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Public Health Efficiency and well-being in Italian province

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Abstract

Health is a fundamental human right, and good health is an essential component of well-being; therefore, an efficient public health system is required to achieve well-being in society. This paper analyses the relationship between public health efficiency and well-being considering a panel of 102 Italian provinces from 2000 to 2016. The results show that public health efficiency enhances well-being in Italian provinces, especially in the North. The findings could help policymakers adopt measures to strengthen the public health system, encourage private providers, and inspire countries worldwide.

JEL Class.: C33, C36, H75, I31, J58.

Keywords: public health efficiency index, bootstrap-data envelopment analysis, well-being index, min-max linear transformation, Italian provinces

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1 Introduction

In recent years, a consensus emerged that the measures of progress and prosperity traditionally used in economics, such as gross domestic product per capita (GDP-PC), is no longer suitable for such purposes (Stiglitz et al., 2014). GDP-PC 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 to 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 need to be considered in addition to economic factors. The state of well-being in humans entails biological, psychological and social aspects, all of which contribute towards characterizing the quality of life, lifestyle, and the living conditions of individuals, both within and between 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, environment and security dimensions that shape people's well-being. Health is an exceptional and fundamental component of well-being and the increase in health care expenditure in Italy is accompanied by an improvement in the health status of individuals (Piacenza and Turati, 2014).

A recent strand of literature analyses the relationship between psychological health and well-being during the COVID -19 pandemic in Italy. The specificities of the COVID -19 pandemic, as well as the restrictive measures taken to combat it, lead to experiences of stress, anxiety, and severe personality disorders that affect people's health and well-being (Antonicelli et al., 2020). Several studies show that adolescents and young adults were among the people most at risk of negative psychological consequences during the pandemic, even in the long term (Matranga et al., 2020; Renati et al., 2023). It should be noted that the central government is intervening because the pandemic is primarily a public health issue.

An effective and accountable public health system is paramount because people generally face 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 et al., 2012). All of 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 fall of 2009 and spring of 2010 in 39 European countries as part of a cross-national collaborative study, Currie et al. (2012) show 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, affecting issues such as mental health, the development of health complaints, tobacco and alcohol use, diet, and physical activity. For an interesting contribution see Matranga et al. (2020).

This paper aims to make a step forward in filling the gap 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 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 could increase the general well-being of people. The current study hypothesises 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, higher efficiency and accountability in the public health sector leads to higher labour productivity, which in turn generates better economic development (Well, 2007). 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 the present paper is original because no study analyses the relationship between an efficient and accountable public health system and the well-being of individuals and communities in a panel of 102 Italian provinces over the period 2000 to 2016. We measure public health efficiency using a bootstrap data envelopment analysis with 3000 replicates at a 95% confidence interval. Then, we assess well-being by the means of the min-max linear scaling transformation technique. Finally, we investigate the relationship between public health efficiency and well-being through the two-stage least squares model, a good tool for addressing the issues of reverse causation and omited variables bias. In accordance with 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 increase the well-being of individuals and communities across the Italian provinces, especially in the North. In other words, provinces with inefficient public health system are also those with less well-being, there are mainly located in the south. The robustness check also holds when dynamic panel data analysis is performed, using a two-step system GMM, to mitigate the criticalities of the instrumental variables model.

This article is organized as follows. Section 2 presents the theoretical literature. Section 3 illustrates the data source and methodologies. Section 4 presents the empirical analysis. Section 5 reports and discusses the main resultss and their implications for policymaking. Section 6 concludes.

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). There are six dimensions that 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 defines the government's ability and capability to introduce and implement sound policies that have a positive impact on the economic system. Shen et al. (2018) rely on the quality of governmental authorities to maximize government efficiency and economic growth. The main goal is to improve people's well-being in their communities. Fonchamnyo and Sama (2016) note 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 argue for 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, Guisan et al. (2010) highlight the positive impact of education and health on government efficiency and economic policies, in order to improve the well-being of people in countries around the world. Zagler and Dürnecker (2003) focus on the health care system, claiming that an efficient and accountable health care system reduces disease and increases the quality of labour to improve economic growth and ultimately increase the well-being of individuals and communities.

