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Do Recovery Plans Improve Public Hospitals Efficiency and Productivity? Evidence from Italy

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The Italian National Health System has experienced a turnaround since 2007, following the development of formal regional recovery plans aimed at reducing healthcare expenditures in the public spending of the weakest regions. With the season of these recovery plans, the Italian Health System started a process of reorganization of the hospital sector. The purpose of this paper is to analyze the efficiency of Italian public hospitals for the period 2010–2013 and to study the effect of the regional recovery plans on the hospitals' productivity. Technical and scale efficiency of 41 public hospitals were analyzed using data envelopment analysis and Malmquist index. t-test was applied to compare hospital efficiencies across regions with and without recovery plans. Results showed that most of the Italian public hospitals were inefficient. They could improve their performance by reducing the amount of inputs used. Regional recovery plans have not improved hospital efficiency. However, compared to those without recovery plans, the mean efficiency of hospitals has not worsened. Thus, the reforms reached their aim of decreasing public health spending without weakening hospital efficiency.

Evaluating the effect of health system reforms on hospital efficiency is crucial for improving the efficiency of the entire healthcare system. This research contributes to the debate about this topic by offering evidence from the Italian context.

Field of Research: Hospitals efficiency and health reforms

Keywords: *Health reforms, Recovery plans, Hospital Efficiency, DEA Analysis*

1. Introduction

Starting in 1970, significant healthcare decentralization reforms have been undertaken in many European countries, with the aim of improving the efficiency and quality of healthcare services (Smith, 1997; Bossert, 1998; Saltman et al., 2006). Decentralization implies a transfer of financial or policy power from a central to a less central authority (Smith, 1997). Decentralized models and their practical implications vary among the countries according to the way health care systems are

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organized and financed (Saltman et al., 2006). Beyond the different solutions adopted, the topic of the healthcare decentralization continues to be explored in order to analyze the real consequences of decentralization processes and its real effect in terms of effectiveness and efficiency of the health system and health care institutions (Magnussen et al., 2007; Pavolini & Vicarelli, 2012).Indeed, even if decentralization has long been regarded as an important management strategy to improve health systems, the recent upsurge in countries that are, in effect, reversing the trend and beginning to recentralize key functions within their health systems raises new doubts about the real effectiveness of decentralization (Saltman,2008).In this context, evidence on the current status of efficiency and quality of healthcare systems is needed (Magnussen et al., 2007). This study contributes to this debate by offering evidence from the Italian context. Italy offers a relevant opportunity for study: in this country, the main effect of the process of decentralization of health care from the central government to the regions has been the creation of regional discrepancies in spending on health care. This has resulted in a significant cumulative deficit, mostly concentrated in a few regions. As a consequence, in 2007, the government imposed on those regions the implementation of Recovery Plans, which define a strategy for retrenchment and stabilization of costs through the implementation of short-term actions and long-term systemic reorganization (Pavolini & Vicarelli, 2012). With the season of Regional Recovery Plans (RRPs), the Italian National Health System (INHS) started a broad process of reorganization for local and hospital health services (Ferrè, 2015), generating, in fact, a re-centralization of healthcare services in favor of the central state. Although some studies have discussed the advantages and disadvantages of RRPs (Ferrè et al., 2012; Rossoet al., 2015), none of these have analyzed the effect of these tools and their correlation with public hospital efficiency and productivity. This is surprising, given that this reform process has involved the hospital sector broadly and altered the way in which Italian public hospitals operate, in particular with a view to resource savings. According to this, our study aims to fill out this research gap and to contribute to the debate regarding the effectiveness of cost containment strategies on the efficiency of health organizations by analyzing the effect of these tools and their correlation with public hospital efficiency. Specifically, our aim was to answer the following research questions:

- *What was the overall, pure technical and scale efficiency of Italian public hospitals in fiscal years 2010-2013?*
- *What is the effect of RRPs on hospital efficiency? Have the RRPs improved the efficiency and productivity of Italian public hospitals over the period 2010-2013?*

In order to analyze the efficiency and productivity of public hospitals, data envelopment analysis (*DEA*) and Malmquist index method were employed. The timeframe of the study was selected considering that the earliest RRP effects can be measured starting from 2010.Indeed, RRPs provide for the adoption of a series of measures to reduce healthcare expenditures, along with reorganization, redevelopment and upgrade interventions on the regional health systems, implemented over a three-year period. Therefore, for hospitals in regions involved in RRP from 2007, it is possible to evaluate the effects of these measures only from 2010; for hospitals in regions involved in RRP from 2010, 2013 is the year in which the effects of RRP can be observed. The next section 2 focuses on Literature

Review. In particular, we provide a brief literature review that includes the most cited literature published on the effects of healthcare reforms on the efficiency of hospitals during the last ten years. We conclude providing our research hypothesis. Section 3 discusses the evolution of Italian health care system. Section 4 contains methodology, introduces the data set, and describes the study variables. Section 5 provides the empirical findings of the efficiency analysis performed and presents a comparison between hospitals located in regions involved in RRP and those not involved in order to analyze the impact of RRP on hospital productivity. Section 6 discusses the conclusions, implications, and limitations of this study.

2. Literature Review

The past two decades saw a considerable increase in health care spending in all of the Organization for Economic Cooperation and Development (OECD) countries, leading many national governments to introduce different cost containment strategies (Cavalieri et al. 2018; Ferrè et al., 2012; Stabile et al., 2013; Murray et al., 2014).These policies were designed to achieve a more efficient use of health care resources and a waste reduction in order to meet cost containment goals (Hung& Chang, 2008;Stabile et al., 2013; Nunes & Ferreira, 2019), particular in the hospital sector (Nayar & Ozcan, 2008; Hung & Chang, 2008; Jiang et al., 2017; Nunes & Ferreira, 2019). As we know, the main reason is that hospital is one of the main organizations in health service system (Torabipour et al., 2014; Jiang et al., 2017): it is the main consumer of resources in health sector and imposes higher costs on the health system compared to the other health system components (Torabipour et al., 2014). For these reasons, the improvement of their efficiency is the main way to decrease the cost of entire health system (Torabipour et al., 2014).According to this, health reforms have largely involved the hospital sector with a serious of actions aimed to improve their operational efficiency (Jiang et al., 2017; Zhang et al., 2018), by optimizing the use of the resources available and avoiding waste (Nayar & Ozcan, 2008; Stadhouders et al., 2016), and resulting in lower costs. Examples of these actions are:

a) Cuts in the number of hospital beds. Bed capacity has been reduced in all EU countries in the past two decades and this reduction will need to continue in future in virtually all EU countries to avoid building up over-capacities, which are substantial in some countries already now;

b) Reduction in the number of physicians (Stabile et al., 2013; Lippi & Mammi, 2017), or freezing of personnel turnover policies (Cavicchi & Vagnoni; 2017);

c) Hospital rate setting is another good example of a cost containment strategy designed to control the price of services provided, focusing on promoting the efficient production of services in one of the most costly sectors of the health care market.

