days of stay	23,288	28,828	2,239	15,567	36,030
y4: Hospital discharges	7,103	6,836	1,369	5,965	10,565
Inputs					
x1: Doctors in direct contact with the patient	120	155	28	66	158
x2: Nurses	188	210	40	112	297
x3: Licensed beds	72	94	13	31	108
x4: Operating rooms	4	4	1	2	5
Out-of-pocket: Private hospitals (n= 182 ***DMUs*****)**	**Mean**	**Std. Dev.**	***q1***	***q2***	***q3***
Outputs					
y1: Surgical medical procedures	971	1,187	124	431	1,493
y2: Total medical consultations	6,425	9,946	829	2,788	7,451
y3: Days of stay	5,189	7,511	662	2,796	6,152
y4: Hospital discharges	1,877	2,210	324	1,044	2,786
Inputs					
x1: Doctors in direct contact with the patient	34	70	5	14	33
x2: Nurses	26	58	2	4	22
x3: Licensed beds	23	37	5	11	24
x4: Operating rooms	3	2	1	2	3
Metafrontier (n= 788 ***DMUs*****)**	**Mean**	**Std. Dev.**	***q1***	***q2***	***q3***
Outputs					
y1: Surgical medical procedures	3,683	4,218	552	431	1,493
y2: Total medical consultations	80,314	89,985	829	2788	7,451
y3: Days of stay	22,178	28,003	662	2796	6,152
y4: Hospital discharges	5,581	5,818	324	1044	2,786
Inputs					
x1: Doctors in direct contact with the patient	111	138	5	14	33
x2: Nurses	180	216	2	4	22
x3: Licensed beds	77	96	5	11	24
x4: Operating rooms	3	3	1	2	3

Source: Authors' calculations.

These data exclude outliers to ensure they do not affect the efficiency coefficients. The first step was to review each group database from various information sources, eliminating all hospitals with missing data or values of zero. Secondly, we applied the command "adaptive computationally efficient outlier blocked nominators" (BACON) algorithm proposed by Billor, Hadi, and Velleman (2000) and analyzed by Weber (2010), to identify multivariate outliers. Finally, super-efficiency coefficients were calculated using DEA according to Wilson (1993); hospitals that presented coefficients less than 0.50 were eliminated.

As mentioned above, these data exclude outliers. Following Billor, Hadi, and Velleman (2000) and Wilson (1993) several procedures were carried out to neutralize their potential effect on efficiency coefficients.

Figure 2. Geographical presence of hospitals according to their funding



The reader can consult this interactive figure to access detailed information on each state at: https://public.tableau.com/profile/academic#!/vizhome/HCMS01_0/HCMS01?publish=yes

One interesting question is to determine the extent to which the geographical presence of hospitals according to funding system differs substantially among states. Figure 2 clarifies this issue by showing the number of licensed beds per number of inhabitants (in thousands)[3]. Several points arise from the figure:

1. Out-of-pocket appears to be the least important in most of the states, although it has a greater presence in the central states than in other areas.

2. Among the public types of financing, global budget is the most predominant, especially in the northern states.

[3] Tableau Public software was used for visual analytics

3. The presence of hospitals under capitation contracts is higher in the southern states.

5. Results

Table 3 shows the key summary statistics obtained for each of the groups and the metafrontier[4]. The average TE_r^k for the first group (global budget) is 0.86 and includes 93 efficient hospitals (25%). The capitation group frontier average score is 0.67 with 34 efficient hospitals (14%). The average score of the third group (out-of-pocket) is 0.89 with 72 efficient hospitals (40%).

Table 3. DEA descriptive statistics for groups' efficiency scores

Groups	***N***	***N*-Efficient**	**Mean**	**Std. Dev.**	**Min.**	**Max**	***q1***	***q3***
Global budget: *IMSS, ISSSTE, 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

Source: Authors' calculations

In this analysis, the global budget group had the lowest score with 0.71, meaning that this group has the greatest potential to increase the outputs that could be achieved using the observed input vector.

The empirical results also show that the private sector hospitals are relatively more efficient than the public hospitals; that is, they are closer to their respective frontier. The average efficiency scores show a slightly better performance of group 3 (private or out-of-pocket) (89%) than public hospitals operating under a global budget (86%). Although this difference is small, the Wilcoxon-Mann-Whitney (WMW) test was performed to confirm that these two groups (out-of-pocket and global budget) are the same in terms of technical efficiency.

Clear differences were found between the efficiency scores of private (89%) and public hospitals operating under a capitation agreement (67%). The WMW test results yield coefficients of z=7.911 and p=0.000, showing that the groups' global budgets and capitation are statistically different.