Good health is essential for achieving well-being in society. Von Heimburg and Ness (2021) emphasized 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 and Smith (2020) argued that the well-being agenda was affecting health policy because good health is a key dimension of well-being and shifting policy focuses away from traditional economic measures aimed at social well-being could lead to increased 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 exacerbated inequalities in health and consequently well-being within and between countries. Von Heimburg and Ness (2021) followed the principle of "health and well-being for all" and "leaving no one behind" and argued that relational well-being was a kind of intersection between the welfare state, democracy, and human relations which reinforced social justice and public values in social development. Matranga et al. (2020) document a positive impact of healthy behaviours, with particular attention to diet, physical activity, alcohol and tobacco abuse, on well-being and recommend building, developing and maintaining individual skills as a means to successfully counteract risky behaviours for health.

Understanding the causal effect of improved public health efficiency on the well-being of individuals and communities is important for policymakers not only for designing 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 acheive greater well-being (Bloom et al., 2004; Well, 2007). Using a panel of developing and developed countries observed every 10 years over the period 1960-1990, Bloom et al. (2004) find that a one-year improvement in health, as measured by life expectancy, contributes to a 4% increase in total product, which has a positive effects on the overall well-being. Well (2007) instead relies on the fact that improvements in health status increase the incentive to acquire schooling and skills that contribute to better labour productivity, greater economic development 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, analysing 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 to make decisions about the allocation of tax revenues lead regional health authorities to be more responsible in their spending decisions and thus tailor their health interventions to the needs of their local populations, thereby improving their well-being.

Hypothesis: Public health efficiency should increase the well-being of individuals and communities across Italian provinces.

3 Data and methodology

3.1 Data

The following data sources were pooled for the empirical analysis: Health for All - National Institute of Statistics (Istituto Nazionale di Statistica - ISTAT), and the Organization for economic Co-operation and Development (OECD), from which data were collected from five inputs and two outputs at provincial level. A multi-input and multi-output production process was used to assess the efficiency of the public health system. All inputs and outputs were selected based on a critical review of the inputs and outputs used in previous studies (Levaggi and Zanola, 2004; De Nicola et al., 2012, 2014). Table 1 reports the descriptive statistics for the input-output variables, while Table 2 presents the same descriptive statistics for all the well-being index indicators, divided according to their respective dimensions (Environment, Economy and labour, Health, Righs and citizenship, Education and training, Gender equity and equal opportunity, Democratic participation). The composite well-being index was generated by aggregating all 27 indicators gathered also at provincial level. As the magnitudes of the indicators and their units of measurement differ from one another, the data were subjected to a process of normalization. The dimensions aggregated to form the well-being index are all equally important and have equal weight. It should be noted that the Italian provinces have been shown to provide a homogeneous sample for the comparison of health care service production (De Nicola et al., 2012, 2014) and for the assessment of well-being (Calcagnini and Perugini, 2019a,b).

3.2 Efficiency index

In the Italian context, the national health service (NHS) is provided at the provincial level, while the regions provide the necessary resources to finance the services. The Italian NHS consists of three levels of decision-making: the central government, the 21 regions, and the local health units (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, as they contribute to the design and

[1]By large area in Italy, we mean the administrative level of provinces and metropolitan cities.

Table 1: Descriptive statistics for the input-output variables

Variable	Obs	Mean	Std.dev.	Min	Max
physicians	1734	1184.47	1617.88	23	12838
nurses	1734	2586.23	3154.17	25	24586
hospital beds	1734	2113.63	2565.84	194	22953
pulmonary ventilator	1734	145.47	169.26	0	1326
anesthesia machine	1734	85.47	106.54	0	810
active mobility	1734	598118.80	757690	58524	6934141