Rate setting is designed to impose limits on hospital revenues, making hospitals operate within a constrained budget. In synthesis, for hospital sector, health reforms have initiated from 2000s a process of transformation to establish conditions for allocating limited health resources in order to achieve efficiency (Stadhouders et al., 2016; Giménez et al., 2019). According to this, literature about cost containment builds up from 2000 with a particular attention towards the impact of these policies on hospitals efficiency (Cavalieri et al., 2008; Stadhouders et al., 2016).In particular, many studies(van Ineveld et al., 2016; Jiang et al., 2017; Giménez et al., 2019) were aimed to evaluate hospitals efficiency before and after the healthcare reform, and further assess the reform effectiveness through the comparative analysis of the efficiency. In some cases, no significant effects of health reform on development in performance of hospitals were seen (van Ineveld et al., 2016, Nunes & Ferreira, 2019): studies found that health reform had not well improved hospital efficiency although hospitals gained a fair developing scale and the corresponding policies and measures should have been implemented to improve efficiency, especially in the level and structure of health investment, operation and supervision mechanism of hospitals (Jiang et al., 2017). On the contrary, recent studies showed a positive effect of the health reforms on hospitals efficiency (Cavalieri et al., 2008; Gimenez et al., 2019). Despite this, studies found an efficiency gain only in the first several years of the reforms, followed by a decrease. In synthesis, the impact of the reform on efficiency was in many cases temporary, and studies suggests to policy makers to reflect on the reasons behind the efficiency decrease (Zhang et al., 2018).Despite this, some studies confirmed that the improvement of hospitals efficiency contributes to the reduction of costs for the entire health system (Chen et al., 2016).Finally, the improvement of efficiency in the hospital sector also appears to have an effect on the quality of care. In particular, evidence suggested that the relationship between efficiency and quality of service responded appropriately to reforms (Alonso et al., 2015; Giménez et al., 2019). In conclusion, it is clear that the debate on the effect of the health reforms on the efficiency of hospitals did not generate agreement between the various experts and academics (Nunes & Ferreira, 2019).Despite this, evaluating the effect of health system reforms on hospital efficiency is crucial for improving the efficiency of the entire healthcare system and, therefore, further studies are still needed. This study contributes to the debate on this topic, offering evidence from the Italian context. Our hypotheses starts from the assumption that the hospitals are the main consumer of resources in any health sector; thus, improvement of their efficiency is the main way to decrease the hospital costs and, as a consequence, the cost of entire health system (Torabipour et al., 2014). According to this, our research hypothesis is the follow:

H1: cost containment strategies, if well-designed, could contribute to reduce the healthcare spending without degrading the efficiency of hospitals (Stadhouders et al., 2019).

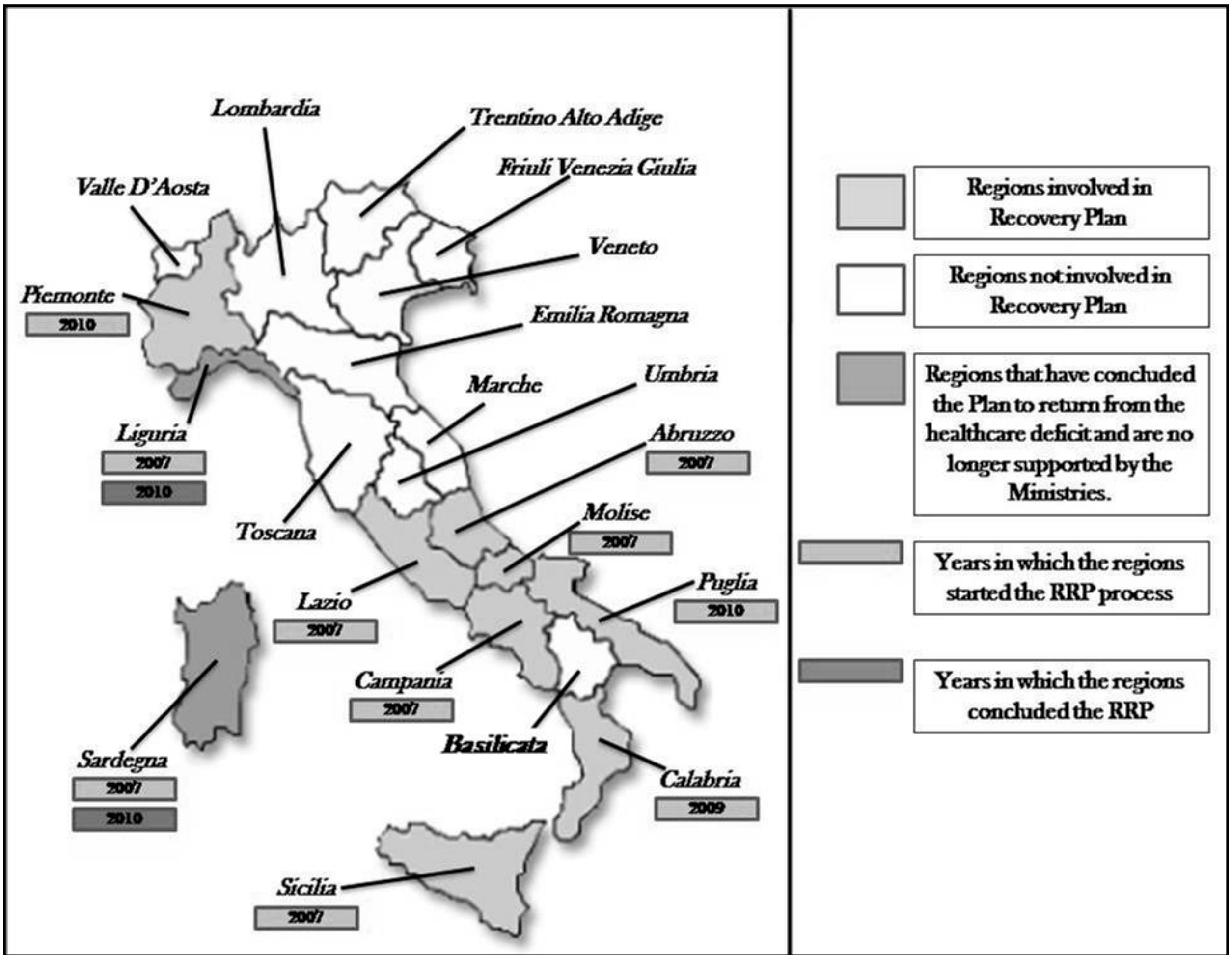
3. The Italian Case

Over the last three decades, the INHS has been gradually but substantially transformed (Del Vecchio & De Pietro, 2011), switching from a centralized system (80’s) to one characterized by the devolution of control to the regional level (90’s) (Ferrera, 1995).

The central government is concerned with the definition and management of basic health objectives, while the regions have the task of developing regional health plans and defining their health care priorities. As a result, since 2001, the regions have become more fiscally autonomous and more financially responsible for the organization of health care services (Ferrè et al., 2012).The main effect of the decentralization process has been the creation of 21 local health systems with significant differences in terms of outcome, resources allocation and health expenditure. In particular, a significant imbalance in health expenditure levels among regions has resulted in considerable health budget deficits in 10 out of the 21 regional health systems (Mladovsky et al., 2012).As a consequence, since 2007, the central government has obliged those regions to adopt RRPs with the aim of reducing their public healthcare and increasing efficiency (Karanikolos et al., 2013) (Figure 1).

The national Minister of Health (MoH) appointed a Commissioner to pursue the central government's targets, thus overriding many of the powers of the regional governments. With the season of RRPs, the INHS started a broader process of reorganization for local and hospital health services (Ferrè, 2015). In this regards, specific tools for rationalizing and limiting regional expenditure were: initiatives of institutional rationalization, or reintegration, through mergers of health facilities (Fiorani et al., 2014); definition of more stringent standards in terms of bed allocation (3.7 PL per 1000 inhabitants) and hospitalization rates (180 per 1000 inhabitants) (Lippi and Mammi, 2017); and freezing of personnel turnover policies (Cavicchi and Vagnoni, 2017).

Figure 1: Italy's Map: RRP and Non-RRP Regions (December 2017)



Source: Our creation. *Note:* Calabria's RP was initiated in 2009 and provided for interventions implemented from 2010-2013.

Table 1 summarizes some of the effects of RRPs on the Italian health system organization.

Table 1: Effect of RRPs

	2007	**2016**
Number of Italian AO*	95	71
Number of Italian ASL**	183	121
Number of Beds	232,160	190,000
Hospitalization rate per 1000 inhabitants	141,33	115,8
Total deficit spending of Italian regions with recovery plan	*Cumulative deficit spending*	*Cumulative deficit spending*
	(BL €) 4.1	*(BL€)* 0.3

* AO: Aziende Ospedaliere, which is an Italian public hospital. Teaching hospitals are included (AOU: Aziende Ospedaliere Universitarie).
** ASL: Azienda Sanitaria Locale (ASL), which is a local health authority.
Source: Adapted from "Osservatorio sulle aziende del sistema sanitario italiano" - Rapporto Oasi, 2016; Monitor, Anno XV number 40 • 2016, Quarterly Agenzia nazionale per i servizi sanitari regionali; SIVEAS; Ministry of Health Website; Open data ISTAT website, 2016.

