The impact of public health efficiency on well-being in Italian provinces

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Abstract

Purpose – This work aims to analyse the relationship between public health efficiency and well-being considering a panel of 102 Italian provinces from 2000 to 2016 and evaluates if there are omitted variable biases and endogeneity biases and also evaluates if there are heterogeneous effects among provinces with different income levels.

Design/methodology/approach – We use a multi-input and output bootstrap data envelopment analysis to assess public health efficiency. Then, we measure well-being indices using the min-max linear scaling transformation technique. A two-stage least squares model is used to identify the causal effect of improving public health efficiency on well-being to account for time-invariant heterogeneity, omitted variable bias and endogeneity bias.

Findings – After controlling for important economic factors, the results show a significant effect of an accountable and efficient public health system on well-being. Those effects are concentrated in the North, the most economically, geographically and environmentally advantageous areas.

Research limitations/implications – The use of the sample mean, probably the oldest and most used method for aggregating the indicators, could be affected by variable compensation, with consequent misleading results in the process of constructing the well-being index. Another limitation is the use of lagged values of the main predictor as an instrument in the instrumental variables setting because it could lead to information loss. Finally, the availability of data over a long period of time.

Practical implications – The findings could help policymakers adopt measures to strengthen the public health system, encourage private providers and inspire countries worldwide.

Social implications – These results draw the attention of local authorities, who play an important role in designing and implementing policies to stimulate local public health efficiency, which puts individuals in the conditions of achieving overall well-being in their communities.

Originality/value – For the first time in Italy, a panel of well-being indices was constructed by developing new methodologies based on microeconomic theory. Furthermore, for the first time, the assessment of the relationship between public health efficiency and well-being is carried out using a panel of 102 Italian provinces.

Keywords Health, Public health efficiency, Bootstrap-data envelopment analysis, Well-being, Italian provinces

Paper type Research paper

JEL Classification — C14, H75, I11, I18, I31, I38, J58

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1. Introduction

In recent years, there has been growing consensus that the measure of progress and prosperity traditionally used in economics, i.e. gross domestic product per capita (GDPPC), is no longer fit for purpose (Stiglitz *et al.*, 2014, 2018). Stiglitz *et al.* (2018) demonstrate that placing excessive reliance on gross domestic product (GDP) as the measure of economic performance led policymakers to fail to prevent the 2008 crisis and to evaluate its economic and social consequences adequately. GDPPC gained legitimacy in the period that followed World War II, becoming the basic indicator of well-being and the most important criterion for its measurement. It is widely accepted that the meaning of development and progress concerns the changes implemented to bring about improvements in people's quality of life, standard of living and well-being in general. It is also accepted that other aspects of individual and collective well-being should be considered in addition to economic factors. The state of well-being in humans comprises biological, psychological and social aspects, all of which contribute to characterising the quality of life, lifestyle and living conditions of individuals in their communities. In a report by the commission on the measurement of economic performance and social progress, Stiglitz *et al.* (2009) argued that well-being should be defined in a multidimensional manner; it should include material living standards, health, education, personal activities such as work, political voice and governance, social connections and relationships, the environment, and security dimensions that shape people's well-being. Health is an exceptional and fundamental component of well-being, and the increase in healthcare expenditure in Italy has been accompanied by an improvement in the health status of individuals (Piacenza and Turati, 2014).

A recent strand of literature analyses the relationship between health and well-being following the introduction of sustainable development goal 3 (SDGs – goal 3). SDGs – goal 3 seeks to ensure healthy life to everyone and improve people's well-being at all ages (UN, 2023). This goal is still challenging since its introduction, due to structural issues that undermine progress towards its achievements (universal health coverage), exacerbating existing health inequalities and, consequently, negatively affecting the well-being of individuals and their communities. Several studies identify the geographic accessibility to health facilities when they are available, as a critical challenge (Surage *et al.*, 2017; Agbenyo *et al.*, 2017). Agbenyo *et al.* (2017) point out the distance from health facilities. Moreover, Oburota and Olaniyan (2020) highlight the issue of inequities in the access to health facilities between rich and poor in Nigeria. Signorelli *et al.* (2020) instead, identify the excessive waiting times as a critical point in Italy. To overcome healthcare deficits stemming from these problems, increased investment is needed not only in health systems but also in infrastructure in order to pave the way for the common objective of *Health for All*, achieve SDGs – Goal 3 target and therefore enhance the well-being of individuals and their communities.

An effective and accountable health system is of paramount importance because people generally have to cope with many stresses and challenges in their lives: academic expectations for young people, career expectations for adult workers, social relationships with family and peers, and changes associated with maturation (Currie, 2012). All these factors can affect not only people's health but also their well-being. Using data on young people's health and well-being collected in the autumn of 2009 and the spring of 2010 in 39 European countries as part of a cross-national collaborative study, Curie (2012) showed how young people's health changes as they move from childhood through adolescence and into adulthood. In principle, behaviours established during each transition period can persist into adulthood and even old age, exacerbating problems such as mental health, the development of health complaints, tobacco and alcohol use, diet and physical activity. For an interesting study on these matters see Matranga *et al.* (2020).