Source: Health for All database

Table 2: Descriptive statistics for the Well-being Index indicators

Variable	Obs	Mean	Std. dev.	Min	Max
Environment					
Population density	1734	250.06	333.75	36.63	2663.88
Waste recycling	1734	31.35	20.11	0.44	87.85
Motorization rate	1734	634.75	146.31	411.20	2455.21
Public transport	1734	88.64	109.46	2.98	790.62
Urban green	1734	122.66	322.74	0.20	2943.63
Urban density	1734	6.61	9.91	0.06	71.86
Air quality	1671	3.49	3.44	0.20	23.386
Economy and Labour					
Unemployment rate	1734	9.40	5.87	1.30	31.50
Theil index	1734	0.61	0.20	0.10	1.00
Financial risk	1734	2.70	2.09	0.16	24.43
Health					
Fertility rate	1734	1299.83	155.47	289.00	4181.00
Mortality rate	1428	104.07	15.63	51.80	153.79
Female life expectancy	1734	83.96	1.08	79.94	86.44
Male life expectancy	1734	78.68	1.43	74.22	82.04
Rights and Citizenship					
Electricity interruption	1734	2.53	1.49	0.40	14.57
Migrant rate	1734	0.05	0.04	0.004	0.16
Children service	1428	12.88	7.52	0.30	40.30
Home assistance	1428	1.63	1.14	0.10	9.30
Crime	1326	0.97	2.49	0.00	83.14
Education and Training					
Diploma	1326	54.12	7.68	30.90	73.00
Graduation	1326	18.91	5.27	5.30	37.50
Formation	1326	6.43	1.84	2.40	16.70
Gender equity and Equal opportunity					
Young	1326	20.528	8.546	4.600	46.200
Equity	1428	20.61	6.21	6.11	41.95
Female administrator	1326	20.70	7.11	4.80	40.20
Democratic participation					
Municipal administrator	1326	31.06	5.07	16.00	46.40
Voter turnout	1224	66.87	9.57	20.00	82.94

Source: ISTAT and OECD database

implementation of policies that affect people's lives, as they are responsible for the implementation of decentralization policies, for example in education, health, culture and transport (Taralli et al., 2015).

To assess the efficiency of public health, we used a non-parametric frontier approach based on a linear programming framework, namely data envelopment analysis (DEA). This method is widely accepted across all disciplines for benchmarking studies. To measure technical efficiency, defined as the ability of Italian provinces to produce a given quantity of outputs with minimal inputs, we applied the input-oriented variable returns to scale model BCC-DEA.[2] The efficiency scores were calculated with respect to an empirical frontier, and a province was considered technically efficient if it lays on the frontier and had a score of one. In the DEA method, measurement error was not taken into account, and the corresponding efficiency measures were sensitive to sample variations in the determined frontier since the statistical estimators of the frontier were obtained from a finite sample (Simar and Wilson, 1998). The bootstrap method constitutes the most suitable tool to analyse the sensitivity of the measured efficiency values to sample fluctuations. To remove any inefficiencies, we applied a consistent bootstrap procedure with 3000 replications at a 95% confidence interval to obtain the sampling distribution of efficiency values and then correct for bias.

3.3 Well being indices

Following the method of Bacchini et al. (2020), the composite well-being index is defined by a real function $\boldsymbol{\mathcal{M}}(\cdot)$ on a sequence of data matrices $\mathbf{A}_j$, where $j = 1, 2, \ldots, k$ refers to a single indicator in Table 2; since each matrix $\boldsymbol{A}_j$, containins n rows (Italian provinces) and T columns (years), for each Italian province and each year we can compute a composite well-being index (Decancq and Lugo, 2013, p. 11) as follows

$$\boldsymbol{\mathcal{M}}(\boldsymbol{A}_1, \boldsymbol{A}_2, \ldots, \boldsymbol{A}_k; \boldsymbol{\beta})\colon \mathbb{R}^{2+(n\times T\times k)} \longmapsto \mathbb{R}^{n\times T}, \tag{1}$$

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

In order to normalize data of well-being indices, we calculated the transformed achievements $\boldsymbol{A}_j$ by the means of the min-max linear scaling transformation technique. In Italy, many scholars use the Adjusted Mazziotta-Pareto

[2]BCC refers to Banker et al. (1984), they introduced the model.

Index (AMPI), a specific form of the min-max linear scaling transformation technique (Bacchini et al., 2020). For an earlier contribution on this approach, see Tarantola et al. (2008). Let a_{it}^{j} be the the element of $\boldsymbol{A}_j$ related to the i-th province for the t-th year, the normalization scheme applied in this study consists of defining a set of matrices $\boldsymbol{Z}_j$ of dimensions $n \times T$ whose each element is

$$z_{it}^{j} = \frac{a_{it}^{j} - m_j}{M_j - m_j}, \tag{2}$$

where $m_j = \min\{a_{it}^{j}\}$ and $M_j = \max\{a_{it}^{j}\}$ for each $i = 1, 2, \ldots, n$ and $t = 1, 2, \ldots, T$. In the case that an increase in the normalized indicator corresponds to a reduction in overall well-being, equation (2) is modified according to the complementary formula