In this context of structural change, the Italian public hospital sector provides an interesting case for studying and assessing the determinants of hospital efficiency.

4. Methods and Data

In this section, the data set is first introduced, then we consider available techniques for measuring efficiencies and explain why we chose DEA methodology. Following this, the DEA and Malmquist index method are described in detail. Finally, the input and output variables are presented.

Starting from the introduction of the data set, from 2010 to 2013, the number of public hospitals in Italy declined from 63 to 58 (Table2).For reasons related to the need to conduct the analysis over a period of 4 years and to ensure data consistency, as a result of an agreement among the authors, we considered public hospitals present throughout the period, thus excluding those that were subject to aggregation processes and mergers (5) during the four years. For the same reasons, we also excluded hospitals for which data regarding the input and output of selected variables(see section *Input and output*) were unavailable (17). After this selection, our final sample was composed of 41 public hospitals.

Table 2: Composition of the Public Hospital Sector and Sample Selection

	Years				
Regions	2010	2011	2012	2013	N of AO included in the efficiency analysis*
Basilicata	1	1	1	1	1
Calabria	3	3	3	3	3
Campania	8	6	6	6	5
Emilia Romagna	1	1	1	1	1
Friuli Venezia Giulia	1	1	1	1	1
Lazio	3	3	3	3	3
Liguria	1	1	0	0	0
Lombardia	29	29	29	29	20
Marche	2	2	2	2	0
Piemonte	5	5	5	3	3
Sardegna	1	1	1	1	1
Sicilia	5	5	5	5	3
Umbria	2	2	2	2	0
Veneto	1	1	1	1	0
Total number of AO	63	61	60	58	41

** Regional public hospitals for which data were unavailable were excluded*

Of these, 23 were located in regions not involved in RRP (56,09%) and 18 in regions in RRP (43,9%) (Table 3).

Table 3: Hospitals Sample

Region	***Context***	***N. of Hospitals***	***ID Hospital***
Lombardia	Not involved in RRP	20	1 – 20
Emilia Romagna	Not involved in RRP	1	35
Basilicata	Not involved in RRP	1	38
Friuli Venezia Giulia	Not involved in RRP	1	39
Campania	Region in RRP	5	21, 23, 31, 33, 40
Sicilia	Region in RRP	3	22, 24, 32
Lazio	Region in RRP	3	25, 28, 30
Piemonte	Region in RRP	3	26, 27, 41
Calabria	Region in RRP	3	29, 34, 37
Sardegna	Region in RRP*	1	36

[*] For the purposes of our study, Sardegna was included among the regions in RRP, despite the fact that it concluded the RP in 2010.

4.1 Analysis Techniques

Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are the principal methodologies most commonly implemented for the measurement of the efficiency and productivity of health care systems and healthcare providers, as is found in systematic literature reviews (Hollingsworth 2003 & 2008, Worthington, 2004, Hussey et al., 2009). Hollingsworth (2008) figures that 74 per cent of the studies in the literature apply DEA; indeed 48% use DEA alone, 19% apply some regression analysis and around 7% apply other methodologies along with DEA. Furthermore, SFA and other parametric frontier methodologies account for 18 per cent of studies and Malmquist index based productivity methods are found in 8 per cent of the related studies. Generally speaking, the index number methods implicitly assume that all decision units (e.g. hospitals) are fully efficient (Coelli et al., 2005). However, DEA and SFA methodologies relax this assumption and estimate frontier functions to compare the efficiencies of decision units with respect to the fitted frontiers. Both DEA and SFA methodologies have their well-documented advantages and disadvantages (Banker, Charnes and Cooper, 1984; Charnes, Cooper and Rhodes, 1978; Coelli et al, 2005; Peacock et al., 2001). DEA is a linear programming method applied to obtain nonparametric frontiers regarding calculated efficiency measures, while SFA is an econometric method that allows deviations from the frontier not only because of inefficiencies but also because of the stochastic error terms. SFA requires model specification for frontier functions and distributional assumptions on inefficiency and error terms. Indeed, while SFA uses one single output, the DEA method can handle multiple inputs and outputs simultaneously (Coelli et al., 2005; Rosko and Mutter, 2008).In this study, according to our aims, we chose the DEA approach and Malmquist Index, for some specific reasons: first of all, the healthcare sector in general and hospitals in particular represent a main application area for DEA (Nunamaker, 1983; Hollingsworth, 2008; Liu et al., 2013;Kohl et al., 2019; Yildirim et al., 2019). DEA program is thought as one of the productive projects that add to the estimation of performance efficiency amongst hospitals (Torabipour et al., 2014; Cook et al., 2014; Khalaf et al., 2019).Another reason is related with the complex nature of the productive process of healthcare structures, one of the main reasons that the measurement of efficiency in healthcare is a difficult exercise (Zere et al., 2006). Indeed, hospitals use multiple input and produce many output (Zere et al., 2006). From this point of view, DEA is particularly suitable for analyze the efficiency of hospitals because it easily accommodates multiple inputs and outputs without the requirement for a common denominator of measurement (Jacobs, 2001; Zere et al., 2006). Furthermore, it provides specific input and output targets that would make an inefficient hospital relatively efficient. It also identifies efficient peers for those hospitals that are not efficient. This helps the inefficient hospitals to emulate the functional organization of their peers so as to improve their efficiency (Zere et al., 2006). Thus, DEA is a very useful technique for hospital administrations seeking to identify opportunities for performance improvement (Nayar & Ozcan, 2008).Also, in the presence of good panel data for a sufficiently longer period of time, DEA-based MPI allows to observe the changes in efficiency and those changes in productivity that are accounted for by technological change (Zere et al., 2006). This is particularly important when you want to analyze the effects over time of health care reforms on the hospital efficiency (Sahin et al., 2011; Sulku, 2012; Yildirim et al., 2019; Kohl et al., 2019).In the following subsections, we introduce DEA and Malmquist productivity index in detail.

4.2 DEA Analysis

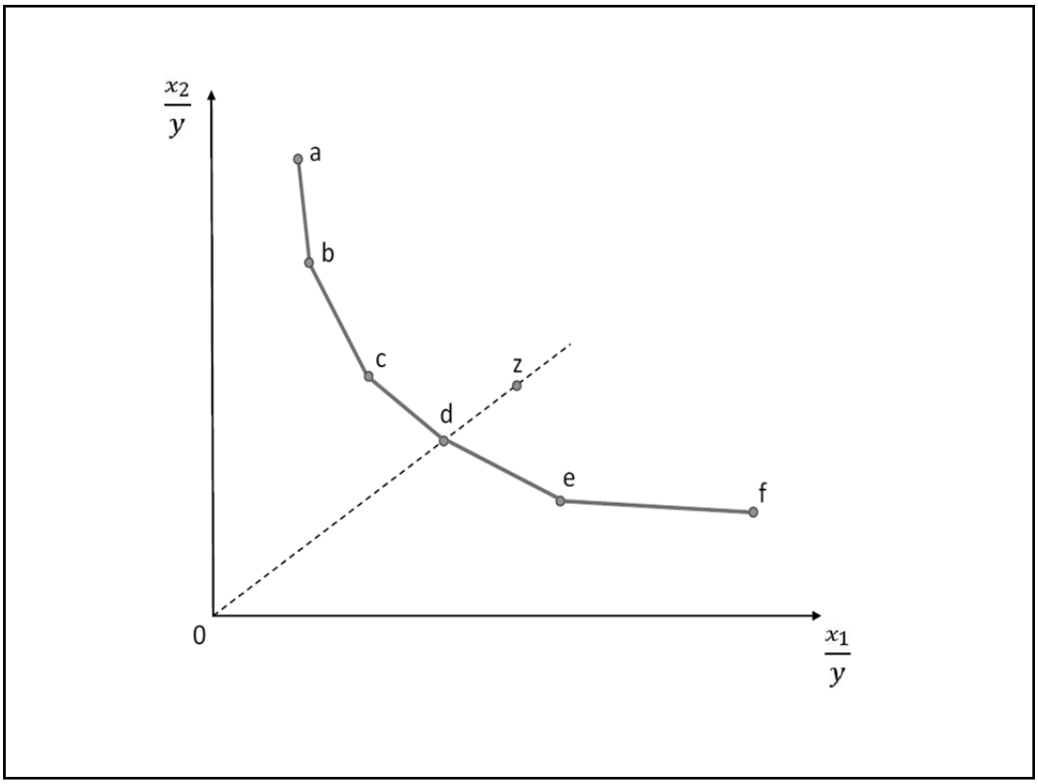
The first aim of this study is to measure the technical and scale efficiency of our sample of hospitals. To achieve this aim, we performed the DEA.DEA is a non-parametric, mathematical programming technique (Charnes, 1978), which measures the relative efficiency of a set of similar decision-making units (DMU) in the presence of multiple inputs and outputs. DEA allows us to identify which units operate efficiently, and therefore belong to the efficient frontier, and which of them do not, and should hence make appropriate adjustments in their outputs or inputs in order to increase their efficiency. The technical efficiency index of one DMU is in the form of an output-to-input ratio. Accordingly, DEA models can be either input or output-oriented. In the former case, technical inefficiency is defined as the proportional reduction in input usage achievable when output set is constant.

