Comparing the efficiency of hospitals in Italy and Spain: a non-parametric approach

Marco F. Martorana* - University of Catania

Abstract.

This paper studies the efficiency of hospitals in the period 2005-2009, in Italy and Spain. The aim of the paper is to assess the dynamics of efficiency at regional level in the two countries in a comparative perspective to investigate whether geographical differences in terms of performance diminished in the observed period. It uses a non-parametric partial frontier estimator (order-m), which overcomes some drawbacks of traditional non-parametric techniques and allow for measuring efficiency robustly with respect to outliers. We find that Italian hospitals are slightly more efficient than Spanish ones. In addition, public ownership is associated to better performance in both the countries. From a dynamic perspective, results show that a process of convergence occurred in Italy that, however, did not lessen the longstanding gap between northern and southern regions. In contrast, Spanish Comunidades Autonomas diverged in the period.

Keywords: Hospital efficiency; Non-parametric frontier estimation; order-m; convergence; Decentralized health systems.

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* marco.martorana@unict.it. Department of Economics and Business - Corso Italia, 55, 95100 Catania CT
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1. Introduction

Efficiency in the provision of services by the public sector has attracted much attention in the last decades as long as more severe budget constraints, especially in the EU, drove countries to control and reduce expenditures and enhance the performance. This is particularly critical in some sectors, such as health care, where the reduction of public funds should not compromise the provision of precisely defined standard levels in terms of health outcomes.

Health systems in several countries are decentralized. Restructuring processes have been undertaken since the second world war in the large majority of European countries and have determined a wide range of institutional forms, which diverge in many aspects. Such institutional heterogeneity raised several unsolved issues on the characteristics and the key aspects of decentralized health systems and their capacity to deal with equity and efficiency (Saltman et al. 2006). This is specifically relevant in countries that are characterized by structural geographical gaps, such as Spain and Italy. In such contexts, the assessment of the efficiency in the provision of health service should take account explicitly of the results in terms of regional divergence.

This paper aims at assessing such issues by studying the efficiency in the provision of hospital services in Spain and Italy in the period 2005-2009. We adopt a comparative perspective so as to examine the difference in the dynamics in the two countries. More specifically, in this paper we aim at: a) evaluating efficiency in the two countries from a comparative perspective by estimating a common production frontier; b) studying the dynamics of efficiency in the two countries, and its dispersion in the period; c) analyzing the dynamics at regional level to verify whether in the period regional differences reduced, which is a relevant issue in decentralized systems.

To do so we use the non-parametric partial frontier (order-m) estimator developed by Cazals et al. (2002) that overcomes some drawbacks of traditional non-parametric techniques and allows for measuring efficiency robustly, with respect to outliers and extreme values. We estimate a full frontier for all the hospitals in the two countries to study the dynamics of efficiency and its dispersion through time. Then, we analyze efficiency at regional level to study whether regional systems converged in the period.

We find that Italian hospitals are slightly more efficient than Spanish ones. However, from a dynamic perspective, results show that a process of convergence occurred in Italy, which, however, did not lessen the longstanding gap between northern and southern regions. In contrast, Spanish Comunidades Autonomas (CA) diverged in the period.

The remainder of the paper is organized as follows. Section 2 provides a review of the related literature and summarizes the most relevant characteristics of Spanish and Italian health system, with a focus on the provision of hospital services and the degree of decentralization. In Section 3
and 4 we describe the methodological framework and the data, respectively. Results are included in section 5. Section 6 concludes the paper with few remarks

2. Background

2.1 Literature review
A large body of literature investigates the efficiency of health sector and the provision of hospital services, with different scopes, methodologies and results, and focused on single countries by using non-parametric frontier approaches (Hollingsworth et al. 1999; Hollingsworth 2003, 2012). Evaluating efficiency in a specific country, however, has some drawbacks and may lead to incorrect conclusions on the actual efficiency levels. Specifically, it may hide systematic inefficiency within a country, driven, for instance, by the specific institutional arrangements. This is due to the fact that non-parametric approaches provide a relative measure of efficiency, representing the distance of a single unit to the frontier, which is estimated on the basis of the observed hospitals. By using data from different countries, comparative studies allow for drawing more precise conclusions on the actual efficiency levels in a specific country although such studies require homogeneous data. Among them, Dervaux et al. (2004) compare US and French hospitals using a directional input distance function approach and found that the two systems use different technologies so that inefficiency in French hospital is driven by long run scale component while long run technical inefficiency is mainly responsible for low performance among US hospitals.