$$z_{it}^{j} = \frac{M_j - a_{it}^{j}}{M_j - m_j}. \tag{3}$$

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

The transformed data enter equation (1), therefore the $n \times T$ matrix containing the well-being index for each Italian province and each year is obtained by using the Nested Constant Elasticity of Substitution (NCES)

$$\boldsymbol{\mathcal{M}}(\boldsymbol{Z}_1, \boldsymbol{Z}_2, \ldots, \boldsymbol{Z}_k; \boldsymbol{\beta}) = \begin{cases} \left[k^{-1} \sum_{d=1}^{D} w_d \boldsymbol{M}_d^{\beta_2} \right]^{1/\beta_2} & \text{for } \beta_2 \neq 0 \\ \bigodot_{j=1}^{k} \boldsymbol{M}_j^{w_d/k} & \text{for } \beta_2 = 0, \end{cases} \tag{4}$$

where D is the number of the dimensions of well-being index indicators (see Table 2), and w_d is the number of such indicators in the d-th dimension with $\sum_{d=1}^{D} w_d = k$. The symbol "$\bigodot$" indicates the Hadamard product,[3] therefore

[3]The Hadamard product performs the element-by-element product between two (or more) matrices with the same dimensions.

the second equation can be seen as a matrix generalization of the Cobb-Douglas function. Technically, equation (4) returns a $n \times T$ matrix whose each element is the composite well-being index calculated as a mean of order β of the different matrices $\boldsymbol{M}_d$ defined as

$$\boldsymbol{M}_d = \begin{cases} \left[w_d^{-1} \sum_{j=1+J_{d-1}}^{J_d} \boldsymbol{Z}_j^{\beta_1} \right]^{1/\beta_1} & \text{for } \beta_1 \neq 0 \\ \bigodot_{j=1+J_{d-1}}^{J_d} \boldsymbol{Z}_j^{1/w_d} & \text{for } \beta_1 = 0, \end{cases} \tag{5}$$

where $J_d = \sum_{r=1}^{d} w_r$, and $J_{d-1} = 0$ when $d = 1$.

Parameters β_1 and β_2 indicates the inner-nest and the outter-nest elasticity of substitution between the various inputs matrices ($\boldsymbol{M}_d$ and $\boldsymbol{Z}_j$ respectively). In the literature, frequently one of these parameters is 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 grade of substitutability between, for instance, "rights and citizenship" and "economy and labour" is the same as the grade of substitutability between "rights and citizenship" and "health". In a composite index, each dimension represents a crucial aspect of a phenomenon; so, perfect substitutability among dimensions may not be suitable. To overcome this specific issue, we can establish a grade of substitutability between dimensions by choosing $\beta_2 \neq 1$. Decancq and Lugo (2013) suggested aggregating the normalized indicators within their respective dimension using equation (5) with a specific β_1 and then aggregating the dimensions obtained once more using equation (4) but setting $\beta_2 < \beta_1 < 1$. Therefore, a suitable composite well-being index can be achieved by first normalizating and then aggregating the indicators to account for unbalanced adjustments between dimensions.

As mentioned in section 3.1, the aggregation of indicators using the sample mean is widely explored in the literarture on composite indices, including studies on the determination of a well-being index in Italy.

4 Empirical analysis

4.1 Preliminary analysis

In the preliminary stage of the this study, we define two indices of well being using the aggregation techniques illustrated in section 3.3. Specifically, setting $\boldsymbol{\beta} = [1\ 0]$ we obtain the first WIAG index (average and geometric mean), while setting $\boldsymbol{\beta} = [0\ -1]$ we obtain the WIGH index (geometric and harmonic mean).

Figure 1 depicts the averages of public health efficiency scores (map a) and well-being index (map b) for the Italian provinces from 2000 to 2016. Provinces with red borders have higher levels of efficiency in the public health system and higher levels of well-being, while those with blue borders have lower levels of efficiency in the public health sector and lower levels of well-being.

The provinces with the most efficient public health services are: Bologna, Brescia, Brindisi, Crotone, Ferrara, Genova, Isernia, Mantova, Modena, Parma, Piacenza, Savona, Terni, Taranto, Torino, Varese and Verona.

