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Abstract:
This paper estimates the total factor productivity of the Italian health care sector using a modified bootstrapped Malmquist Index including the quality of the production process provided to the population. Decomposing the productivity process in three different components (efficiency change, technological change and quality change) we can detemine if the increasing/decreasing health care productivity of the 20 Italian regions is strictly related to any of the changes during 1999-2008. The results highlights also significant difference in the terms of North-South divide.

Key words: Malmquist, quality, DEA, health care, regional differences, Italy.

Introduction
Measuring hospital productivity has incorporated methodological changes including adding quality to the Malmquist approach [1-2] as well as applying the bootstrapping methods to the Malmquist approach championed by Simar and Wilson [3]. In this paper, we combine both quality as part of productivity change and the bootstrapping to develop confidence intervals for the productivity change of health care services as well as for the decomposed parts: efficiency change, technological change, and quality change. We apply this approach to hospital regions operating in Italy between 1999 and

2008. Given the administrative operations of these hospital regions, we focus our quality measure on more policy oriented issues rather than direct patient care. Our first measure is defined as the miscoding of DRGs on patients records; the second measure is defined as the amount of patient migration from his/her home region to another for health care. We do this for two reasons. First, hospital reimbursements in Italy are based on specified financing schemes based on predefined budgets. One method for determining these predefined rates is based on diagnostic related groups (DRGs) is by the primary diagnosis of patients treated in the hospital. Second, the payment mechanism is also determined by the average costs to deliver care. If we assume that average costs decrease when hospitals are operating in the increasing returns to scale portion of the average cost curve, treating more patients will reduce these costs. Conversely, if regions are losing patients to other regions, these average costs may increase/decrease depending on economies of scale. In either case, reimbursements will be affected. In Italy, there is a concern of the impact on costs that the incorrect assignment of a DRG code may have. In fact, gaming the system for higher reimbursements, is referred to as DRG "creep", may be prevalent [4]. Whether or not this type of gaming is prevalent, there is also the straightforward problem of incorrectly assigning the correct DRG code by coding errors [5] in that the reason for errors is simply an error in the use of basic classifications. Irrespective of the source of the error, these mistakes can lead to either higher than needed reimbursements from the government or lower than needed reimbursements which may affect the hospitals and in our case, region's "bottom line."

Whereas correcting DRG coding can be done at the hospital level with incentive structures from the state, the patients' mobility among regions is another issue affecting the regions' hospitals'. Starting in 1992-93, by the legislative decrees 502/92 and 517/93, laws were introduced allowing patients to receive medical treatment in a region different from that one of his/her residence. However, as suggested by [6], this patient mobility may create several problems. One issue is that this free choice can establish an increasing imbalance between supply and demand of health care. Another problem is that budget problems arise given that funding can be redistributed from region to region. This may be especially detrimental to poorer regions that have to reimburse other regions where their residents receive care.

During the last fifteen years, several reforms were introduced with the aim of reducing this mobility by increasing the power of the regions in determining the quality standard of care provided by their regional hospitals. A minimum level of care must be guaranteed everywhere but the quality and the quantity of the health care service still might vary among regions [7]. Again, the poor regions may have to take the brunt of these policy corrections if higher quality and amenities are available to patients from poor regions in other regions. The economic cost is that poor regions will have to pay these other regions rather than investing in their own hospitals and health care services.

Other economic implications include increased travel costs for individuals and the inefficiency of both regions characterized non-optimal allocation of resources if patient in/outflows are not accounted for correctly.

Pica et al., [6] demonstrated that central and northern regions exhibited a higher level of attraction capacity (more patient inflow) than from the South macro-area. For the period 2003-2007 they measured an average inflow of between 3.2 and 4.04% of patient inflow into these regions, whereas in the southern regions there was an average outflow of patient of between 5.02 and 6.30%.

Whatever the reason for this migration: patients in search of better quality or long waiting times in their home region, the cost implications are clear. As long as funding to the regions do not match the patients, there will be disequilibrium between demand and supply of medical services and financing for these services.

The remainder of this paper is organized as follows: first, in Section 1 the methodology of evaluation is presented. Section 2 describes the sample and the variables used in this nonparametric analysis. The results are then presented in Section 3. Finally we conclude by outlining the considerations that we believe to be relevant and interpreting the results obtained.