The very large majority of studies apply Data Envelopment Analysis (DEA) to study efficiency at hospital level. Among them, Mobley and Magnussen (1998) study the effect of (public or private) ownership on efficiency. They fund that public owned Norwegian hospital are more efficient than private Californian counterparts, Other examples of comparative studies using DEA include Linna et al. (2006), which compare efficiency of hospitals in Norway and Finland, and Medin et al. (2011), which study efficiency on a sample of university hospitals in Nordic countries. Furthermore, Varabyova and Schreyögg (2013) use DEA and the Stochastic Frontier Analysis to compare hospital efficiency among OECD countries in the period 2000-2009. They find that higher health expenditures are associated to higher efficiency levels and countries with higher income inequality are less efficient while (private or public) ownership is not relevant. Finally, Varabyova et al., (2016) uses partial frontier estimation, following a conditional approach, to compare hospitals in Italy and Germany and found that ownership and specialization, among other factors, affect hospital efficiency.

While the previous literature focused on the effect of ownership and environmental characteristics, no effort has been devoted so far in analyzing efficiency in terms of geographical divergence, at the
best of our knowledge. We start to fill up this lacuna by studying efficiency in two countries, namely Spain and Italy, which undertook a process of decentralization of health care at regional levels. Although we will not study directly the effect of decentralization on hospital efficiency, the institutional setting in the two countries has to be discussed beforehand.

2.2 Health system in Spain: basic features
Health care in Spain has undertaken a process of decentralization since the transition to a democratic institutional setting after the Franco period, which ended in 2002. According to the 1978 Spanish Constitution, the central government sets the basic legislation, including minimum standards, conditions and requirements to guarantee equality in the provision of service within the country, while the 18 CA\(^1\) are fully responsible for the provision of health services, according to the General Health Law approved in 1986. CA have full autonomy in the organization and provision of services, including health care as well as in the allocation of funds among different services. Funds are received by CA from several sources of taxation. However, the functions of coordination and planning have been assigned (and furtherly improved in 2003) to the Consejo Interterritorial del Sistema Nacional de Salud, including representatives of the central government and CA. Hospitals management also followed a process of reform which progressively increased their autonomy, although the governing boards are still controlled by CA (Saltman et al., 2006, Ministry of Health, Social Services and Equality, 2012). Services are provided at two levels: basic assistance is provided by the net of Centre d’atenció primària (CAP), homogenously distributed in the territory, while specialist assistance is provided by specialist centers and the about 770 hospitals, which can be private or public. In general, private hospitals are specialized in services which are not included in the public guaranteed care. Public hospitals are funded by the CA, thus the central government has no direct role on the financing of hospital services (Cots et al., 2011). Currently, the very large majority of CA have introduced prospective payment system based on the Diagnosis Related Groups case-mix adjustment (Casasnovas et al., 2009).

2.3 Health system in Italy: basic features
The Italian National Health System was established in 1978 to provide universal care. Since then, health care was administered at municipal level through the Local Health Units. Starting by the late ‘80s a process of reform progressively shifted the responsibility to Regions. Starting by 1992, Local Health Units turned to independent public owned Local Health Enterprises (LHE). More recently, by 2001, national government’s functions diminished, and simultaneously the autonomy of Regions

\(^1\) To be precise, there are 17 Comunidad Autonomas and 2 autonomous cities in northern Africa, Ceuta and Melilla.
was extended. The national government defines health targets and standards in the National Health Plan, including the essential levels of care, through the Ministry of Health. It also set the overall budget and funds regions through the National Solidarity Fund.

The 20 Regions\(^2\) are responsible for funding, organization and provision of health services and develop the regional health plans. Regions are autonomous in the allocation of their revenues to fund the health system. In addition, Regions may widen the range of services to which co-payment applies and increase co-payment. Moreover, they may choose to reimburse drugs and services which have not been included in the national list defined by the central government. Primary care, non-hospital specialist medicine, and residential care are provided and organized by LHE, whose general managers are appointed by Regions, operating with regional funds and structures provided by public hospital trusts. Hospital services are provided in Italy by hospital trusts, which are independent from Local Health Enterprises, hospitals run by LHE and accredited private hospitals. However, the wide autonomy granted to Regions results in a marked heterogeneity between regional systems (Cavalieri et al. 2016). In fact, Regions choose the managerial structure of hospitals (that is, run by the LHE or fully autonomous) and the accreditation policy which allow to adjust the extent of private hospitals in the provision of services.