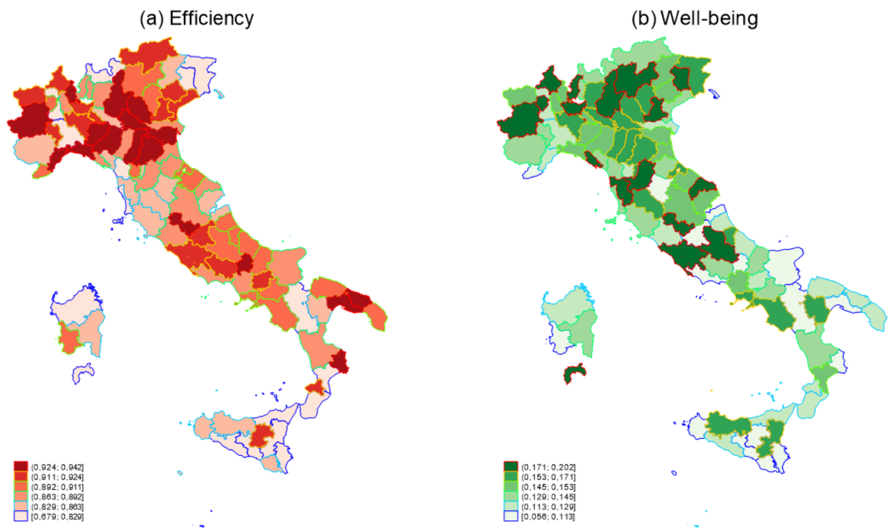
The provinces found to have the highest levels of well-being were: Ancona, Biella, Brescia, Cagliari, Como, Firenze, L'Aquila, La Spezia, Milano, Padova, Pisa, Pordenone, Roma, Terni, Trento, Torino and Verbano-Cusio-Ossola.

It should be noted that the provinces of Brescia, Terni and Turin appear in both the aforementioned lists.

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 due to the availability of data for these years only. The results show that the impact of public health efficiency on well-being across the Italian provinces is positive and highly statistically significant, meaning that an efficient and accountable public health system enhances the well-being of individuals and communities in Italian provinces, especially in the

Figure 1: Public health efficiency and well-being indexes (Average of 2000 - 2016)



north. These results also held when a dynamic analysis was performed using the two-step system GMM model.

The empirical literature on how an efficient and accountable public health sector may affect people's well-being has grown substantially over recent years, mainly as a response to the COVID-19 pandemic (Karnon, 2020). 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. The dependent variable is the well-being index, which varies within the range [0 ; 0.5], and the main predictor is public health efficiency, which varies within the range [0.39 ; 0.99]. 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 (i.e. that the equitable and sustainable well-being of individuals and communities might give rise to an effective public health sector) and omitted variable bias. In other words, we used 2SLS to estimate the causal effect of public health efficiency on well-being, free from asymptotic bias due to unobserved time-varying heterogeneity. In this setting, the lagged value of public health efficiency was used as an instrument (Reed, 2015). A robust standard error was also employed to control for correlations between provinces. To control for province-and time-specific effects, we clustered the sample of 102 provinces to reduce the risk of bias due to omitted variables. In addition, we included time dummies in the model 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 follows

$$\mathrm{WI}_{it} = \alpha + \beta \mathrm{BEFF}_{it} + \boldsymbol{X}'_{it}\gamma + \mu_{it}, \tag{6}$$

where WI_{it} is the index of well-being (WIAG or 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 error term clustered at the provincial level; and $\boldsymbol{X}'_{it}$ is a row vector of control variables.

The vector of control variables includes incomes, taxes, intergovernmental transfers, and population density. These variables may impact both the well-being index and the public health efficiency score, and their absence may lead to biased results in the estimation. The impact of income on well-being is a controversial issue (Easterlin, 2003; Easterlin et al., 2010). Bartolini et al. (2013) found that declining well-being is mainly predicted by income growth. They highlighted that the sum of the negative changes in well-being predicted by income growth more than compensates for the positive change predicted by income growth. Easterlin et al. (2010) also demonstrated that increased income does not increase well-being. Sacks et al. (2012), on the other hand, challenged Easterlin's findings by examining the relationship between income and well-being in Japan, European countries and the United States, and found a positive correlation in Japan and European countries, but a negative correlation in the United States.

The relationship between taxes and well-being was an important finding brought to light in the field of neuroeconomics (Harbaugh et al., 2007). In fact, the intrinsic motivation of taxpayers to pay taxes constitutes a new determinant of well-being in the sense that tax honesty generated a greater payoff than fraud for virtuous taxpayers compared to less virtuous ones (Lubian and Zarri, 2011). However, a number of studies have found a negative relationship between average levels of fiscal morale and the size of the shadow economy. People are unwilling to pay taxes when they believe that government officials spend money inefficiently and sometimes use it for personal gain. They also deem not paying taxes to be legitimate when the taxes are considered to be unjust. In Italy, the national health service and its various departments are funded by general taxation and transfers from the central government.