[4] R software was used to calculate the empirical results

The next step is to calculate a metafrontier by pooling all hospitals, but without taking into account the differences in financing schemes in the Mexican health system. Table 4 shows metafrontier scores (TE_r^M) ranging from 0.25 to 1.00, with 92 fully efficient hospitals out of 788 (around 12% of the total database). The largest proportion of fully efficient hospitals is found in out-of-pocket with 29%, followed by 7% for global budget hospitals and 6% for capitation hospitals. The least efficient group relative to the metafrontier is the capitation frontier. Overall, hospital efficiency in Mexico had a mean score of 0.65, implying that substantial areas of opportunity remain where efficiency can be improved.

Once the efficiencies of individual groups and the metafrontier have been calculated, the technology gap (TGR_r) can be obtained, which measures the distance of each hospital in a specific group frontier from a metafrontier.

Table 4. Metafrontier, group frontier and TE_r^M

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, 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

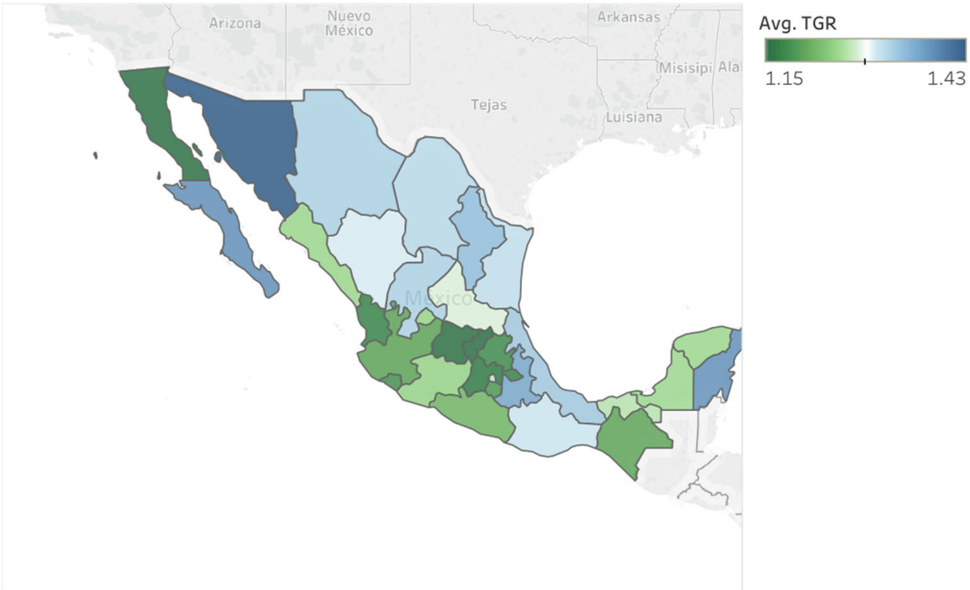
Source: Authors' calculations.

The WMW test for TGR_r between groups yielded the following results: global budget and capitation technological gap, z=7.321 and p=0.0000; global budget and out-of-pocket technological gap, z=8.511 and p=0.0000; capitation and out-of-pocket technological gap, z=8.511 and p=0.0000. The populations in each group comparison are different, which therefore provides evidence of statistical differences in their efficiency when they are classified according to their financing scheme.

The DEA results reveal that the average meta-technology ratio for global budget, capitation and out-of-pocket 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 Mexico (unrestricted technology without considering the financing system) 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 extremes: while hospitals that receive budget financing can produce 81% of the maximum output in relation to the metafrontier, hospitals in the out-of-pocket group are in full production of outputs.

Figures 3 and 4 provide additional information to describe the results more clearly. Figure 3 depicts the TGR by state, showing that the worst results are concentrated in northern states, excluding Baja California, and that the worst situation corresponds to the states of Sonora and Quintana Roo. The best performance is achieved in central states and most of the states of the Yucatan peninsula; the best results are found for the states of Baja California Colima, Estado de México, Guanajuato, Nayarit and Querétaro.