3. Methods

To evaluate the efficiency of hospital provision we use the non-parametric partial frontier approach (order-m) developed by Cazals et al. (2002). Non-parametric frontier estimation techniques have been increasingly used for the evaluation of efficiency in spite of some drawbacks, because of their properties and, among them, because of their flexibility. They are specifically useful when the definition of the production process is not straightforward, such as in the provision of several public services including hospitals, as they do not require the \textit{a priori} definition of a functional form.

This class of estimators are grounded on the studies of Debreu (1951), Koopmans (1951) and Farrell (1957) and, among them, the two most adopted are the Data Envelopment Analysis, developed by Charnes et al. (1978) and the Free Disposal Hull elaborated by DePrins et al. (1984). Basically, the idea is to estimate the production frontier by comparing all the available combinations of inputs and outputs in the sample. Through linear programming techniques, these models return for each Decision Making Unit (DMU) a relative measure of inefficiency (the efficiency score) that represents the distance between the DMU and the estimated full efficiency frontier. The abovementioned DEA and FDH, however, are very sensible to extreme values and outliers, which can bias frontier estimation and, in turn, efficiency measurement. To overcome such

\(^2\) To be precise, there are 19 Regions and the 2 autonomous provinces of Trento and Bolzano/Bozen.
a drawback, some recent and robust developments, namely the \textit{order-m} (Cazals et al. 2002) and the \textit{order-\(\alpha\)} (Aragon et al. 2005, Daouia and Simar, 2007), estimate a partial frontier inside the cloud of data, but close to the lower boundary. As a consequence, the estimated frontier does not envelop all the data, and thus it is relatively unaffected by outliers. Following Cazals et al. (2002) notation, we consider a ‘production’ process where DMUs, hospitals in our case, use a combination of \(x \in \mathbb{R}^p_+\) inputs and produce \(y \in \mathbb{R}^q_+\) outputs.\(^3\) The production technology is the set of all feasible combinations of inputs and outputs, \(\Psi = \{(x, y) \in \mathbb{R}^{p+q}_+ | x \text{ can produce } y\}\), which is \(\Psi\) unknown, and thus it has to be estimated from a sample of DMUs, \(\chi_n = \{(x_i, y_i) | i = 1, ..., n\}\).

The output-based production process, according to the probabilistic formulation (Cazals et al. 2002), is defined as the probability that a single observation \((x, y)\) is dominated:

\[
H_{X,Y}(x, y) = \text{Prob}(X \leq x, Y \geq y)
\]

(1)

where \(X\) is the set of inputs and \(Y\) is the set of outputs. (1) can be decomposed as

\[
H_{X,Y}(x, y) = Pr(Y \geq y | X \leq x)Pr(X \leq x)
= S_{Y|X}(Y \geq y | X \leq x)F_X(X \leq x)
= S_Y(y|x)F_X(x)
\]

(2)

where \(S_Y(y|x)\) is the conditional survivor function of \(Y\) and \(F_X(x)\) is the cumulative distribution of \(X\). Assuming that \(\Psi\) is freely disposal, the upper boundary of \(S_Y(y|x)\) is equal to the output-oriented efficiency measure derived by Farrell (1957):

\[
\lambda(x, y) = \sup \{\lambda | S_Y(\lambda y|x) > 0\}
= \sup \{\lambda | H_{X,Y}(x, \lambda y) > 0\}
\]

(3)

The estimator of the efficiency is derived by estimating the empirical distributions \(\hat{H}_{X,Y}(x, y)\) and \(\hat{S}_Y(y|x)\) and substituting them into the equation (3). Note that, the following estimator corresponds to the FDH estimator (Cazals et al. 2002).

\[
\lambda_n(x, y) = \sup \{\lambda | \hat{S}_{Y,n}(\lambda y|x) > 0\}
\]

(4)

\(^3\) In what follows, we use an output-oriented model assuming that TDs maximize their outputs for given inputs.
the FDH is known to be very sensitive to the presence of outliers and extremes. Cazals et al. (2002) suggests to estimate a partial frontier, instead of the full frontier which envelops all the data, to overcome such drawback. The order-m efficiency measure $\lambda_m(x,y)$ benchmarks a single DMU to the expected value of the maximum output among $m<n$ randomly drawn DMUs, which uses a level of inputs lower than $x$. Cazals et al. (2002) show that $\lambda_m(x,y)$ depends on $S_Y(y|x)$, such that

$$
\lambda_m(x,y) = \int_0^\infty \left[ 1 - (1 - S_Y(u|x))^m \right] du
$$

(5)