This paper aims to bridge the gap in the literature by investigating the relationship between public health efficiency and well-being in a panel of 102 Italian provinces over the period 2000–2016. It considers the extent to which public health efficiency could positively impact on well-being broadly defined as happiness, life satisfaction, quality of life, standards of living, and the quality of personal development or progress (Easterlin, 2003). The idea is that the efficiency of public health can increase the general well-being of people. This study's hypothesis is that higher levels of efficient and accountable public health systems are associated with higher levels of well-being as perceived by citizens for two reasons: first, greater efficiency and accountability in the public health sector leads to higher labour productivity (Ullah and Malik, 2019), which in turn improves the quality of life, the standard of living and the well-being of people (Anderson *et al.*, 2018). For a recent review see Ungaro *et al.* (2024). Second, better collaboration between the central government and subnational levels of government improves the efficiency of the public health system, thereby increasing well-being at the individual and collective levels (Kyriacou and Roca-Sagalés, 2014).

The contribution of this paper is original because it analyses the relationship between an efficient and accountable public health system and the well-being of individuals and communities. We measure public health efficiency by conducting a bootstrap data envelopment analysis (DEA) with 3,000 replicates at a 95% confidence interval. Then, we assess well-being through a composite index. Finally, we investigate the relationship between public health efficiency and well-being with a two-stage least squares model, a good tool with which to address the issues of reverse causation and omitted variables bias. Following Reed (2015), the lagged value of public health efficiency scores is used as an instrument to deal with these issues. Moreover, province-specific and time-specific effects are controlled to reduce omitted variables bias. The results show that public health efficiency increases the well-being of individuals and communities in the 102 Italian provinces, especially in the Centre–North. In other words, provinces with inefficient public health systems are those with less well-being, and they are mainly located in the South.

This article is organised as follows. Section 2 reviews the theoretical literature. Section 3 illustrates the data source and methodologies. Section 4 presents the empirical analysis. Section 5 reports and discusses the main results. Section 6 provides policy implications and conclusions.

2. Theoretical literature

The quality of institutions is crucial in the economic system because institutions can generate economic synergies and ensure performance standards among different economic agents (Kimaro *et al.*, 2017). Six dimensions measure the quality of institutions: voice and accountability; political stability and absence of violence and terrorism; government efficiency; regulatory quality; rule of law; and control and corruption (Nifo and Vecchione, 2014). Thus, government efficiency is grounded in the quality of institutions and determines the government's capacity to implement sound policies that have a positive impact on the economic system. Shen *et al.* (2018) relied on the quality of governmental authorities to maximise government efficiency and economic growth. The main goal is to improve people's well-being in their communities. Fonchamnyo and Sama (2016) noted that public sector efficiency depends on factors such as education, regulatory environment, quality of governance, cost-effectiveness, investment and openness of the economy. These factors tend to foster an efficient and accountable public sector that promotes economic development and improves well-being. Likewise, social capital, education and health appear to have positive effects on government efficiency, economic growth, prosperity and well-being. In fact, Calcagnini and Perugini (2019a) found a positive association among social capital, social cooperation and social security programmes, and well-being in Italian provinces. Guisan and Esposito (2010) highlighted the positive impact of education and health on government efficiency and economic policies, intended to improve the well-being of people in countries around the world. Zagler and Dürnecker (2003) focused on the healthcare system, claiming that an efficient and accountable healthcare system reduces disease and increases the quality of labour, thereby improving economic growth and ultimately increasing the well-being of individuals and communities.

Good health is essential for achieving well-being in society. Von Heimburg and Ness (2021) emphasised relational well-being and recalled that health is a basic need and a human right, and that equity in health and well-being is, therefore, fundamental to achieving sustainable societies. Cylus *et al.* (2020) argued that the well-being agenda affected health policy because good health is a key dimension of well-being. Hence, shifting policy focuses away from traditional economic measures aimed at social well-being could increase resources for health systems. In the same vein, Marmot (2020) argued that countries with greater inequality tend to be less healthy, have a lower life expectancy and experience more crime. This feature exacerbated health disparities and consequently well-being within and between countries. Matranga *et al.* (2020) documented a positive impact of healthy behaviours – with particular regard to diet, physical activity, alcohol and tobacco abuse – on well-being, and they recommended building, developing and maintaining individual skills as means to successfully counteract behaviours risky for health.

Understanding the causal effects of improved public health efficiency on the well-being of individuals and communities is important for policymakers not only for the design of effective and efficient health policies, but also from a socioeconomic perspective, given the contribution of healthy and satisfied people (human resources) in society. The theoretical literature supports the claim that health affects long-term well-being through two main channels. The first is the direct impact via labour productivity, i.e. healthier people work harder, longer, better, think more clearly, earn higher wages, contribute to their country's economic development and thus achieve greater well-being (Umoru and Yaqub, 2013; Ullah and Malik, 2019). Using the generalized method of moments (GMM) methodology, Umoru and Yaqub (2013) find that investing in health capital boosts the productivity of workforce in Nigeria. Like many under-developed countries, Nigeria is heavily labour-intensive; thus, prioritising a healthier workforce becomes imperative to optimise productivity. Ullah and Malik (2019) instead, use an auto regressive distributed lag approach on data from Pakistan over the period 1980–2010 and show that a 1% improvement in health status leads to around 13.40% rise in worker productivity. They also find that improvement in health status increases the incentive to pursue education and acquire skills that contribute to better worker productivity and higher well-being. The second channel focuses on the impact of the decentralisation process, particularly in health systems where the central government and subnational government agencies collaborate and make joint policy decisions to improve the efficiency and accountability of the health system and enhance people's well-being (Kyriacou and Roca-Sagalés, 2014; Cavalieri and Ferrante, 2020). Cavalieri and Ferrante (2020) look at the gradual impact of policy changes resulting from the 1997–2000 health reform and the 2001 constitutional reform, analyse a panel of 20 Italian regions over the period 1996–2016, and find that the gradual increase in the fiscal responsibilities of regions and the associated greater autonomy in making decisions about the allocation of tax revenues induced regional health authorities to be more responsible in their spending decisions and thus tailor their healthcare measures to the needs of their local populations, thereby improving their well-being.