In the latter case, technical inefficiency is defined as a proportional increase in output with given input levels. In our study, we used an input-oriented approach in order to examine whether the hospital units increased or decreased the amount of resource input while keeping the level of output constant. Indeed, according to input oriented DEA, for a given amount of outputs, the units using lower amounts of inputs will be more efficient. In order to illustrate this, figure 2 shows different DMUs, given the set of units (A, B,C, D, E, F, Z) that use two inputs (x_1 and x_2) to produce a single output (y) (Coelli, 1996). Knowledge of the quant of the fully efficient unit, represented by the curve in the figure, offers the measurement of technical efficiency. If a given unit uses quantities of inputs, defined by the point z, to produce a quantity of output, the technical inefficiency of that unit could be represented by the distance dz, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is expressed in percentage terms by the ratio dz/oz, which represents the percentage by which all inputs could be reduced. The technical efficiency (TE) of a unit is most commonly measured by the ratio

$$TE_{\textit{input oriented measure}} = od/oz$$

which is equal to one minus dz/oz. It will take a value between zero and one (Coelli, 1998), and hence provide an indicator of the degree of technical efficiency of the unit. A value of one indicates that the unit is fully technically efficient. For example, the point d is technically efficient because it lies on the efficient isoquant.DEA models may either assume constant returns-to-scale (CRS) (Charnes et al., 1978), or variable returns-to-scale (VRS)(Banker, 1984). The CRS score captures global (in)efficiency, whereas the VRS and ‘‘scale” scores break down the global score into pure technical efficiency and scale efficiency respectively (Coelli, 1998).The comparison between CRS and VRS models allows for the identification of which decision units operate at increasing, decreasing or optimal scale conditions. Both models have been applied in our study.

Figure 2: Illustration of Input Oriented DEA



Source: Our elaboration, following Coelli (1996)

4.3 The Malmquist Index

Productivity measurement is an important research topic of DEA. A useful approach for productivity measurement in DEA is the Malmquist productivity index (MPI)(Caves,1982). The MPI calculates the relative performance of a DMU at different periods of time using the technology of a base period.MPI allows us to identify a) technical efficiency change (EFFCH); b) technological change(TECHCH); c) pure technical efficiency change (PEFFCH); d) scale efficiency change (SECH); e)total factor productivity change(TFPCH).

In formal terms:

$$m_0 = \left(\frac{d_0^{t+1}(x^{t+1}, y^{t+1})}{d_0^t(x^t, y^t)} \right) \times \left[\frac{d_0^t(x^{t+1}, y^{t+1})}{d_0^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_0^t(x^t, y^t)}{d_0^{t+1}(x^t, y^t)} \right]^{1/2}$$

where m_0 represents the MPI, d_0 and d_0^{t+1} represent the distances between hospital annual data and national production frontier at the time t and $t+1$, and (x^t, y^t) and (x^{t+1}, y^{t+1}) represent the Cartesian coordinates associated with inputs and outputs at times$t$ and $t+1$.

A value greater than one will indicate the positive total factor productivity growth from period t to period t+1. On the contrary, if the index is less than 1, the productivity has decreased, and if the index is equal to 1 then no productivity change has occurred.MPI of productivity change (TFPCH) can be used to measure productivity changes and to break down this productivity change into technical efficiency change (EFFCH) and technological change (TECHCH), as follows: TFPCH = EFFCH x TECHCH. We first examine MPI from the DEA approach to reflect the average productivity changes of the DMUs over time.

4.4 Input and Outputs

The application of DEA requires, first of all, the definition of outputs and inputs, described in Table 4. The dataset was compiled from various sections of the 2010/2013 Ministry of Health (MoH) website. Data were used as reported, without any processing or manipulation.

Table 4: Definition of Study Variables

Variables	Definition	Measurement	Data Source
		Input Variables	
BEDS	Beds	Total number of ordinary, day hospital and day surgery hospital beds during the period 2010-2013	MoH Website 2010/2013
STAFF	Hospital Staff	Total number of doctors, nurses, administrative personnel, other personnel.	MoH Website 2010/2013
		Output variables	
INPATIENT DISCHARGES	Discharges	Total number of inpatient discharges during the period 2010-2013	MoH Website 2010/2013

As a measure of hospital input, we used two variables: a) the number of hospital staff and b) the number of beds. These input variables offered a good measure of the capital used in hospital production (Santías et al., 2011). As a measure of hospital output, we considered the total number of inpatient discharges in each year. This choice was justified by the reasons expressed below. First, the availability of data: the MoH website provided the total number of discharges for each public hospital, as well as the average length of stay (ALOS) and the day of hospitalization. These variables are very strongly correlated. The number of discharges, for example, directly determines the ALOS. Secondly, the number of discharges is among the most common measures used in empirical studies testing the technical efficiency of hospital production (Hollingsworth et al., 1999).Finally, one of the aims of the RRP is to reduce the number of "inappropriate" admissions. Hospitals are called to manage complex cases, while territorial assistance, through a reorganization process, is called upon to effectively manage specialist and outpatient care (MoH Website, 2011).For these reasons, we agreed that this output variable could help us capture a significant part of the hospital activities, even if it does not reflect the entire production process.

5. Results

5.1 Descriptive Analysis of Input and Output Variables

Table 5 presents the descriptive statistics for inputs and outputs variables for our sample.

In the RRP regions, both the average number of health personnel and hospital discharges decreased during the period analyzed. For non-RRP regions, the mean number of hospital discharges also decreased, but unlike RRP regions, the average number of health personnel kept increasing during the period. This can be explained by the freezing of personnel turnover, which reduced health personnel units in RRP regions. The average bed size also decreased in both groups of regions.