And the efficiency score $\hat{\lambda}_m(x,y)$ can be calculated by substituting the empirical $\Hat{S}_{Y,n}(y|x)$ in equation (5), as follows:

$$
\hat{\lambda}_{m,n}(x,y) = \int_0^\infty \left[ 1 - \left( 1 - \Hat{S}_{Y}(uy|x) \right)^m \right] du
$$

(6)

In finite samples, the estimator $\hat{\lambda}_m(x,y)$ is more robust to outliers and extreme values than the FDH estimator as it does not envelop all the observations. As a matter of fact, a single DMU performing better than the average $m$ observations in its reference sample will get a score $\hat{\lambda}_m < 1$ and will be referred as a super-efficient DMU (Daraio and Simar 2007). Efficient observations are located on the frontier and obtain $\hat{\lambda}_m = 1$. Inefficient DMUs get $\hat{\lambda}_m > 1$. The inefficiency level $(1 - \hat{\lambda}_m)$ indicates the potential percentage increase in terms of outputs the DMU would produce as efficiently as its references $m$. Frontier estimation is very sensible to the value of $m$ that drives the share of superefficient DMUs. However, there are no operative rules that are generally accepted. Daraio and Simar (2005) state that $m$ should be chosen as the value that stabilizes the number of super-efficient DMUs. Following the last suggestion, we performed a set of estimations using different values of $m$ and finally selected $m=366$.

Finally, to assess the convergence, firstly we analyse the distribution of scores and then we compute regional level average scores and compare the relative efficiency of a single region in 2009 with its own and its national counterparts’ efficiency in the first year.

\footnote{This value corresponds to $m = \sqrt{N^2}$, which is the one suggested by Tauchmann (2012). Main results hold when using different values of $m$. Among them, we also estimate the frontier setting $m = \sqrt{N}$ as Daouia et al. (2012) propose although in this case the share of superefficient DMUs dramatically increase. Estimation outcomes using different values of $m$ are available upon request.}
4. Data

Data on Italian and Spanish hospitals are drawn from the statistical offices of the Italian Ministry of Health and of the Spanish Ministry of Health, respectively. We use data on hospitals, either public or private, working on behalf of the Italian or the Spanish National Health Systems, with the exclusion of long stay structures and psychiatric hospitals which have very specific features so that their inclusion would bias the comparison. Although we use an estimator that is robust to the presence of extreme values, data were examined for the presence of data errors and outliers and cleaned accordingly. The final dataset contains 4391 observations on Italian hospitals and 2604 on Spanish hospitals in the period 2005-2009.\textsuperscript{5} Input and output selection has proven to be critical for non-parametric frontier estimation techniques. Taking into account that the aim of this study is to compare efficiency across two different NHS, variable selection has been driven by two concerns. On one hand, we would make our results comparable to those of previous studies and thus we choose the most commonly used variables in the related literature. On the other hand, this choice is constrained by the availability of data for both the two sources. As a consequence, we employ a production process involving the use of 4 inputs to produce 2 outputs (in bold we denote the name of the variables which will be used henceforth). Inputs include the number of available beds, physicians, the number of nurses and the other personnel. Selected outputs are the number of Inpatient days, and the case-mix adjusted number of patients (adj. patients). There is a longstanding debate on the case-mix adjustment in comparative studies\textsuperscript{6}. In a nutshell, and with respect to our analysis, the main issue is that adjustment is generally based on DRG which may lead to different sets of weights for different countries.

The few comparative studies that use data from countries adopting different DRG classifications generally group patients into a small number of categories based on the kind of intervention on patient age (Dervaux et al. 2004, Steinmann et al. 2004). Conversely, Mateus et al. (2015) apply weights derived by the DRG system used in each country. Varabyova et al. (2016) adjust the number of inpatient discharges for the average length of stay (LOS) in different diagnostic groups. However, Fattore and Torbica (2006) show that tariff systems affect LOS in different diagnostic categories, thus leading to biased adjustment. To overcome such problem we weight the number of patients for the ratio of inpatient days to the yearly national average length of stay in the national

\textsuperscript{5} The last year available for data on Spain is 2009. The relatively short time-span of 5 years has been chosen taking in account that pooling data, which is needed to allow for comparison, implicitly entails the assumption of invariant technology.