1. Methodology

The classical Malmquist productivity index, first proposed by Caves et al.[8] and then decomposed into technical change and efficiency change index by Färe et al. [9], measures productivity changes between two different time periods by estimating the ratio of the distance functions based on a common technology. This early representation of the Malmquist decomposition analyzes productivity changes accounting only for inputs and outputs. In the health care sector, quality changes may influence the productivity since offering higher productivity at the expense of quality is not optimal for patients or the system. In order to address the imposition of quality into the productivity measure, we implement a consistent bootstrap procedure into the Malmquist index decomposition proposed by Färe et al. [10]. We apply this approach to studying the Italian health sector and to ascertain whether quality changes as defined here has an impact on the Malmquist results.

We begin by including N homogeneous Italian regions as our sample, each using x inputs to produce y desirable outputs and a desirable attributes of quality. The production technology of each DMU is characterized by the technology set, defined as:

$$S^t=\{(y^t, a^t, x^t): x^t \text{ can produce } y^t, \text{ and } a^t \text{ at time } t\} \quad (1)$$

The Shepard's distance function [11], at the period t is defined:

$$D_i^t(y^t,a^t,x^t) = \sup\{\lambda: (x^t/\lambda, y^t, a^t) \in S^t\} \qquad t= t, t+1 \qquad (2)$$

As suggested by Färe et al. [10] , we treat quality as possessing the same requirements of efficiency and technology, i.e., monotonically quality is increasing and convex. Adopting the Shepard's distance function, we can express the input-based productivity index as:

$$M_i^{t,t+1}(y^{t+1},a^{t+1},x^{t+1},y^t,a^t,x^t) = \sqrt{\frac{D_i^t(y^{t+1},a^{t+1},x^{t+1})D_i^{t+1}(y^{t+1},a^{t+1},x^{t+1})}{D_i^t(y^t,a^t,x^t)D_i^{t+1}(y^t,a^t,x^t)}} \qquad (3)$$

A value of the Malmquist index less than one indicates improvements in productivity between *t* and *t+1;* values greater than one indicate decreases in productivity. The Malmquist index equaling one means that there is no change in productivity. In order to highlight the components of the Malmquist productivity index, it is possible to write the productivity index defined in (3) as a product of quality change (QUAL), the traditional efficiency change (EFF) and the traditional technical change (TECH). It is assumed that the distance functions are multiplicatively separable in attributes and inputs/outputs. So the Malmquist productivity index can be expressed as:

$$M_i^{t,t+1}(y^{t+1},a^{t+1},x^{t+1},y^t,a^t,x^t) =$$

$$\sqrt{\frac{A_i^t(a^{t+1})A_i^{t+1}(a^{t+1})}{A_i^t(a^t)A_i^{t+1}(a^t)}} \times \frac{D_i^{t+1}(y^{t+1},x^{t+1})}{D_i^t(y^t,x^t)} \times \sqrt{\frac{D_i^t(y^{t+1},x^{t+1})D_i^t(y^t,x^t)}{D_i^{t+1}(y^{t+1},x^{t+1})D_i^{t+1}(y^t,x^t)}} =$$

$$= QUAL \times EFF \times TECH \qquad (4)$$

To compute the quality index in (4), we need to compute the four terms involved which is done by taking the ratios of the distance functions given in equation (5):

$$A^t(a^{t+1}) = D_i^t(y^t, a^{t+1}, x^t) / D_i^t(y^t, x^t) \quad (5)$$

Therefore, to obtain the overall Malmquist index and its component parts, we need to solve eight DEA problems for each region. (See 10 for further details and proofs.) However, as discussed by Simar and Wilson [3], the computation of the Malmquist index and of its components does not allow us to determine whether changes in productivity are real or merely artifacts since we do not know the true production frontiers. To correct for this, we apply the Simar and Wilson bootstrapping approach in order to designate a statistically sound estimate of the "true" production function. The algorithm was implemented through the FEAR software library linked to the statistical package R [12].