Table 5: Descriptive Statistics of Study Variables

Years		**2010**			**2011**		
		Inputs		Output	Inputs		output
Regions		Personnel	Beds	Discharges	Personnel	Beds	Discharges
Not in RRP	Mean Std.er	2,498.82 (818.15)	546.86 (244.35)	26,325.17 (7,727.13)	2,532.3 (821.78)	556.21 (257.09)	26,023.52 (7,437.43)
	Min	787	245	10752	758	244	11009
	Max	3834	1213	42493	3888	1215	41495
in RRP	Mean Std.er	2177.5 (853.23)	667 (197.07)	22,705 (7,997.909)	2163.83 (770.769)	672 (200.458)	22,055.9 (6,671.591)
	Min	1,145	288	13,447	1399	321	13772
	Max	4,569	1,043	43,661	4375	1,012	39488
t-test*	t-stat	1.2248	-1.6991	1.4662	1.4637	-1.5754	1.7723
	p-val	0.228	0.0973	0.1506	0.1513	0.1232	0.0842
Years		**2012**			**2013**		
		Inputs		Output	Inputs		output
Regions		Personnel	Beds	Discharges	Personnel	Beds	Discharges
Not in RRP	Mean Std.er	2,541.26 (826.81)	532.30 (243.27)	25,721.21 (7,334.14)	2,534.78 (824.341)	520.43 (242.89)	25,077.39 (7,183.001)
	Min	764	233	11266	758	213	10289
	Max	3912	1091	40497	3893	1066	39223
Regions in RRP	Mean Std.er	2,037.83 (718.38)	656.88 (180.92)	21,406.78 (5,700.15)	1,984.72 (714.18)	653.66 (184.21)	20,758.66 (5,640.72)
	Min	1296	434	14097	1285	436	13993
	Max	4136	1027	35314	4056	1030	35181
t-test	t-stat	2.0472	-1.8135	2.0551	2.246	-1.9309	2.0934
	p-val	0.0474	0.0775	0.0466	0.0304	0.0608	0.0429

Note: Std.er: Standard errors are in given in the parenthesis. * Within the two groups: RRP and non-RRP region.

5.2 First Step: Measurement Of Hospitals Technical And Scale Efficiency

In this section we show the results obtained using DEA. Data was analyzed by DEAP.2.1 software(Coelli, 1996).We calculated the scores for each hospital in terms of overall technical efficiency (TE CRS), pure technical efficiency (TE VRS) and scale efficiency (SE) during each year. Efficiency scores range from 0 (totally inefficient) to 1 (100% efficient). The difference between total and pure technical efficiency scores implies the scale inefficiency, so SE can be stated: SE = TECRS/ TEVRS. We provided the efficiency scores comparing hospitals in regions involved in RRP and those not involved (Table 6).Overall, of the 41 public hospitals included in the study, 39 were identified as inefficient relative to the other hospitals observed, because their efficiency scores were less than one.

Table 6: Hospitals' Technical and Scale Efficiency (Mean Scores 2010-2013)

Context	H	*Mean Scores 2010 – 2013*			Context	H	*Mean Scores 2010 - 2013*		
	ID	*Mean TE CRS*	*Mean TE VRS*	*Mean SE*		ID	*Mean TE CRS*	*Mean TE VRS*	*Mean SE*
Hospitals in not RRP regions	1	*0.916*	*0.991*	*0.923*	Hospitals in RRP regions	21	*0.691*	*0.765*	*0.904*
	2	*0.621*	*0.642*	*0.968*		22	*0.799*	*0.804*	*0.994*
	3	*0.606*	*0.701*	*0.866*		23	*0.815*	*0.934*	*0.876*
	4	*0.592*	*0.609*	*0.974*		24	*0.696*	*0.742*	*0.938*
	5	*0.65*	*0.676*	*0.96*		25	*0.703*	*0.724*	*0.972*
	6	*0.707*	*0.822*	*0.861*		26	*0.796*	*0.808*	*0.985*
	7	*1*	*1*	*1*		27	*0.689*	*0.694*	*0.992*
	8	*0.753*	*0.878*	*0.859*		28	*0.535*	*0.542*	*0.987*
	9	*0.975*	*1*	*0.975*		29	*0.954*	*0.956*	*0.997*
	10	*0.822*	*0.825*	*0.995*		30	*0.693*	*0.697*	*0.994*
	11	*0.962*	*0.998*	*0.964*		31	*0.874*	*0.939*	*0.932*
	12	*0.805*	*0.806*	*0.999*		32	*0.684*	*0.699*	*0.98*
	13	*1*	*1*	*1*		33	*0.652*	*0.664*	*0.982*
	14	*0.873*	*0.88*	*0.992*		34	*0.882*	*0.887*	*0.994*
	15	*0.805*	*0.859*	*0.937*		36	*0.814*	*0.82*	*0.993*
	16	*0.764*	*0.772*	*0.99*		37	*0.912*	*0.919*	*0.991*
	17	*0.815*	*0.953*	*0.857*		40	*0.955*	*0.959*	*0.995*
	18	*0.627*	*0.641*	*0.978*		41	*0.629*	*0.736*	*0.856*
	19	*0.614*	*0.636*	*0.965*					
	20	*0.85*	*0.884*	*0.962*					
	35	*0.822*	*0.855*	*0.961*					
	38	*0.941*	*0.979*	*0.96*					
	39	*0.75*	*0.775*	*0.968*					
	Total	*18.27*	*19.182*	*21.914*		***Total***	*13.773*	*14.289*	*17.362*
	Mean	*0.7943478*	*0.834*	*0.9527826*		***Mean***	*0.7651667*	*0.7938333*	*0.9645556*
						t-stat* p-value	*0.7267 0.4717*	*1.0027 0.3222*	*-0.8141 0.4205*

* Within the two groups: RRP and not RRP region.

Even though hospitals from non-RRP regions have slightly higher mean technical efficiency scores under both CRS and VRS than hospitals in RRP regions, these differences were not statistically significant as none of the *t*-test statistics were significant at a 5% level.

When we consider the scale efficiencies, we observed that the mean of RRP regions' SE (0.965) was greater than that of non-RRP regions (0.952).Furthermore, we observed an overall increase in VRS technical efficiency during the period considered only for hospitals located in non-RPR regions. This finding may be attributed to efficiency-enhancing innovations in home health care during this period. Indeed, in non-RRP regions, the absence of budget deficits permitted them to invest in improving the functioning of the health system. Efficient hospitals useless inputs to produce more outputs compared to inefficient hospitals. Through DEA, it is possible to determine which and how many inputs were utilized inefficiently, and which and how many of the outputs were not produced. These measures are labeled excess inputs and total inefficiencies, respectively. Descriptive analysis of the output and input inefficiencies are set forth in Table 7 for the 39 inefficient hospitals (as only 2 hospitals were efficient during the entire period).

Table 7: Excess Input and Output Total Inefficiencies for Inefficient Hospitals (n= 39) (Mean [Standard Deviation])

Hospitals in Region in RRP (18)		**Hospitals in region not involved in RRP (21)**		**t-stat[p-value]**
Excess Input		*Excess Input*		
Number of beds	148.75 [116.478]	Number of beds	105.03 [116.391]	1.169 [0.25]
Number of physicians	484.31 [446.843]	Number of physicians	483.35 [473.588]	0.007 [0.99]
Output totalinefficiencies		*Output totalinefficiencies*		
Number of discharges	6,465.13 [6,004.25]	Number of discharges	6,226 [6,145.9]	0.123 [0.903]

From table 7, we see that hospitals in RRP regions have higher average inefficiencies and excessive usage of inputs compared to non-RRP regions. However, these differences are not statistically important as none of the *t*-test statistics are significant at a 5% level. During the four years considered, inefficient hospitals located in region involved in RRP on average wasted 148 beds and 484 units of personnel. To achieve efficiency, these hospitals would have to decrease inputs, while outputs would have to increase to 6,465.13 discharges during the four years considered. On the contrary, hospitals located in region not involved in RRP would have to decrease inputs by 105.03 beds and 483.35 units of personnel, while outputs would have to increase to 6,226 discharges during the time considered.

5.3 Second Step. The Effect of Recovery Plans on Hospitals Productivity: A Comparison between Regions.

After analyzing the technical and scale efficiency of hospitals through the use of the DEA, we attempted to respond to the following question: Did the RRPs improve the productivity of Italian hospitals over the period 2010-2013? In order to answer this question, we explored the evolution of hospital productivity during this period using the MPI (Table 8). We distinguished between hospitals located in regions involved in RRPs and those in regions that were not involved. As seen from the Table 8, the average total factor productivity (Tfpch) for hospitals in RRP regions improved slightly, in line with the 2010-2013 period overall average Tfpch=1.004>1.