3. Data and methodologies

3.1 Efficiency index

In Italy, the National Health Service (NHS) operates at the provincial level, while the regional administrations provide the resources necessary to finance the services. The Italian NHS consists of three levels of decision-making: the central government, the 21 regional administrations and the local health units (Lo Scalzo *et al.*, 2009). The local health units are located at the provincial level in the so-called *area vasta* (large area) [1]. In general, local governments are important in the policy-making process because they contribute to the design and implementation of policies that affect people's lives, as well as being responsible for the implementation of decentralisation policies, for example in education, health, culture and transport (Taralli *et al.*, 2015).

To assess the efficiency of public health, we used the DEA technique. This method is widely accepted by all disciplines for benchmarking and performance evaluation studies, fits better with the input-output production process and offers a large range of efficient combinations of the observed input-output. DEA has several advantages over other efficiency analysis methods (free disposable hull, stochastic frontier analysis, etc) because it can include input and output factors measured in different units in the analysis. In the DEA setting, we can assume that each input element has a relationship with one or more output elements without knowing the functional relationship between them and there is no need to determine any weight for the variables in advance because it assigns optimal weights to all inputs and outputs (Jiang *et al.*, 2020). To measure technical efficiency, defined as the ability of decision-making units (DMUs) to produce a given quantity of output with minimal inputs, we applied the input-oriented variable returns to scale model Banker, Charnes and Cooper (BCC)-DEA [2].

The Italian provinces were the DMUs which convert multiple inputs into a single output. The input variables referred to doctors and dentists, nurses, hospital beds, pulmonary ventilators and anaesthetic machines of public and private accredited health facilities in each province. The output referred to all hospital days produced by hospitals located within a given province, both those related to resident patients and those related to patients residing in other provinces, so-called active mobility. Italian national institute of statistics (Istat) evaluates these data on the basis of hospital discharge cards. Inputs and output were measured in terms of physical quantities, because no reliable price data were available (Nicola *et al.*, 2012, 2014) and they were selected based on a critical review of the inputs and outputs used in previous studies (Levaggi and Zanola, 2004). Table 1 reports the descriptive statistics for the input-output variables over the period 2000–2016, for the 102 DMUs (Italian provinces).

The efficiency scores were calculated with respect to an empirical frontier, and a DMU was considered technically efficient if it lay on the frontier with a score of one. It should be stressed that technical efficiency scores can be considered as weak efficiency measures because they do not account for slacks in some inputs. Therefore, a DMU is efficient if it lies on the frontier and all the slacks are equal to zero. For a review, see Hauner *et al.* (2010).

Despite the benefits and the widespread use of the DEA, one drawback of this technique is the assumption that any deviations from the frontier result from inefficiencies. In fact, DEA

Table 1. Descriptive statistics of input-output variables over the period 2000–2016

Variables	Units	Obs	Mean	Std. Dev	Min	Max
Doctors	Person	1,734	1184.475	1617.883	23	12,838
Nurses	Person	1,734	2586.235	3154.169	25	24,586
Hospital beds	Number	1,734	2113.633	2565.838	194	22,953
Pulmonary ventilators	Number	1,734	145.471	169.261	0	1,326
Anaesthetic machines	Number	1,734	85.475	106.536	0	810
Active mobility	Day	1,734	598118.76	757690.032	58,524	6,934,141
Time	Year	1,734	2,008	4.900	2,000	2,016

Source(s): Health for all database

does not account for measurement error, and the corresponding measures of efficiency are sensitive to the sampling variations of the frontier obtained, since the statistical estimators of the frontier are obtained from finite samples (Simar and Wilson, 1998).

The bootstrap method, introduced by Efron (1979), is a suitable tool with which to analyse the sensitivity of the measured efficiency scores to the variation of the sampling. In the research reported by this study, to mitigate possible inefficiency, a consistent bootstrap procedure with 3,000 replicates at 95% confidence intervals was applied to obtain the sampling distribution of the efficiency scores and then to correct for bias (Simar and Wilson, 1998) [3]. Figure A in Online Appendix shows the variation and increase of the bootstrap-DEA public health efficiency scores over the period 2000–2016.

3.2 Well-being indices

Building on the methodology used by ISTAT to measure equitable and sustainable well-being at the provincial level and consistently with it, we propose a panel of composite indicators for assessing well-being accounting for the variability between and within the local units. We thus, selected 27 indicators from the original dataset of 70 indicators provided at provincial level by ISTAT (Istat, 2023) on the basis of their analytical soundness, measurability, country coverage, relevance to the phenomenon being measured and relationship to each other (JRC and OECD, 2008). These 27 indicators were divided into seven dimensions instead of the eleven domains suggested by ISTAT because we decided to follow the methodological framework of studies by Segre *et al.* (2011), Calcagnini and Perugini (2019a, b) and Bacchini *et al.* (2021). Table A in Online Appendix shows the domains and dimensions of the equitable and sustainable well-being (benessere equo sostenibile - BES) provided by ISTAT and the composite well-being index of our study, respectively.