2. Data and variables

This paper uses a balanced panel data for 20 Italian regions over the period 1999-2008. Data used for this analysis are extracted from the Italian Ministry of Health[1] and from the "Health for All" databases[2]. When selecting inputs and outputs for our analysis, we followed the literature for measuring health care performance [13-15] using the DEA framework. For each region we specify three inputs (physicians, nurses and number of beds) and two outputs (discharge and case mix index). All the variables are measured in terms of physical quantities, as no reliable price data are available. The number of

[1] www.ministerosalute.it
[2] www.istat.it

physicians is measured by the number of salaried physicians and dentists; the nurses' variable is measured by the number of salaried nurses. Because direct measurement of capital in health-care industry is problematic, we consider the number of beds as a proxy for capital investment [16-17]. In terms of outputs we use the number of discharged as indicator of health activity and the case mix index [18-19-20]. We use case mix as a separate output so that the peer groupings among the regions are more closely matched on the types of patients treated and the resources that are necessary to treat these patients.

To consider quality aspects inside the production process we use the number of improper and proper DRG coding and the rate between patient mobility inflow and patient mobility outflow. This quality measure also directly relates to the case mix index we use as an output. For example, if a region has a high case mix but there is a good deal of miscoding, the region will not be adequately reimbursed for appropriate resource use. Because of the curse of dimensionality, we combine miscoded DRGs and surgical patients discharged with a medical DRG together. This type of aggregation follows the suggestion by Daraio and Simar [21].

In table 1 the summary statistics for the variables used is given.

Table 1: Descriptive statistics of inputs, output and quality index 1999-2008.

		Mean	Median	Min	Max	St.Dev
Inputs	Physicians	5122	3777	221	13934	3624.424
	Nurses	12918	8525	618	39415	9399.422
	Beds	11904	7800	400	45141	9785.939
Output	Discharge	431787	275863	13718	1593378	3564.994
	Case mix index	0.9958	0.9950	0.85	1.15	0.088
Quality index	Inflow	9.514	9.570	1.18	26.54	5.106
	Outflow	9.899	7.875	3.81	24.8	5.658
	% surgical discharge with medical DRG	39.99	40.27	25.90	61.84	7.163

The findings given in Table 1 reveal that the data are right skewed, which support our choice to use a non parametric estimator, as discussed by Wilson and Carey [22].

The descriptive statistics for the variables used in the analysis sorted by macro-area are given in Table 2.

Table 2: Descriptive statistics of inputs, output and quality index 1999-2008 sorted by macroareas.

	North		Centre		South	
	Mean	St.Dev	Mean	St.Dev	Mean	St.Dev
Physicians	5461.06	4098.88	5162.23	3048.81	4763.84	3389.73
Nurses	15896.56	11589.21	13084.42	7300.5	9856.975	6591.1
Beds	13961.25	12089.9	12372.83	9296.83	9611.64	6532.77
Discharge	476747.1	438126.3	411338.7	274430	397052	295851.7
Case mix	1.067	0.053	1.0350	0.51	0.9052	0.04
Inflow	10.37	2.09	11.24	2.65	7.8	7.25
Outflow	8.84	5.06	8.25	2.26	11.79	6.81
% surgical discharge with medical DRG	0.03	0.005	0.03	0.003	0.02	0.002

These statistics show the existing differences that characterized the country in particular differences in terms of the North–South divide [23]. If we look at the patient mobility, we see that in the South macro area there is a higher outflow coupled with a lower inflow. At the same time the percentage of miscoding of the DRG, appear very similar across all regions.

3. Results

In table 3, overall productivity (and its components for the health care system) of the Italian regions are displayed by every two years time intervals as well as between the first and the last years.

Table 3: Summary of the results.

Year	M			EC			TC			QU		
	Mean	**S.D**	**# sign. Obs**	**Mean**	**S.D.**	**# sign. Obs**	**Mean**	**S.D.**	**# sign. Obs**	**Mean**	**S.D.**	**# sign. Obs**
99-01	1.025	0.07	15	1.038	0.06	12	0.991	0.05	10	0.997	0.01	10
01-03	1.067	0.09	13	0.99	0.05	4	1.08	0.04	12	0.999	0.01	10
03-05	0.993	0.04	19	0.99	0.05	5	1.001	0.03	1	0.998	0.01	10
05-07	1.01	0.04	15	0.98	0.04	8	1.04	0.02	11	0.997	0.01	9
99-08	1.082	0.1	12	0.982	0.06	7	1.113	0.07	10	0.991	0.02	11

M:Malmquist index, EC: efficiency change, TC: technological change, QU: Quality change. Mean: geometric mean, # sign. Obs: statistically significant at 10%.