At the same time, the mean productivity slightly worsened for hospitals from non-RRP regions, as their overall average Tfpch=0.9843<1.

Table 8: Malmquist Indices of TFP Change in Italian Public Hospitals (2010-2013)

		2010-2011	2011-2012	2012-2013	Over all Mean values 2010-13
Tfpch	RRP regions' Mean	0.982556	1.036944	0.995167	1.004889
	non-RPR regions' Mean	0.981	0.991174	0.980739	0.984304
Techch	RRP regions' Mean	1.004556	1.013889	1.025389	1.014611
	non-RPR regions' Mean	0.982609	0.987957	0.99513	0.988565
Effch	RRP regions' Mean	0.978667	1.0225	0.970611	0.990593
	non-RPR regions' Mean	0.998957	1.003522	0.985913	0.99613
Pech	RRP regions' Mean	0.995611	1.004167	0.989	0.996259
	non-RPR regions' Mean	1.015696	1.003696	0.993043	1.004145
Sech	RRP regions' Mean	0.983833	1.0205	0.981444	0.995259
	non-RPR regions' Mean	0.984043	1.000174	0.993087	0.992435

Note: Tfpch: Total factor productivity change. Techch: Technical efficiency change, Effch: Efficiency Change, Pech: Pure Technical efficiency change, Sech: Scale efficiency change.

However, the mean difference between Tfpch in RRP and non-RRP regions was statistically significant (as t-stat=-2.1437, p-value=0.0384<0.05) (see table 9). Thus, we can conclude that, during the 2010-2013 period, the average total factor productivity of the hospitals in RRP regions was significantly improved compared to those not in RRP regions. Indeed, the main reason for the productivity gain achieved in RRP regions was the average improvement in technology employed, as the overall mean Techch = 1.0146>1.Furthermore, there was a slight deterioration in the average technical efficiency (Effch) of hospitals from both RRP and non-RRP regions, as their overall mean technical efficiencies were less than one: respectively, 0.9905 and 0.9961. Even though these are slight reductions, these means are almost equal to 1, so we may conclude that there was no important change in the overall technical efficiency of the hospitals. Indeed, the mean difference between Effch in the two groups is not statistically significant (as t-stat=0.5306, p-value=0.9961>0.05) (Table 9).Lastly, we must consider the mean pure technical efficiency changes (Pech) and the scale efficiency changes (Sech) in order to better understand the mean technical efficiency changes. We see that, for all hospitals, the overall means in the 2010-2013 period were very close to 1. Hence, we may conclude that during this period on average there were no significant changes (improvement or deterioration) in pure technical efficiency and scale efficiency. Furthermore, it should be noted that hospitals located in RRP regions have a high value of standard deviation, indicating greater heterogeneity within the group. Thus, even if some negative effects are seen in terms of average variation of efficiency, RRPs produced positive effects on technological change, scale efficiency, and overall total factor productivity variation. Table 9 shows *t*-test results for all Malmquist indices in each year. As can be seen, for technological changes (Techch) and for Total factor productivity (Tfpch) we can affirm that the differences between the means of the two hospital groups can be correlated to the RRPs. Indeed, RRPs seem to have led to an improvement in the technology used, which has impacted positively on total factor productivity throughout the period considered. Hence, RRPs produced positive effects on overall TFP (tfpch) variation through improved technological innovations compared with regions not involved in RRP.

Table 9: T-Tests on the Equality of Means
(Within the Two Region Groups: Involved and Not Involved in RRP)

	2010-2011	**2011-2012**	**2012-2013**	**Overallmeanvalues 2010-13**
Tfpch	-0.0814	-2.3306	-1.0558	-2.1437
	(0.9356)	(0.025)	(0.2975)	(0.0384)
Techch	-3.0227	-4.402	-5.6335	-4.3916
	(0.0044)	(0.0001)	(0)	(0.0001)
Effch	0.9974	-1.0206	1.065	0.5306
	(0.3247)	(0.3137)	(0.2934)	(0.5987)
Pech	0.9112	-0.0233	0.3184	0.824
	(0.3678)	(0.9816)	(0.7519)	(0.415)
Sech	0.0209	-1.3875	1.1092	-0.5111
	(0.9834)	(0.1732)	(0.2742)	(0.6122)

Note: Pr(|T| > |t|) in parentheses. Tfpch: Total factor productivity change, Techch: Technical efficiency change, Effch: Efficiency Change, Pech: Pure Technical efficiency change, Sech: Scale efficiency change.

From our findings, we can confirm our hypothesis: cost containment strategies, if well-designed, contribute to reduce the healthcare spending without degrading the efficiency of hospitals (Stadhouders et al., 2019). Indeed, RRPs played a positive role in the Italian public hospital sector. The total deficit spending in RRR regions was reduced to € 0.3 billion in 2016, from € 4.1 billion in 2007. As the public health expenditure was reduced without impacting overall hospital efficiency, total factor productivity has improved compared to non-RRP regions' average.

6. Discussion and Limitations

Evaluating the effect of health system reforms on hospitals efficiency is crucial for improving the efficiency of the entire healthcare system (Colombi et al., 2017). This study aimed to contribute to the debate about this topic by offering evidence from the Italian context. In particular we analyzed the efficiency of Italian public hospitals for the period 2010–2013 and investigated the effect of RRPs on hospital productivity. From our findings, we can confirm our hypothesis described at the end of section 2: first of all, the RRPs played a positive role in the Italian public hospital sector. DEA has demonstrated that hospitals in RRP regions have a higher average inefficiency and excessive usage of inputs compared to the averages of those in non-RRP regions. However, these differences are not statistically significant. The examination of the evolution of hospital productivity shows that hospitals located in regions affected by RRPs have slightly higher, if statistically insignificant, losses in efficiency compared to non-RPR regions in terms of efficiency with constant scale returns (effch) and variable scale returns (pech). Furthermore, RRPs produced positive effects on technological change (techch), scale efficiency (sech), and overall TFP (tfpch) variation.

Additionally, *t*-test results for all Malmquist indices confirmed that RRPs helped in improving technological progress and total factor productivity. Finally, we know that total deficit spending in RRR regions was reduced to € 0.3 billion in 2016, from € 4.1 billion in 2007. As the public health expenditure was reduced without impacting overall hospital efficiency, total factor productivity has improved compared tonon-RRP regions' average.

These results allow us to evaluate the main effects of policy makers' responses to the economic crisis in the health sector on health care systems performance, demonstrating the impact of the RRP. Our study explored a question relevant not only to the Italian health system, but to many others. Around the world, governments have implemented different public health cost containment strategies, whose effectiveness is at the center of debate among policy makers and scholars. Our study contributes to this debate by offering new insight through the analysis of the Italian case, which can be, for health systems with similar institutional arrangements, a source of inspiration and comparison. Indeed, although each single national health system is structure differently and has distinct needs and defects, there is a continuous exchange of policy ideas among countries, particularly within Europe: reforms adopted in one country are often inspired by, or grow out of, reforms undertaken elsewhere. Methodologically, in order to improve hospital performance, health policy makers need information about how well the hospitals are utilizing the resources they have (Mujasi et al., 2016). From this point of view, this study demonstrates that DEA may contribute to increasing understanding of critical issues, particularly in a context of scarce resources. Additionally, DEA Malmquist indices can be used to examine productivity changes over time (Hollingsworth et al., 1999). DEA allows analysts to produce robust efficiency estimates for hospitals and may reveal changes in efficiency and productivity across hospitals by using routinely available data. The findings of our study provide empirical evidence of the technical efficiency of the sampled hospitals and the input and output changes required to make the inefficient hospitals relatively efficient.