Moreover, intergovernmental transfers performed under the so-called *capacity equalization* scheme might also affect public health efficiency and well-being in Italy. The overall aim is to provide each level of government with sufficient funds, obtained from its own sources plus transfers, to deliver a more or less equal level of goods and services (Bird and Tarasov, 2004) in areas such as health, education, public transportation, economic development and welfare.

The literature has largely established the population growth rate to be higher in urban areas than in rural areas in all developed countries, and that urban areas have long been considered more appealing due to the presence of firms and, as a result, employment. Despite high congestion costs in Italy, the low magnitude of Italian urbanization and its geography has favoured an acceptable trade-off between urban population density and well-being. Indeed, Accetturo et al. (2019) argued that Italy's largest urban areas have a lower population share compared with those in Spain, France, Germany and the United Kingdom.

Table 3: Descriptive statistics of the main variables

Variable	Obs	Mean	Std.dev.	Min	Max
WIAG	1734	0.28	0.06	0.1	0.45
WIGH	1734	0.14	0.05	3.0e-5	0.5
BEFF	1734	0.88	0.069	0.39	0.99
GDPPC	1734	10.15	0.86	7.30	12.74
Taxes	1734	0.48	0.79	0.004	32.28
Transfers	1734	0.26	0.14	0	0.89
POPDENS	1734	250.06	333.75	36.63	2663.88

Table 3 reports the descriptive statistics of the main variables of the model where: WIAG is the composite well-being index obtained by aggregation using the sample means within dimensions and the geometric means between dimensions; WIGH is the composite well-being index obtained by aggregating the geometric means within dimensions and the harmonic means between dimensions; BEFF is the bootstrap-DEA public health efficiency score; GDPPC is the gross domestic product per capita; POPDENS is the population density.

5 Results

5.1 Baseline results

In the preliminary setting, we obtained the composite well-being index by aggregating the indicators within their respective dimensions using the sample mean and then aggregating the dimensions using the geometric mean. Table 4 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 the under-identification and weak identification of individual endogenous regressors, respectively, both indicated the lagged value of order one of BEFF (L.BEFF$_{it}$) to be 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. For more details see Sanderson and Windmeijer (2016).

Table 4: First-stage regressions of the impact of public health efficiency on well-being

BEFF	Coeff
L1.BEFF	0.398***
	(0.034)
F(1, 101)	135.95
	(0.000)
Sanderson Windmeijer Chi-sq(1)	137.30
	(0.000)
Sanderson Windmeijer F(1,101)	135.95
	(0.000)
Num.Obs	1632

Standard errors and p-value in parentheses and * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 reports the two-stage least squares (2SLS) estimates of the impact of public health efficiency on well-being across the Italian provinces. We emphasized that the well-being index (WIAG) derives from the aggregation of the indicators within the respective dimensions using the sample mean, while the aggregation of dimensions takes place through geometrical mean. Model (1) was estimated without controlling for the other well-being determinants. The public health efficiency coefficient was positive and highly statistically significant. The coefficient 0.53 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).

Table 5: 2SLS estimates of the impact of public health efficiency on the well-being index (WIAG)

	(1)	(2)	(3)	(4)	(5)
BEFF	0.532***	0.528***	0.529***	0.527***	0.427***
	(0.134)	(0.136)	(0.135)	(0.136)	(0.124)
GDPPC		-0.281***	-0.280***	-0.275***	-0.205***
		(0.0831)	(0.0831)	(0.0841)	(0.0760)
Taxes			4.091***	4.055***	3.305***
			(1.269)	(1.272)	(0.972)
Transfers				-20.51	-15.11
				(30.45)	(29.13)
POPDENS					1.951***
					(0.488)
K-P LM	39.148	39.148	39.139	38.875	37.886
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
K-P Wald	137.373	137.373	137.245	135.148	130.473
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Num.Obs	1632	1632	1632	1632	1632

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

K-P: Kleibergen-Paap

Column (2) presents the results after controlling for incomes (GDPPC). The estimated GDPPC coefficient was negative and highly statistically significant in all model specifications. This result contradicts the findings reported by Sacks et al. (2012), who created a time series and discovered a positive relationship between income (GDPPC) and well-being in Japan and many European countries. This result also seems to be consistent with Easterlin's view. Column (3) shows the estimated coefficient of taxes (Taxes in thousands) to be positive and highly statistically significant in all model specifications. This result is consistent with the findings reported by Lubian and Zarri (2011). Column (4) shows variable transfers (Transfers in thousands) to be negatively correlated with well-being, although its coefficient is not statistically significant. Column (5) shows population density (POPDENS in thousands) to be positively correlated with well-being, with a highly statistically significant coefficient. This finding is consistent with the results reported by Accetturo et al. (2019).