From the results given in table 3, on average, the Italian health care sector has shown a steady decline in the overall productivity index (M) with the exception for the period 2003-2005 which had a slight increase. Although the findings highlight a steady state of quality during the years, on average, the Italian health care system at regional level has shown a steadily decline in productivity index, -8.2% ((1-1.082)* 100 = -8.2). While there appeared to be an improvement in efficiency for every year (with the exception for the period 1999-2001), the technological change is characterized by a steady negative decline the whole sample period, with the exception for the period 1999-2001.

Looking at the first and the last years (1999-2008) not all the regions are characterized by a significant productivity improvement.

Table 4: Summary of the results for the Italian regions between 1999-2008.

Regioni	Malm	Eff	Tech	Qual
Piemonte	1.096**	1.016	1.081	0.998***
Valle d'Aosta	0.931***	1	1.039	0.896***
Lombardia	1.083***	0.894	1.214	0.997***
Trentino A.A.	1.244***	1.068	1.169**	0.997
Veneto	1.064	0.935**	1.138*	1**
Friuli V.G.	1.015	0.892***	1.146***	0.992***
Liguria	1.051	0.968	1.084	1.001
Emilia R.	0.983*	0.906***	1.088	0.997***
Toscana	1.046	1.002	1.045	0.999**
Umbria	0.999	0.988	1.009	1.002
Marche	1.071	0.973	1.106*	0.996
Lazio	1.238***	0.957	1.297***	0.997***
Abruzzo	1.029	0.935***	1.104**	0.997
Molise	1.177***	1.054	1.174***	0.951***
Campania	1.031	1	1.031	1**
Puglia	1.212***	1	1.212***	1***
Basilicata	1.217***	1.097**	1.113***	0.997
Calabria	1.186***	1.085**	1.093**	1
Sicilia	1.104***	1.025	1.078	1
Sardegna	0.952***	0.88***	1.083	0.999

Notes: statistical significance: ***statistically significant at 1% level, **statistically significant at 5% level, *statistically significant at 10% level according to the bootstrap confidence intervals.

It is interesting to note that, although the productivity index results for most regions are significant, the efficiency changes and the technological changes are often not significant. Further, only eleven regions demonstrate a significant quality improvement. Looking at a more the macro-area level (North, Centre and South), we found different rates of productivity and quality changes.