The indicators and dimensions which constitute the composite well-being index were also the results of a consultation and deliberation process involving associations, non-governmental organisations, and networks active on social issues, solidarity, environment, promotion of civil rights, education, health, consumer protection and alternative economic activities (Segre *et al.*, 2011; Rondinella *et al.*, 2017; Calcagnini and Perugini, 2019a, b; Bacchini *et al.*, 2021). Compared to other indices such as the composite index of quality of life at the provincial level developed by Colombo *et al.* (2014) and the composite index of human development at the regional level developed by Costantini and Monni (2009) which lacked legitimation in the choice of dimensions and variables, the indicators and dimensions of our composite well-being index had positive outcomes in their validation and legitimation process. Unlike any other index, our composite well-being index was based on an equitable and sustainable well-being approach (Istat, 2023) that also considers a good quality of local development (Segre *et al.*, 2011; Chelli *et al.*, 2016; Ciommi *et al.*, 2017; Calcagnini and Perugini, 2019a, b). Table 2 presents the descriptive statistics of the 27 indicators within their respective dimensions over the period 2000–2016. It also shows that the number of observations was not the same for all variables.

To construct the composite well-being index, we used the method introduced by Bacchini *et al.* (2020) and defined a real function $M(\cdot)$ on a sequence of data matrices A_j, where $j = 1, 2, \ldots, k$ referred to a single indicator in Table 2. Since each matrix A_j, contained n rows (Italian provinces) and T columns (years), we could compute a composite well-being index (Decancq and Lugo, 2013, p. 11) as follows:

$$M(A_1, A_2, \ldots, A_k; \beta) : \mathbb{R}^{(n \times T \times k + 2)} \rightarrow \mathbb{R}^{n \times T}, \quad (1)$$

where $\beta = [\beta_1\ \beta_2]$ is a bidimensional vector containing two integers.

Table 2.
Descriptive statistics for the well-being Index indicators over the period 2000–2016

Variables (units)	Obs	Mean	SD	Min	Max
Environment					
Population density (pop/km^2)	1,734	250.064	333.750	36.63	2663.88
Waste recycling (%)	1,734	31.352	20.109	0.443	87.853
Motorisation rate (%)	1,734	637.923	168.916	411.197	2455.213
Public transport (%)	1,734	88.644	109.455	2.977	790.622
Urban green (m^2/pop)	1,734	122.657	322.739	0.204	2943.631
Urban green density (%)	1,734	6.609	9.908	0.061	71.859
Air quality (100 km^2 of area)	1,428	3.384	3.397	0.2	23.386
Economy and labour					
Unemployment rate (%)	1,734	9.404	5.873	1.3	31.5
Theil index (index)	1,734	0.614	0.195	0.099	1.2
Financial risk (%)	1,734	2.701	2.085	0.164	24.432
Health					
Life expectancy female (year)	1,734	83.961	1.077	79.94	86.44
Life expectancy male (year)	1,734	78.677	1.434	74.22	82.04
Fertility rate (‰)	1,734	1299.826	155.466	289	4,181
Mortality rate (‰)	1,428	104.072	15.632	51.8	153.79
Rights and citizenship					
Migrant integration (migrant/pop)	1,734	0.051	0.035	0.004	0.16
Electricity interruption (hour)	1,734	2.521	1.481	0.4	14.57
Home assistance (%)	1,428	1.63	1.143	0.1	9.3
Childcare (%)	1,428	12.947	9.018	0.3	159.1
Crime rate (‰)	1,428	0.95	2.406	0	83.137
Education and training					
High-school diploma (%)	1,326	54.123	7.678	30.9	73
University degree (%)	1,326	18.91	5.265	5.3	37.5
Continuing training (%)	1,326	6.429	1.837	2.4	16.7
Gender equity and equal opportunity					
Young adults (%)	1,326	20.528	8.546	4.6	46.2
Female administrators (%)	1,326	20.696	7.107	4.8	40.2
Gender equity (%)	1,326	20.819	6.220	6.108	41.954
Democratic participation					
Municipal administrators (%)	1,326	31.059	5.066	16	46.4
Voter turnout (%)	1,326	66.985	9.424	20	82.94

Source(s): ISTAT and OECD database

In order to normalise data of well-being index over time, we calculated the transformed achievements A_j by means of the min-max linear scaling transformation technique. With a^t_{ji} being the element of A_j representing the *j*th indicator of the *i*th province at time *t*, the normalisation scheme applied consisted of defining a set of matrices Z_j, in which each element was (JRC and OECD, 2008, p. 85):

$$z^t_{ji} = \frac{a^t_{ji} - min_{t\in T}\, min_i\left(a^t_j\right)}{max_{t\in T}\, max_i\left(a^t_j\right) - min_{t\in T}\, min_i\left(a^t_j\right)}, \tag{2}$$

for each $j = 1,2, \ldots, k; i = 1,2, \ldots, n$ and $t = 1,2, \ldots, T$, where the minimum and maximum values for each indicator were calculated across Italian provinces and time, in order to account for the evolution of indicators over the sampling period. If an increase in the normalised indicator corresponded to a reduction in overall well-being, equation (2) was modified according to the complementary formula:

$$z_{ji}^{t} = \frac{max_{t\in T}\, max_{i}\left(a_{j}^{t}\right) - a_{ji}^{t}}{max_{t\in T}\, max_{i}\left(a_{j}^{t}\right) - min_{t\in T}\, min_{i}\left(a_{j}^{t}\right)}, \tag{3}$$

It should be stressed that this transformation is not stable when new data become available, requiring an adjustment of the sample period T which of course affects the minimum and maximum for some indicators and consequently the values of z_{ji}^{t}. Therefore, the composite well-being index must be re-calculated when new data are available (JRC and OECD, 2008; Bacchini *et al.*, 2020).