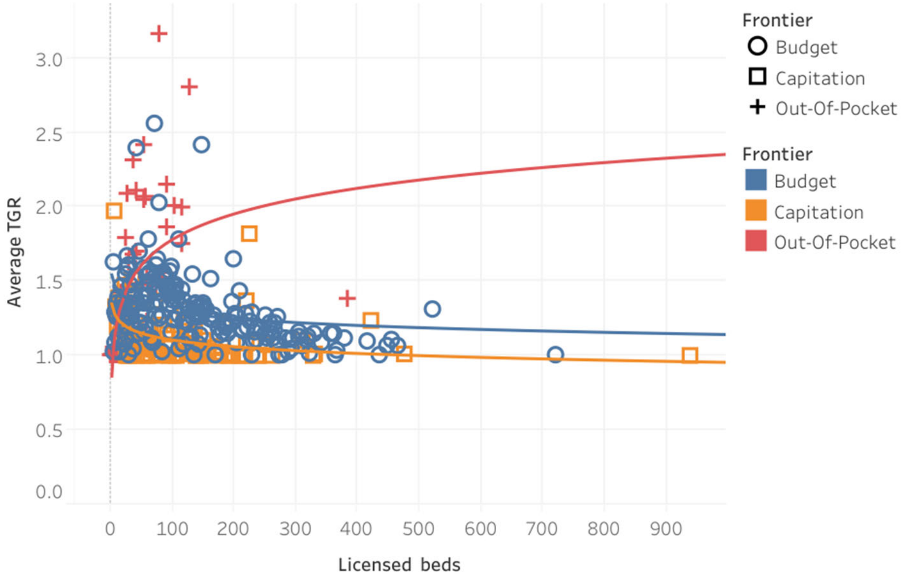
Figure 3. TGR by state



The reader can consult this interactive figure to access detailed information on each state at: https://public.tableau.com/profile/academic#!/vizhome/HCMS01_0/HCMS01?publish=yes

The visual analytics presentation gives the reader a more comprehensive picture of the results by state. For instance, although the presence of hospitals is similar in some states (see Figure 2), the distribution of inefficiencies appears to be diverse (as shown in Figure 3). This might be explained by the formal or informal quality of institutions (North, 1990).

Figure 4. TGR by hospital size



The reader can consult this interactive figure to access detailed information on each state at: https://public.tableau.com/profile/academic#!/vizhome/HCMS01_0/HCMS01?publish=yes

Figure 4 exhibits results by hospital size. For small hospitals (fewer than 150 licensed beds), the out-of-pocket funding system seems to operate more efficiently. For more complex and high-technology hospitals, public funding appears to be the best option, and capitation appears to be the most appropriate way of negotiating their funding. Unfortunately, the low presence of private hospitals prevents us from drawing more decisive conclusions on this question. From the information in Figure 4, we can infer that the predominantly public financing system (the global budget) is the least efficient in most of the states. Policymakers should take this into account to design a more efficient system in the future.

6. Conclusions and implications

The main motivation behind the vast literature on health financing systems across many countries is to measure the effect of financial reforms that impact healthcare. Countries studied include Argentina (Cavegnero & Bilger, 2010), Colombia (Bertranou, 1999), Spain (Antonanzas, 2013), Sweden (Dahlgren, 2014), the United States (Zweifel & Tai-Seale, 2009) among others, and regions like Europe (O'Reilly et al., 2012), Latin America Iriart, Merhy & Waitzkin, 2001), as well as international comparisons of healthcare systems (Wranik, 2012); however, empirical analysis of Mexico's efforts to achieve UHC is limited (Keith & Prior, 2014).

UHC requires a solid financing scheme for service providers, and even though there have been advances in Mexico's health system, funding is a strategic issue that has not yet been defined. NPM has provided the theoretical basis on which to establish the conditions for the portability of health services to introduce competition in pursuit of the optimization of resources by public and private hospitals. The results of this study suggest some guidelines for public policies that encourage efficiency in allocating public resources to the health system and define agreements that allow public-private collaboration to enhance the efficiency of the sector. In 2016, Mexico took the first steps towards universal health coverage by allowing the public health systems, comprising the *IMSS*, the *ISSSTE* and the *SESA*, to offer medical services. Initially, 700 medical services (those dealing with the most common medical conditions among the Mexican population) were included in the program, allowing the public health systems to take advantage of each other's infrastructure and medical equipment.

Our results highlight the importance for the Mexican health system of separating delivery of medical services from specific health financing functions. To be efficient, effective and transparent, policymakers should increase the capacity to objectively evaluate medical service providers' performance and grant them greater organizational and financial freedom to manage their budgets and planning systems. The efficiency of these changes would be subject to public scrutiny, which can easily be measured in terms of patient satisfaction and the introduction of performance agreements.

These results suggest that the out-of-pocket funding system, on average, generates incentives for more efficient behavior. This is particularly true for smaller sized hospitals. The direct implications of these results therefore appear to support the inclusion of more competition in the health care sector, which aligns with NPM proposals, especially in less complex treatments provided by smaller units. However, public funding seems to be the best option for more complex and high technological hospitals that treat the most severe pathologies– a finding that is probably influenced by the low presence of big private hospitals in our sample –and capitation appears to be the most appropriate way of negotiating their funding.

One of the limitations of 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 future research lines.

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