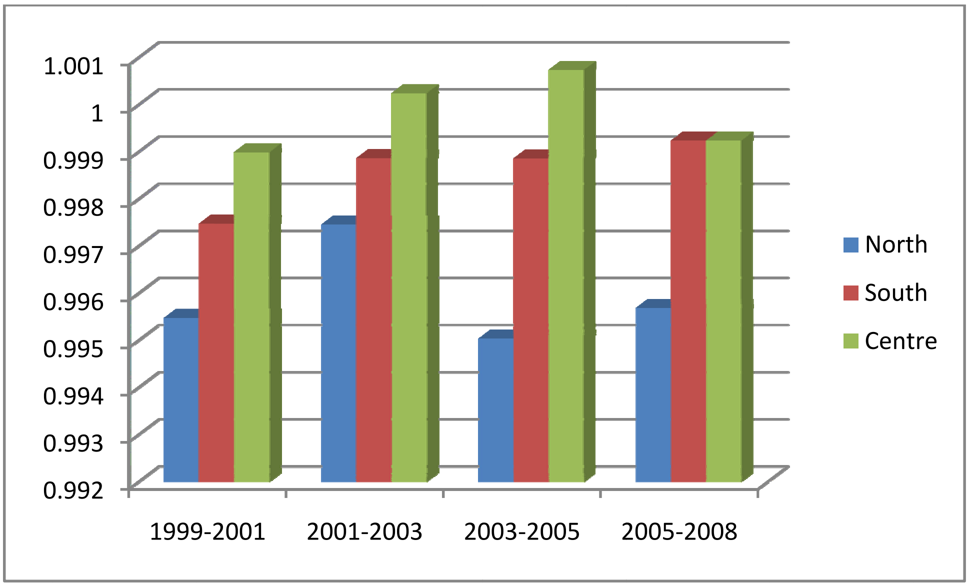

Figure 1. Malmquist index

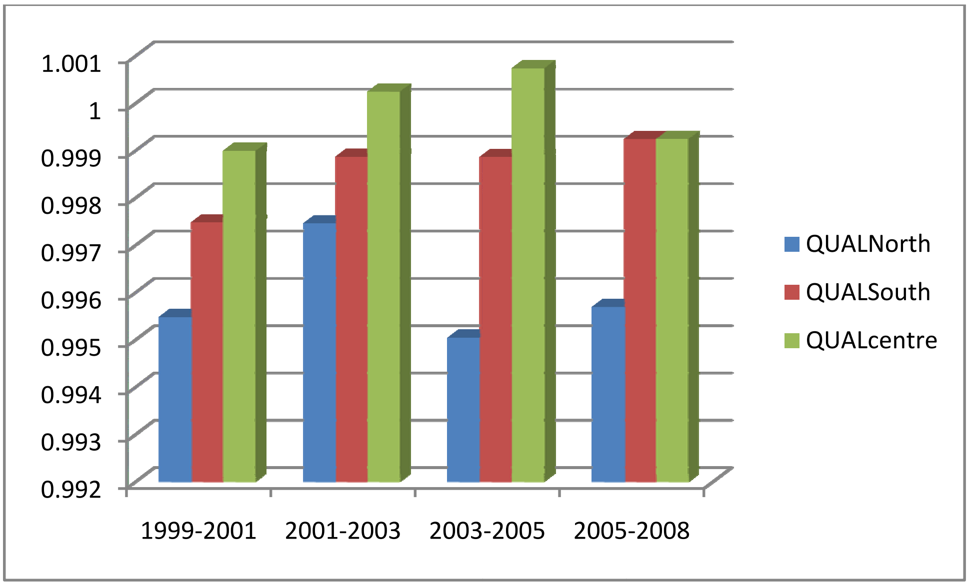

Figure 2. Quality changes

Considering the results from figures 1 and 2, we find an emerging pattern. Recall that if the measures are greater than one, then there is decreasing performance. Therefore, the higher up on the graph, the worse the quality change in figure 1 and the worse the productivity change in figure 2. The North macro-area is characterized by constant increases in quality change but a decreasing productivity change until the 2003. If we look at the South macro-area, the trend of the productivity and quality change are different. In fact this area is characterized by an always decreasing productivity and by a steadily increasing quality. If we look at the Centre, the results highlight a different situation. In fact, the productivity and the quality index begin to increase only starting from the 2003.

There results suggest that the North offers higher quality services as well as increasing productivity. Moreover, these findings demonstrate that a strong relationship exists between productivity and quality. The only macro-area that is characterized by decreasing productivity is the South. This finding may be attributed to the finding that a significant portion of the population seek health care outside the region of residence. This phenomenon may be strictly related with the quality and the quantity of the service provided that are not sufficient as compared to the quality of the systems offered elsewhere. These important outpatient flows could also be causing a decreasing productivity change, if inputs remain constant over time, but at the same time, outputs continually decrease.

4. Discussion and conclusion

The purpose of this paper was to explore the productivity change in the Italian health care region between 1999-2008 to ascertain if a particular relationship between quality and productivity exist. To do this, we employ a further decomposition of the Malmquist index proposed by Färe et al. [10] which takes into account also quality changes. We also try to overcome some of the limitations of the linear programming approach by including bootstrapping confidence intervals to test statistically the hypothesis of productivity changes.

In general, we find that, over the period considered for this analysis, the Italian regions are characterized by a decreasing productivity in the health care sector. However, we do not consider any miscoding to be the main cause of a system based decrease in quality.

Rather, the decline in productivity may be caused by patient mobility affecting the number of patients treated given resources. We also consider quality changes inside the productivity analysis which can be helpful in understanding whether productivity is decreasing because of the quality changes in the health care system. The results show that an important relation exists between quality and productivity showing that when productivity starts to increase, quality likewise increases. especially in the North and the Centre macro-areas. The South macro area however, is characterized by an always decreasing productivity probably related with the strong phenomenon of the patient outflow.

The regions that are reimbursing other regions for patient care may also face future reductions in the quality of direct patient care. This would be especially the case if these reimbursements cause to the region to reduce quality enhancing labor and capital or at the least, not be able to move beyond the minimum standard of care given by Italian law. This relationship may be particularly deleterious for the South which is a poorer macro-area to begin with, and may have to expend more resources than in the North. Moreover, the federalism law was approved so that regional governments could finance public services including health care services, through regional taxes. However, if there is exists a poorer region with a lower tax base, this difference in the health service provided among macro-areas could represent one of the most important drivers of the Italian health care systems' falling short of optimal productivity.

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