The transformed achievements deriving from equations (2) and (3) were useful for two reasons (Decancq and Lugo, 2013): first, they removed the problem of different units of measurement for the different indicators (waste recycling is measured in percentages, life expectancy in years, electricity interruption in hours, etc.); second, they diminished the excessive importance of outliers or extreme values when the distribution of the indicator was skewed.

The transformed data entered equation (1). Therefore, the n × T vector of each element of the composition of dimensions, obtained using a generalisation of the Cobb–Douglas function can be defined as:

$$(M_d)_{it} = \begin{cases} \left[W_d^{-1} \sum_{j=1+J_{d-1}}^{J_d} \left(z_{ji}^{t}\right)^{\beta_1}\right]^{1/\beta_1} & for\ \beta_1 \neq 0 \\ \left[\prod_{j=1+J_{d-1}}^{J_d} z_{ji}^{t}\right]^{1/W_d} & for\ \beta_1 = 0 \end{cases} \tag{4}$$

where $J_d = \sum_{r=1}^{d} W_d, J_{d-1} = 0$ when $d = 1$ and W_d is the number of indicators in the *d-th* dimension.

Technically, equation (4) returned a n × T vector of each dimension of the composite well-being index, obtained by using the nested constant elasticity of substitution (NCES). The formulae element-wise for province i and time t were defined as:

$$(M(Z_1, \ldots, Z_k;\ \beta))_{i,t} = \begin{cases} \left[D^{-1} \sum_{d=1}^{D} (M_d)_{i,t}{}^{\beta_2}\right]^{1/\beta_2} & for\ \beta_2 \neq 0 \\ \left[\prod_{d=1}^{D} (M_d)_{i,t}\right]^{1/D} & for\ \beta_2 = 0 \end{cases} \tag{5}$$

where D is the number of dimensions of the composite well-being index (see Table 2). As in Segre *et al.* (2011) and Calcagnini and Perugini (2019a, b), the seven dimensions of the composite well-being index have equal weight. However, within each dimension, all the indicators have the same weight, which may be different from one dimension to another.

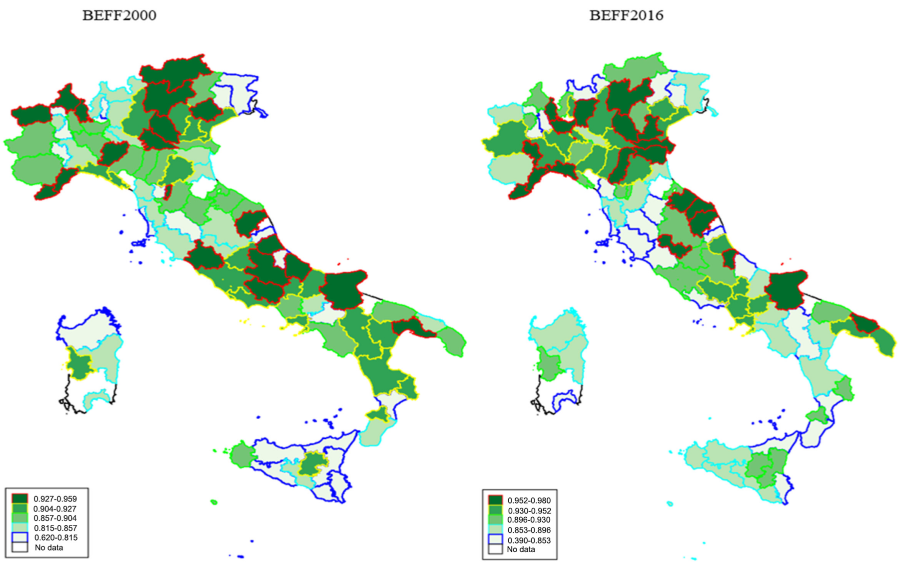
Parameters β_1 and β_2 indicate the inner-nest and the outer-nest elasticity of substitution between the various input matrices (M_d and Z_j respectively). In the literature, one of these parameters is frequently set to unity, in order to obtain a matrix with the input sample means. In this case, the elasticity of substitution is infinite and the dimensions are perfect substitutes. However, it is not reasonable to consider that the degree of substitutability between, for instance, “rights and citizenship” and “economy and labour” is the same as the degree of substitutability between “rights and citizenship” and “health”. In a composite index, each dimension represents a crucial aspect of a phenomenon. Consequently, perfect substitutability among dimensions may not be suitable. To overcome this specific issue, one can establish a degree of substitutability between dimensions by choosing $\beta_1 \neq 1$ and $\beta_2 \neq 1$. Decancq and Lugo (2013) suggested aggregating the normalised indicators within their respective dimension using equation (4) with a specific β_1 and then aggregating the dimensions once again, using equation (5) but setting $-1 \leq \beta_2 < \beta_1 \leq 1$. Therefore, a suitable composite well-being index can be achieved by democratically selecting the set of indicators, normalising and then aggregating these indicators to account for unbalanced adjustments between dimensions. The aggregation of indicators using the sample mean has been widely explored in the literature on composite indices, including studies on the determination of a well-being index in Italy. Therefore, the composite well-being index of this study has been defined as follow: by setting $\beta = [1\,0]$ we obtained the WIAG index (well-being index assessed by aggregating variables using arithmetic mean within dimensions and geometric mean among dimensions); setting $\beta = [0\,0]$ we obtained the WIGG index (well-being index assessed by aggregating variables using geometric mean both within dimensions and among dimensions); setting $\beta = [0\,1]$, we obtained WIGA index (well-being index assessed by aggregating variables using geometric mean within dimensions and arithmetic mean among dimensions) and setting $\beta = [0\,-1]$, we obtained the WIGH index (well-being index assessed by aggregating variables using geometric mean within dimensions and harmonic mean among dimensions). Since geometric and harmonic means cannot be computed from zero values, we set an external minimum value equal to min – ε and an external maximum value equal to max + ε, with $\varepsilon = 0.1$ (UN, 2016, p. 7). Figure B in Online Appendix shows variations and changes in each index of well-being for the 102 Italian provinces over the period 2000–2016. Figure C in Online Appendix also shows Italy’s composite well-being indices taken as the average of the 102 Italian provinces over the sampling period.