\textsuperscript{6} See Varabyova et al. 2016 for a discussion on such a debate.
subsamples\textsuperscript{7}. Table 1 shows the usual descriptive statistics for the two samples. Clearly, the two NHS share several common features as shown by comparable mean values as well as standard deviation. However, some diverging elements emerge. Spanish hospitals employ a higher share of administrative and non-specialist personnel and are in general larger than Italian counterparts. Also Spanish hospitals manage on average to produce larger outputs than Italian counterparts. Finally, dispersion is larger in Spain, meaning that there is a larger variation in the size of hospitals in this country than in Italy.

Table 1. descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed</td>
<td>4391</td>
<td>217</td>
<td>253.43</td>
<td>5</td>
<td>1791</td>
</tr>
<tr>
<td>Physicians</td>
<td>4391</td>
<td>130.97</td>
<td>166.40</td>
<td>1</td>
<td>1313</td>
</tr>
<tr>
<td>Nurses</td>
<td>4391</td>
<td>282.68</td>
<td>388.71</td>
<td>3</td>
<td>2872</td>
</tr>
<tr>
<td>Other</td>
<td>4391</td>
<td>248.50</td>
<td>375.48</td>
<td>1</td>
<td>3878</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>4391</td>
<td>61717.49</td>
<td>78229.16</td>
<td>596</td>
<td>569605</td>
</tr>
<tr>
<td>Adj. patients</td>
<td>4391</td>
<td>8577.66</td>
<td>10869.06</td>
<td>82.68</td>
<td>80115.40</td>
</tr>
</tbody>
</table>

Source: our elaboration on data provided by the Italian Ministry of Health and the Spanish Ministry of Health

5. Results and discussion

We present estimation outcomes for the full model, which include all the input and output variables previously discussed, derived by a common efficiency frontier for all the DMUs in the sample. That is, we assume that Spanish and Italian hospitals can be directly comparable.\textsuperscript{8} Moreover, we estimate a single intertemporal frontier, thus implicitly assuming that no technological changes occur in the observed period.\textsuperscript{9} Table 2 shows standard statistics on the efficiency measures in the two countries for the full sample and the subsamples of public hospitals. Results show that the two countries share

\textsuperscript{7} Results are robust to weighting based on the whole sample.

\textsuperscript{8} Results on within country distribution and convergence hold when estimating two national level frontiers. Results hold when excluding inputs and outputs one by one. Estimates are available upon request.

\textsuperscript{9} Yearly based frontier and DEA is the available alternatives to a common intertemporal frontier, which does not require the assumption on invariant technology. However, since DEA provides a measure that is relative to the estimated frontier, results from yearly frontier would not allow for analysing the dynamics. Conversely, the choice of a relatively short time span make us confident on the validity of the assumption on no technological change.
a common context. Low variability and dispersion are associated with public ownership while private hospitals show lower average efficiency in the two countries.\textsuperscript{10} However, Spanish hospitals shows a relatively larger variability and lower efficiency.

Table 2. Efficiency estimates: descriptive statistics.

<table>
<thead>
<tr>
<th>Country</th>
<th>efficiency score</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>full sample</td>
<td>4391</td>
<td>1.312203</td>
<td>0.5315736</td>
<td>0.3280756</td>
<td>8.042434</td>
</tr>
<tr>
<td></td>
<td>public hospitals</td>
<td>2771</td>
<td>1.157253</td>
<td>0.3454817</td>
<td>0.3280756</td>
<td>4.993289</td>
</tr>
<tr>
<td>Spain</td>
<td>full sample</td>
<td>2604</td>
<td>1.356264</td>
<td>0.5831976</td>
<td>0.6265606</td>
<td>5.170458</td>
</tr>
<tr>
<td></td>
<td>public hospitals</td>
<td>1188</td>
<td>1.141961</td>
<td>0.4205674</td>
<td>0.6265606</td>
<td>4.957579</td>
</tr>
</tbody>
</table>

Source: our computation.

Table 3. Efficiency estimates: average yearly scores.