This study has several limitations. First, we employed the DEA technique using the hospital as a whole as the decision making unit. However, the inefficiency/efficiency of a single operating unit within the hospital could have a major impact on the final result. Case studies of single hospitals wards from selected inefficient and efficient hospitals would be extremely helpful to confirm the results of the DEA and to identify potential areas for improvement in the future. Further studies are still in progress. Second, we want to specify that this is only a first attempt to observe the effects of RRPs on hospitals efficiency. Indeed, the lack of data has made the input-output set very limited and this explains only partially the results. No data were available on input prices, provision for case mixes and quality of outcomes, and the discharges output variable alone cannot reflect the entire hospital production process. Thirdly, the two samples account for 41 hospitals, including 20 from one region (Lombardy). Accordingly, there is a risk of bias in the results. However, this reflects the composition of the Italian public hospital sector. It should be noted that the analysis conducted in this study regards an intermediate productive process of the health care system, only focusing on the health services provided by hospitals, which are one of the most important heath care inputs in terms of both outcome and health care expenditure. Finally, a main limitation of this work is that it analyzes only Italian public hospitals, excluding IRCCS, AOU and private hospitals. Following our framework, future research could replicate this study by expanding the sample and including the other levels and private hospitals so as to provide a more complete and transversal analysis of the National healthcare systems. For example, the DEA model could be used to assess the effect of inefficiency at one level on higher levels. Future research may be able to resolve some of the problems noted above as better risk-adjustment methods are developed in the future and as additional data for hospitals become available. Certainly, replication of our approach using data from more recent years and with additional subsets of variables will be worthwhile to assess whether our findings are robust. Despite these limitations, we believe that this paper adds to the literature on health care services for different reasons. First of all previous studies have shown a growing interest in hospital efficiency measurement using DEA (Hollingsworth 2008; Colombi et al. 2017; Chowdhury & Zelenyuk 2016), yet often they have dealt with production and not on the effect of health reforms because of measurement difficulties. This study provides insight into the efficiency and productivity of public hospitals during reform, offering evidence from an important reorganization of regional health services within the Italian context. Specifically, this is the first DEA study, which presents an analysis of hospital performance in Italy in the first 6 years of there form.

Methodologically, we assessed the variations (negative or positive) in efficiency scores obtained with the DEA over the time-series (2010-2013).The measurement of the technical efficiency over time allows us to understand how a single hospital unit responds to external pressures in terms of necessary operational adjustments. We also broke down overall efficiency into pure technical and scale efficiency, which allowed us to calculate the amount of wasted inputs for each hospital during each year. Given the possibility to replicate this analysis, further studies along the lines presented here are warranted.

In conclusion, our study has implications for policy makers and managers working in the INHS. In particular our findings can assist policymakers in better understanding the impact of RRPs on hospitals efficiency and productivity. Specifically, the DEA model in this study, identified potentials for optimal utilization of inputs by inefficient hospitals in order to improve efficiency, as for example, redistribution or even reduction in the number of beds. Analysis of excess input and total inefficiencies could provide valuable information also to hospital managers for creating strategies to increase the efficiency and improve productive practices, potentially leading to further savings.

References:

Alonso J.M., Clifton J., Díaz-Fuentes D. 2015. The impact of New Public Management on efficiency: an analysis of Madrid's hospitals. *Health Policy*, Vol. 119, Issue 3, Pages 333-40.

Banker R.D., Charnes A., Cooper W.W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science*, Vol. 30, Issue 9, Pages 1078-1092.Bossert T. 1998. Analyzing the decentralization of health systems in developing countries: decision space, innovation and performance. *Social science & medicine*, Vol. 47, Issue 10, Pages 1513-1527.

Cavalieri M., Guccio C., Lisi D., & Pignataro G. 2018. Does the extent of per case payment system affect hospital efficiency? Evidence from the Italian NHS. *Public Finance Review*, Vol. 46, Issue 1, Pages 117-149.

Caves D.W., Christensen L.R., Diewert W.E. 1982. The economic theory of index numbers and the measurement of input, output, and productivity. *Econometrica: Journal of the Econometric Society*, Vol. 50, Issue 6, Pages 1393-1414.Cavicchi C., Vagnoni E. 2017. Does intellectual capital promote the shift of healthcare organizations towards sustainable development? Evidence from Italy. *Journal of Cleaner Production*, Vol. 153, Pages 275-286.

Charnes A., Cooper W.W., Rhodes E.1978. Measuring the efficiency of decision making units. *European Journal of Operational Research*, Vol. 2, Issue 6, Pages 429-444.Chen Z., Barros C.P., Hou X. 2016. Has the medical reform improved the cost efficiency of Chinese hospitals? *Soc Sci J,*Vol. 53, Issue 4, Pages 510-20.

Chowdhury H., & Zelenyuk V. 2016. Performance of hospital services in Ontario: DEA with truncated regression approach. *Omega*, Vol. 63, Pages 111-122.

Coelli T. 1996. A guide to DEAP version 2.1: a data envelopment analysis (computer) program. Centre for Efficiency and Productivity Analysis, University of New England, Australia, Vol. 96, Issue 08.

Coelli T. 1998. A multi-stage methodology for the solution of orientated DEA models. *Operations Research Letters*, Vol. 23, Issue 3, Pages 143-149.

Coelli T.J., Rao D.S.P., O'Donnell C.J., Battese G.E. 2005. An Introduction To Efficiency and Productivity Analysis. Second Edition, Springer, New York, USA.

Colombi R., Martini G., and Vittadini G.2017. Determinants of transient and persistent hospital efficiency: The case of Italy. *Health Economics*, Vol. 26, Issue S2, Pages 5-22.

Cook W.D., Tone K., & Zhu J. 2014. Data envelopment analysis: Prior to choosing a model. *Omega*, Vol. 44, Pages 1-4.

Del Vecchio M., De Pietro C. 2011. Italian public health care organizations: specialization, institutional deintegration, and public networks relationships. *International Journal of Health Services*, Vol. 41, Issue 4, Pages 757-774.Ferré F. 2015. Three Essays on the Challenges to New Public Management-Style Reforms in as Age of Multiple Crises: Evidence from the Healthcare Sector (Doctoral dissertation, University of Parma. Department of Economics).

Ferrè F., Cuccurullo C., Lega F.2012. The challenge and the future of health care turnaround plans: evidence from the Italian experience. *Health Policy*, Vol. 106, Issue 1, Pages 3-9.Ferrera M. 1995. The rise and fall of democratic universalism: health care reform in Italy, 1978–1994. *Journal of Health Politics, Policy and Law*, Vol. 20, Issue 2, Pages 275-302.

Fiorani G., Kunz S.,Meneguzzo M.2014. Strategic management in the Italian NHS: the implementation of the cost-cutting" plans for regional health services. In *Strategic Management in Public Organizations*, Pages 305-321. Routledge.

Giménez V., Prieto W., Prior D., &Tortosa-Ausina E. 2019. Evaluation of efficiency in Colombian hospitals: An analysis for the post-reform period. *Socio-Economic Planning Sciences*, Vol. 65, Pages 20-35.

Hollingsworth B. 2003. Non-parametric and parametric applications measuring efficiency in health care. *HealthCare Management Science*, Vol. 6, Issue 4, Pages 203-218.

Hollingsworth B. 2008. The measurement of efficiency and productivity of health care delivery. *Health Economics*, Vol. 17, Issue 10, Pages 1107-1128.

Hollingsworth B., Dawson P.J., ManiadakisN., 1999. Efficiency measurement of health care: a review of non-parametric methods and applications. *Health care management science*, Vol. 2, Issue 3, Pages 161-172.

Hung J.H., & Chang L. 2008. Has cost containment after the National Health Insurance system been successful? Determinants of Taiwan hospital costs. *Health Policy*, Vol. 85, Issue 3, Pages 321-335.

Hussey P.S., De Vries H., Romley J., Wang M.C., Chen S.S., Shekelle, P.G., McGlynn E. A. 2009. A systematic review of health care efficiency measures. *Health services research*, Vol. 44, Issue 3, Pages 784-805.