4. Empirical analysis

4.1 Preliminary analysis

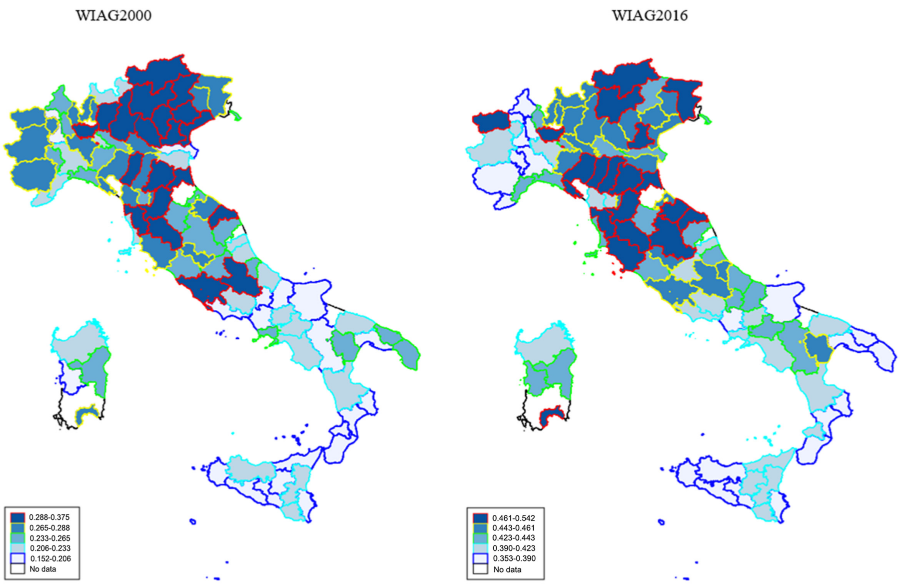
In the preliminary stage of our analysis, we presented graphically the main indicators at the beginning and at the end of the sampling period. Figure 1 depicts how public health efficiency changed in the years 2000 and 2016. Provinces with red borders are those with the highest levels of public health efficiency scores, while those with blue borders are those with the lowest levels of public health. It is evident that provinces with the highest levels of public health were unevenly distributed across the country in the years 2000 and 2016. The provinces of Aosta, Bolzano, Chieti, Frosinone, L’Aquila, Mantova, Piacenza, Prato, Taranto, Teramo, Treviso, Verbano-Cusio-Ossola and Viterbo lost efficiency in their local public health system in 2016. Conversely, Ancona, Asti, Bergamo, Brindisi, Ferrara, Genova, Milano, Modena, Padova, Pesaro Urbino, Pescara, Rovigo and Terni gained and became provinces with efficient local public health system. It is also apparent that the level of local public health systems increased over the sampling period. Foggia, Imperia, Macerata, Savona, Trento, Varese and Verona are provinces which maintained a higher level of their local public health system in 2000 and in 2016.

Figure 2 instead, shows how the composite well-being index changed in 2000 and in 2016. We concentrated on only one composite index, WIAG. Also in this case, provinces with red borders have a higher level of well-being, while those with blue borders have a lower level of well-being. It appears that provinces with relatively high levels of well-being are concentrated in the Centre–North, particularly in 2016. In 2016 the level of well-being increased in absolute value compared to 2000 in all 102 Italian provinces in our sample. In the ranking by deciles of



Source(s): Authors' own elaboration

Figure 1.
Public health efficiency scores BEFF in 2000 and 2016



Source(s): Authors' own elaboration

Figure 2.
The composite well-being index WIAG in 2000 and in 2016

the composite well-being index, we found that Bolzano, Firenze, Milano, Padova and Trento belonged to the first decile in 2016 and to the fifth decile in 2000 (See Table B in Online Appendix). We observed that this increase in absolute value was driven by the dimensions of environment, rights and citizenship, gender equity and in particular health and education. Five provinces with black borders were excluded from the sample in both Figures 1 and 2 because data for all the variables were not available for Gorizia and Barletta-Andria-Trani, Fermo and Monza e della Brianza were created in 2004 and Sud Sardegna was created in 2016.