<table>
<thead>
<tr>
<th>Country</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>1.284409</td>
<td>1.309046</td>
<td>1.338679</td>
<td>1.303738</td>
<td>1.324562</td>
<td>1.312203</td>
</tr>
<tr>
<td>Spain</td>
<td>1.334734</td>
<td>1.352761</td>
<td>1.372950</td>
<td>1.364053</td>
<td>1.356510</td>
<td>1.356264</td>
</tr>
<tr>
<td>Sample</td>
<td>1.303077</td>
<td>1.325432</td>
<td>1.351326</td>
<td>1.326109</td>
<td>1.336574</td>
<td>1.328608</td>
</tr>
</tbody>
</table>

Source: our computation.

From a dynamic perspective, efficiency in the observed period did not changed remarkably (Table 3). After decreasing in the period 2005-2007 efficiency gradually improved in the last two years under observation in Spain, and stagnated in Italy. However, variation in the distribution of efficiency scores was very limited as can be viewed in figure 1 where we present univariate Kernel density estimates for the full sample (a), Italy (b) and Spain (c), respectively, comparing the first (2005) and last (2009) years. Univariate kernel smoothing distribution (Wand and Jones 1995) has been estimated through reflection and the plug-in method proposed by Sheather and Jones (1991) for bandwidth selection.

\textsuperscript{10}There is large but mixed evidence on the association between efficiency and private/public ownership in the literature on hospital efficiency. See Tiemann et al. (2012) for a recent review.
Figure 1. Kernel density estimation. Full sample (a), Italy, (b) and Spain (c). Year 2005 and 2009 comparison.

Note: Univariate kernel smoothing distribution estimated through reflection and the plug-in method for bandwidth selection. Plots show respectively the first, and the last year kernel estimates. Source: our computation.

5.1 Regional convergence.

We now analyze the dynamics of efficiency along the observed period focusing on geographical differences. Considering that NHS in Spain and Italy are organized at regional level, we study the efficiency change in between 2005 and 2009 by looking at regional averages in the two countries. Our analysis is twofold: firstly we look at the distribution of scores in the two selected years at regional level and then we study the relative position of regions and CA with respect to the national average. In figure 2a (Italy) and 2b (Spain) we show the univariate Kernel smoothing distribution (Wand and Jones, 1995) estimated through reflection method and compare years 2005 and 2009.

A slight process of convergence took place in Italy as evident by the thickness of the tails while divergence occurred in Spain. Both the two processes occurred at the expenses of average efficiency which decreased to some extent as distribution in 2009 is negative skewed for the two countries with respect to 2005.
Thus, apparently, a process of divergence occurred in Spain and slight convergence in Italy. However, countries such as Spain and Italy are characterized by longstanding economic gaps at regional level. To study whether such gaps exists also in the provision of hospital services in terms of efficiency and whether they worsened, we compare the relative position of regions and CA with respect to national averages in figure 3a and 3b.

In the two figures, sample averages are represented through dashed lines that divide the figures in four quarters, identifying the relative position of each region with respect to the yearly average. The bisector allows to discriminate regional health systems according to their efficiency gain (or loss) in the period. It is useful to recall that efficiency scores range potentially from 0 to infinitive, where a value of 1 represents full efficiency, an efficiency score higher than 1 indicates that the observed unit is inefficient, and superefficient units are denoted by a score lower than 1. Thus, regions that improved their efficiency are located above the bisector. The crossing of the bisector with the national average dotted lines allows also to distinguish six areas, so as to classify regional health systems’ efficiency change in the period with respect to national averages and to their counterparts.

We analyze the two countries one by one starting by Italy. The lower-left quarter includes leading regions, whose performance was better than the average in the 2005 and in 2009. Nine Italian regions are located in this area, and among them we can identify 3 regions moving forward while the others (Emilia Romagna, Abruzzo, Veneto, Lazio, and Puglia) show a lower performance level in the last year compared to the baseline. In terms of convergence the upper left and lower right quarter are of greater interest. The first one (catching up) contains regions which improved
efficiency so as to move from below to above the national average. The second one identifies regions which were above the average and worsened their performance so as to be in 2009 below the average. No regions are catching up. Conversely, Piemonte and Molise are falling behind, that is, they were among the leaders but decreased their performance in recent years and are now among the followers. 10 regions remained in the group of followers along all the period but five of them managed to improve their performance. In general, the large majority of regions did not change efficiency dramatically in the period as they lie close to the bisector, with few exceptions. Namely, Veneto, Abruzzo, Molise, Piemonte, Sicilia and Sardegna showed a noteworthy decrease in terms of performance, as shown by their distance from the bisector. In general, efficiency clearly reflects the longstanding gap between north and south. Only Puglia, among southern regions is among the leaders but decreased its performance in the last year. In addition, only two southern regions are among those which managed to increase efficiency in the period, and none of them is catching up. However, the distance between leaders and followers did not reduce remarkably. Scores in 2005 range between 0.987 (Valle d’Aosta) and 1.531 (Calabria) and, in 2009, between 0.927 (Valle d’Aosta) and 1.582 (Sicilia). Thus, the slight process of convergence did not lessened the north-south gap remarkably.