Jacobs R. 2001. Alternative methods to examine hospital efficiency: data envelopment analysis and stochastic frontier analysis. *Health care management science*, Vol. 4, Issue 2, Pages 103-115.

Jiang S., Min R., & Fang P.Q. 2017. The impact of healthcare reform on the efficiency of public county hospitals in China. *BMC health services research*, Vol. 17, Issue 1, Page 838.

Karanikolos M., Mladovsky P., Cylus J., Thomson S., Basu S., Stuckler D., McKee M. 2013. Financial crisis, austerity, and health in Europe. *The Lancet*, Vol. 381, Issue 9874, Pages 1323-1331.Khalaf W., Obiano O., &Karami N. 2019. Hospital Efficiency using Data Envelopment Analysis (DEA).

Kohl S., Schoenfelder J., Fügener A., Brunner J.O. 2019. The use of Data Envelopment Analysis (DEA) in healthcare with a focus on hospitals. *Health care management science*, Vol. 22, Issue 2, Pages 245-286.

Lippi Bruni M., Mammi I. 2017. Spatial effects in hospital expenditures: A district level analysis. *Health economics*, Vol. 26, Issue S2, Pages 63-77.Liu J.S., Lu L.Y., Lu W.M., & Lin B.J. 2013. A survey of DEA applications. *Omega*, Vol. 41, Issue 5, Pages 893-902.

Magnussen J., Hagen T.P., Kaarboe O.M. 2007. Centralized or decentralized? A case study of Norwegian hospital reform. *Social science & medicine*, Vol. 64, Issue 10,Pages2129-2137.Murray R., Imison C., &Jabbal J. 2014. Financial failure in the NHS. What causes it and how best to manage it [Internet]. London: The Kings Fund.

Ministry of Health Website. http://www.salute.gov.it/imgs/C_17_navigazioneSecondariaRelazione_3_listaCapitoli_capitoliItemName_6_scarica.pdf 2011.

Mladovsky P., Srivastava D., Cylus J., Karanikolos M., Evetovits T., Thomson S., World Health Organization. 2012. Health policy responses to the financial crisis in Europe edited by Philipa Mladovsky et al.

Mujasi P.N., Asbu E.Z., Puig-Junoy J. 2016. How efficient are referral hospitals in Uganda? A data envelopment analysis and to bit regression approach. *BMC health services research*, Vol. 16, Issue 1, Page 230.

Nayar P., & Ozcan Y.A. 2008. Data envelopment analysis comparison of hospital efficiency and quality. *Journal of medical systems*, Vol. 32, Issue 3, Pages 193-199.

Nunamaker T.R. 1983. Measuring routine nursing service efficiency: a comparison of cost per patient day and data envelopment analysis models. *Health Services Research*, Vol. 18, Issue 2, Page 183.

Nunes A.M., & Ferreira D.C. 2019. The health care reform in Portugal: Outcomes from both the New Public Management and the economic crisis. *The International journal of health planning and management*, Vol. 34, Issue 1, Pages 196-215.

Paci P., Wagstaff A. 1993. Equity and efficiency in Italian health care. *Health economics*, Vol. 2, Issue 1, Pages 15-29.

Pavolini E., Vicarelli G. 2012. Is decentralization good for your health? Transformations in the Italian NHS. *Current Sociology*, Vol. 60, Issue 4, Pages 472-488.

Peacock S., Chan C., Mangolini M. Johansen D. 2001. Techniques for Measuring Efficiency in Health Services, Productivity Commission Staff Working Paper, July, https://www.pc.gov.au/research/supporting/measuring-health-services/tmeihs.pdf, access date: 25.02.2019.

Rosko M., Mutter R. 2008. Stochastic frontier analysis of hospital inefficiency: a review of empirical issues and an assessment of robustness. *Medical Care Research and Review*, Vol. 65, Issue 2, Pages 131–166.

Rosso A., Marzuillo C., Massimi A., De Vito C., de Belvis A. G., La Torre G., Villari P. 2015. Policy and planning of prevention in Italy: Results from an appraisal of prevention plans developed by Regions for the period 2010-2012.*Health Policy*, Vol. 119, Issue 6, Pages 760-769.

Sahin I., Ozcan Y.A., & Ozgen, H. 2011. Assessment of hospital efficiency under health transformation program in Turkey. *Central European Journal of Operations Research*, Vol. 19, Issue 1, Pages 19-37.

SaltmanR.B. 2008. Decentralization, re-centralization and future European health policy. *European Journal of Public Health*, Vol. 18, Issue 2, Pages 104-106.

Saltman R., Busse R., Figueras J. 2006. Decentralization in health care: strategies and outcomes. McGraw-Hill Education (UK).

Santías F. R., Cadarso-Suárez C., Rodríguez-Álvarez M. X. 2011. Estimating hospital production functions through flexible regression models. *Mathematical and Computer Modelling*, Vol. 54, Issue 7-8, Pages 1760-1764.

Smith B. C. 1997. The decentralization of health care in developing countries: organizational options. Public Administration and Development: *The International Journal of Management Research and Practice*, Vol. 17, Issue 4, Pages 399-412.

Stabile M., Thomson S., Allin S., Boyle S., Busse R., Chevreul K., ... &Mossialos E. 2013. Health care cost containment strategies used in four other high-income countries hold lessons for the United States. *Health affairs*, Vol. 32, Issue 4, Pages 643-652.

Stadhouders N., Koolman X., Tanke M., Maarse H., &Jeurissen P. 2016. Policy options to contain healthcare costs: a review and classification. *Health Policy*, Vol. 120, Issue 5, Pages 486-494.

Stadhouders N., Kruse F., Tanke M., Koolman X., &Jeurissen P. 2019. Effective healthcare cost-containment policies: A systematic review. *Health Policy*, Vol. 123, Issue 1, Pages 71-79.

Sulku S.N. 2012. The health sector reforms and the efficiency of public hospitals in Turkey: provincial markets. *The European Journal of Public Health*, Vol. 22, Issue 5, Pages 634-638.

Torabipour A., Najarzadeh M., Mohammad A.R.A.B., Farzianpour F., & Ghasemzadeh R. 2014. Hospitals productivity measurement using data envelopment analysis technique. *Iranian journal of public health*, Vol. 43, Issue 11, Page 1576.

Van Ineveld M., van Oostrum J., Vermeulen R., Steenhoek A., & van de Klundert, J. 2016. Productivity and quality of Dutch hospitals during system reform. *Health care management science*, Vol. 19, Issue 3, Pages 279-290.

Worthington A. 2004. Frontier efficiency measurement in health care: a review of empirical techniques and selected applications. *Medical Care Research and Review*, Vol. 61, Issue 2, Pages 135-170.Yildirim C., Kacak H., Yildirim S., & Kavuncubasi S. 2019. Comprehensive Efficiency Assessment of Turkish Teaching Hospitals: Technical, Pure Technical and Scale Efficiencies with Data Envelopment Analysis. *Journal of Applied Business and Economics*, Vol. 21, Issue 3, Pages 124-140.

Zhang X., Tone K., & Lu Y. 2018. Impact of the Local Public Hospital Reform on the Efficiency of Medium-Sized Hospitals in Japan: An Improved Slacks-Based Measure Data Envelopment Analysis Approach. *Health services research*, Vol. 53, Issue 2, Pages 896-918.

Zere E., Mbeeli T., Shangula K., Mandlhate C., Mutirua K., Tjivambi B., & Kapenambili W. 2006. Technical efficiency of district hospitals: evidence from Namibia using data envelopment analysis. *Cost Effectiveness and resource allocation*, Vol. 4, Issue 1, Page 5.

Author contribution statements

Marianna Mauro conceived the original idea and developed the section 1 and 3. *Monica Giancotti* collected data, supervised the project and writes paragraph 2, 4 and paragraph 6. Also, she has revised the paper according to the referees' suggestions.
Seher Nur Sulku provided critical feedback and writes subsections 4.1, 4.2, and 4.3.
Vito Pipitone performed the analysis and writes subsections 4.4, and paragraph 5.