4.2 Estimation

Given that the relationship between public health efficiency and well-being can suffer from reverse causation, we analysed the impact of the former on the latter using a two-stage least squares (2SLS) model. Following Reed (2015), we used the lagged value of public health efficiency scores as an instrument to avoid simultaneity and omitted variables bias. The empirical analysis was performed on a balanced panel of 102 Italian provinces for the period spanning 2000 to 2016 because data were available only for those years. The results show that the impact of public health efficiency on well-being across the Italian provinces is positive and statistically significant, meaning that an efficient and accountable public health system enhances the well-being of individuals and communities.

The empirical literature on how an efficient and accountable public health sector may affect people's well-being has grown substantially in recent years. The most convincing strategy for identifying causal effects considers variations in public health efficiency scores and well-being index data over time and within a given spatial entity. Tables 3 and 4 display, respectively, the descriptive statistics and the pairwise correlation matrix among the key variables of our model (Table C shows in Online Appendix the descriptive statistics by year of key variables of our model).

The composite well-being index WIAG correlates positively with public health efficiency, GDPPC, Taxes and population density. However, it correlates negatively with intergovernmental transfers. The variable time has a significant impact on the relationship between key variables and allows capturing and quantifying the direction and magnitude of

Table 3. Descriptive statistics of the main variables over the period 2000–2016

Variables	Obs	Mean	Std. Dev	Min	Max
WIAG	1,734	0.364	0.075	0.151	0.547
BEFF	1,734	0.878	0.069	0.39	0.99
GDPPC (€)	1,734	10.152	0.866	7.304	12.737
Taxes (100,000 €)	1,734	0.0005	0.0008	0	0.032
Transfers (100,000 €)	1,734	0.026	0.014	0	0.089
POPDENS (pop/km^2)	1,734	5.159	0.765	3.601	7.888
Time (year)	1,734	2,008	4.900	2,000	2,016

Source(s): Authors' own elaboration

Table 4. Pairwise correlation matrix of the key variables of the model over the period 2000–2016

	WIAG	BEFF	GDPPC	Taxes	Transfers	POPDENS	Time
WIAG	1.000						
BEFF	0.21***	1.000					
GDPPC	0.05**	0.13***	1.000				
Taxes	0.05**	0.04	−0.02	1.000			
Transfers	−0.08***	−0.2***	0.1***	−0.1***	1.000		
POPDENS	0.15***	0.13***	−0.33***	0.038	−0.15***	1.000	
Time	0.67***	0.10***	−0.032	0.05**	−0.05**	0.023	1.000

Note(s): Stars indicate the p-value: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$
Source(s): Authors' own elaboration

changes over the period 2000–2016. Table D in Online Appendix displays the pairwise correlation matrix between the composite well-being index WIAG and the 27 indicators used for its construction.

The primary objective was to assess the net effect of public health efficiency on well-being in the 102 Italian provinces from 2000 to 2016 using a two-stage least squares (2SLS) estimate to control for reverse causation and omitted variable bias. In this setting, the lagged value of public health efficiency was used as an instrument (Reed, 2015). We clustered the sample at provincial level to avoid heterogeneous and segmented data issues. In addition, we included time dummies in the model in order to control for time effects whenever unexpected changes or shocks may have affected the well-being of individuals and communities. The relationship between public health efficiency and well-being was thus defined as

$$WI_{it} = \alpha + \beta BEFF_{it} + X'_{it}\gamma + \mu_{it}, \tag{6}$$

where WI_{it} is the composite index of well-being (WIAG WIGG, WIGA and WIGH) in province i at time t; α is a constant which captures the correction factor included in the model comparison; $BEFF_{it}$ is the bootstrap public health efficiency score. μ_{it} is the disturbance term specified as a two-way error component model as

$$\mu_{it} = \varepsilon_i + \delta_t + \omega_{it} \tag{7}$$

ε_i denotes a province-specific effect, δ_t denotes a time-specific effect and ω_{it} the error term.

X'_{it} is a row vector of control variables which includes incomes, taxes, intergovernmental transfers and population density. These variables may impact on both the well-being index and the public health efficiency score, and their absence may lead to biased results in the estimation.

5. Results

Table 5 presents the first-stage regressions of the impact of public health efficiency on well-being across the Italian provinces with statistics robust to heteroskedasticity and clustered at the provincial level. The coefficient of the first lag of the main predictor of interest was positive and highly statistically significant. The Sanderson-Windmeijer (SW) first-stage χ^2 test and the F statistic test for under-identification and weak identification of individual endogenous regressors, respectively, indicated that the lagged value of order one of bootstrap-DEA public health efficiency (BEFF) is a valid instrument. Since there is only a single endogenous regressor, the SW statistic will be identical to the under-identification statistic provided by the Kleibergen-Paap rk Wald statistic in the second-stage regressions.