Figure 2a and 2b: efficiency in 2005-2009 at regional level in Italy (2a) and Spain (2b)
As previously noted, Spanish hospitals are on average less efficient than Italian ones. This is clear from the comparison of figure 2a and 2b as the cloud of Italian regions lies closer to the axes than the Spanish one. From Figure 1c it is already clear that in contrast to Italy, a process of regional divergence took place in Spain and was associated to a generalized decrease of efficiency. Figure 2b shows that a larger share of CA in Spain (than regions in Italy) worsened efficiency and 4 of them (Castilla y Leon, Aragon, Comunidad Valenciana, and Murcia) felt behind, although the large majority of CA had a small efficiency change, and only Murcia showed an important efficiency change. No CA lie in the catching up area, and among the 5 CA that managed to improve efficiency only Castilla-La Mancha was among the followers in 2005. Thus, divergence occurred as followers in 2005 did not manage to improve efficiency. Similarly to Italy, the efficiency range did not change dramatically as scores oscillate between 1.145 (Asturias) and 1.643 (Extremadura) in 2005, and 1.048 (Cantabria) and 1.642 (Extremadura) in 2009. In this country, however, the distribution of efficiency in the two years does not follows the longstanding economic gaps. As a matter of fact, relatively richer regions such as Pais Vasco and La Rioja lie in the lagging behind area while Canarias and Andalusia remained in the leading group in both the period.

To summarize, results show that Italian hospitals are slightly more efficient than Spanish ones on average. A slight process of convergence at regional level occurred in Italy, which, however did not lessen the longstanding gap between northern and southern regions. In contrast, Spain experienced a process of divergence although on average, regions did not show remarkable efficiency changes.

### 6. Concluding remarks

This paper assessed the efficiency in the provision of hospital services in Spain and Italy in a comparative perspective in the period 2005-2009. Spain and Italy have decentralized NHS, with a large degree of autonomy at regional level, and that geographical gaps are of major concern in both the countries, we studied and discussed the dynamics of efficiency in the period to assess whether a process of convergence between regions occurred. We employed the non-parametric partial frontier estimator (order-m) developed by Cazals et al. (2002), which overcomes some drawbacks of traditional non-parametric techniques and provides robust efficiency measurement. To compare the two countries we estimated a common frontier, thus implicitly assuming a common technology in the provision of hospital services. Although some even relevant differences in the regulation and organization of health care services in the two countries exist, the slight differences in terms of

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11 Here we refer to data drawn from the Spanish National Institute of Statistics (INE).
efficiency make us confident on the common technology assumption. In general, we found that Italian hospitals are slightly more efficient than Spanish ones. In both the countries, public hospitals are more efficient, which in turn depends on regulations and incentive schemes that allow for very limited differences in the organization of the service among public hospital. As a consequence, dispersion of scores among public hospitals is very low. Looking at the dynamics, results show that average efficiency did not vary remarkably in the period. More specifically, efficiency increased in between 2005-2007 and then stagnated. Differences among leaders and followers in the two countries did not decreased. In the period, a process of geographical convergence occurred in Italy, which, however, did not diminished remarkably the gap between northern and southern. In contrast, efficiency in Spain diverged as only leading regions managed to improve efficiency. Apparently, national level regulation jointly with the decentralized organization of hospital provision did not resulted in an increasing pattern of efficiency nor allowed for a process of convergence in efficiency.

Our results are robust with respect to several alternative sets of input/outputs, as well as to national/common frontier estimation. Although they are derived through the use of a robust frontier estimator, it must be noticed that our analysis does not take in account the operational environment which potentially influence hospital efficiency. Further researches would consider a richer set of input and output variables, including outcome-based variables which take in account quality in the provision of health service, to assess performance on a broader perspective.
References