BEFF	Coeff
BEFF(−1)	0.382***
	(0.041)
F(1, 101)	86.64
	(0.000)
Sanderson Windmeijer Chi-sq(1)	88.53
	(0.000)
Sanderson Windmeijer F(1, 101)	86.64
	(0.000)
Num. obs	1,632

Note(s): Standard errors and p-values in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source(s): Authors' own elaboration

Table 5. First-stage regressions of the impact of public health efficiency on well-being

Table 6 reports the two-stage least squares (2SLS) estimates of the impact of public health efficiency on well-being across the Italian provinces in all four specification models. We concentrate on the first composite well-being index WIAG, the other specifications WIGG, WIGA and WIGH provide a check on the robustness of the 2SLS method. The public health efficiency coefficient is positive and statistically significant at 5% level in model (1). The public health efficiency coefficient 0.1 indicates the expected change in the expected value of the well-being index WIAG associated with a one-unit increase in the observation value *i* of bootstrap-DEA public health efficiency score (BEFF). The estimated GDPPC coefficient is positive and statistically significant at 10% level. This result is consistent with the findings of Sachs *et al.* (2012), who found a positive relationship between income and well-being in Japan and some European countries. The estimated coefficient of Taxes is higher, positive and highly statistically significant. This result is coherent with the findings reported by Lubian and Zarri (2011). Intergovernmental transfers (Transfers) and population density (POPDENS) are positively correlated with well-being and their coefficients are not statistically significant.

The Kleibergen-Paap rank Lagrange Multiplier (LM) test (the under-identification test) rejects the null hypotheses stating that models are identified. The test for weak identification is also important and necessary when the excluded instruments are only weakly correlated with the endogenous regressors. The Kleibergen-Paap Wald rank F statistics are greater than 10 for all specification models, meaning that the models are successfully identified. The restriction test for over-identification does not allow rejection of the null hypothesis of instrument validity. The endogeneity test confirms that our main regressor of interest is endogenous. Overall, these results support the causal interpretation that public health efficiency has a positive and significant impact on well-being in 102 Italian provinces.

6. Policy implications and conclusions

In a context of institutions weakened by an inefficient public administration, especially in the healthcare sector, an effective and efficient public health system undoubtedly contributes to

	(1) WIAG	(2) WIGG	(3) WIGA	(4) WIGH
BEFF	0.1**	0.09**	0.067*	0.14*
	(0.044)	(0.043)	(0.04)	(0.07)
GDPPC	0.027*	0.029**	0.04***	0.019
	(0.014)	(0.014)	(0.013)	(0.024)
Taxes	0.86***	0.83***	0.88***	0.75*
	(0.208)	(0.29)	(0.24)	(0.44)
Transfers	0.109	0.071	0.011	0.10
	(0.11)	(0.10)	(0.09)	(0.17)
POPDENS	0.097	0.24***	0.36***	0.13
	(0.06)	(0.064)	(0.055)	(0.11)
Kleibergen-Paap LM (*p*-value)	0.000	0.000	0.000	0.000
Kleibergen-Paap Wald rk F (stat.)	86.638	86.638	86.638	86.638
Endogeneity test-BEFF (*p*-value)	0.008	0.009	0.016	0.011
Num. observations	1,632	1,632	1,632	1,632
Province fixed effects	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes

Note(s): Cluster-standard errors and *p*-values in parentheses and $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source(s): Authors' own elaboration

Table 6.
2SLS estimates of the impact of public health efficiency on well-being

citizens' well-being. Everyone has the constitutional right to good health since it is a fundamental and basic need. In the analysis reported by this paper, public health efficiency was measured using bootstrap DEA, while the well-being index results were assessed by aggregating indicators linked to the local characteristics of Italian provinces. The public health efficiency scores and well-being index showed high variability among neighbouring provinces. An interesting finding of this study is that the decentralised health system in Italy and the resulting differentiation of health policy capacities have led to different health policy responses and outcomes, also in terms of well-being. We attempted to quantify the socioeconomic significance of our findings by predicting the increase of human resources in society determined by the positive impact of an effective and efficient public health system on well-being. We found that a one unit increase in public health efficiency leads to an increase in the expected value of the well-being index WIAG of 0.1 in each province per year.

The added value of this study is that it exploits, for the first time, a panel data constructed using well-being measures for a sample of 102 Italian provinces over the period 2000 to 2016. This allows for a more reliable estimation of the relationship between public health efficiency and well-being. Discussion is ongoing in Italy on how to organise the national health system so that it achieves its constitutional objectives in a sustainable and equitable way, and, by consequence, improves the well-being of citizens. Given the importance and sensitivity of the issue, policy and technical decision-makers need to rely on the output of rigorous scientific studies.

Many studies have shown that concrete measures can be taken to promote and support an effective and efficient public health sector, thereby improving people's well-being by enhancing their self-expression, civic and democratic participation, autonomy, freedom and sense of belonging to their community (Picchio and Santolini, 2020; Signorelli *et al.*, 2020).

The use of the sample mean, arguably the oldest and most used method for the aggregation of indicators, may suffer from variable compensation, resulting in misleading results. Furthermore, the loss of information caused by using lagged values of the main predictor of interest as instruments in the instrumental variables setting may also be considered a limitation.

Future research should consider health expenditure as an input to a production process, and the relative well-being achieved as an outcome, and investigate the relationship between health expenditure and well-being through non-parametric analyses that take reverse causation into account.

Notes

1. By large area in Italy, we mean the administrative level of provinces and metropolitan cities.
2. BCC refers to Banker *et al.* (1984), who introduced the model.
3. The software used to evaluate public health efficiency scores was *DEAR* (*Rstudio to compute DEA*) with *benchmarking*, *psych* and *readxl* packages.

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Appendix

The supplementary material for this article can be found online.

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