The Kleibergen-Paap rank LM statistics (the under-idenfication test) reject the null hypotheses stating that models are identified. The test for weak identification is also important, which occurs when the excluded instruments are only weakly correlated with the endogenous regressors. In this case, the estimators performed rather poorly and the Cragg and Donald test for weak instruments was proved to be invalid, whereas the Kleibergen and Paap Wald rank F statistic was found to be robust and, therefore, appropriate. Since the values of these statistics were greater than 10 for all specification models, the models were successfully identified. The restriction test for over-identification did not allow the null hypothesis of instrument validity to be rejected. Overall, the results support the causal interpretation that public health efficiency has a positive impact on well-being.

In the following setting, the well-being index derives from the aggregation of the indicators within the respective dimensions through the geometric mean, while the aggregation of the dimensions takes place through the harmonic mean. The principal reason for this is to avoid some weaknesses and criticalities arising from aggregating indicators through the sample mean, which suffers from variable compensation and is unable to deal with outliers. Table 6 shows the coefficient of the main predictor of interest to be positive and highly statistically significant in all model specifications. Its coefficient (0.24) is approximately half the value obtained in the preliminary estimate. Some results seem to be counter-intuitive and call for clarifications, which can be provided using the correlation matrix constructed using the key variables. Table 7 shows the presence of a positive correlation between BEFF and GDPPC (0.126), BEFF and WIAG (0.18), BEFF and WIGH (0.095), and a negative correlation between GDPPC and WIAG (-0.047), and GDPPC and WIGH (-0.061). These results also prove this method as appropriate for assessing indices of well-being and obtaining credible findings.

Table 6: 2SLS estimates of the impact of public health efficiency on the well-being index (WIGH)

	(1)	(2)	(3)	(4)	(5)
BEFF	0.240***	0.239***	0.239***	0.239***	0.195***
	(0.0710)	(0.0694)	(0.0694)	(0.0696)	(0.0653)
GDPPC		-0.118***	-0.117***	-0.116***	-0.0852**
		(0.0416)	(0.0416)	(0.0416)	(0.0379)
Taxes			2.348***	2.340***	2.014***
			(0.630)	(0.631)	(0.507)
Transfers				-4.693	-2.348
				(19.76)	(19.50)
POPDENS					0.847***
					(0.264)
K-P LM	38.860	39.050	39.041	38.760	37.837
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
K-P Wald	134.498	135.619	135.493	133.628	129.021
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Num.Obs	1632	1632	1632	1632	1632

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

K-P: Kleibergen-Paap

Table 7: Correlation matrix of the key variables

Variable	WIAG	WIGH	BEFF	GDPPC	Taxes	Transfers	PODENS
WIAG	1.000						
WIGH	0.735	1.000					
BEFF	0.18	0.095	1.000				
GDPPC	-0.047	-0.126	-0.016				
Taxes	0.055	0.058	0.039	-0.021	1.000		
Transfers	-0.116	-0.121	-0.211	0.106	-0.122	1.000	
POPDENS	0.105	0.145	0.108	-0.239	0.014	-0.046	1.000

5.2 Robustness Checks

The two-step system GMM estimators seem suitable since they account for the extra variance arising from the unobserved fixed effects. Moreover, if endogenous regressors are present, serial correlation might still affect the first admissible lag for the instruments and, therefore, indicate the appropriateness of a dynamic panel model to avoid omitted variables bias. This study applied a two-step system GMM with a doubly corrected robust variance estimator (Hwang et al., 2022).

Table 8: Two-step system GMM estimte of the impact of public health efficiency on well-being

WIGH	Coefficient	DC-Robust std.err.	t	P>|t|	95% conf.	interval
L.WIGH	0.783	0.422	1.85	0.067	-0.054	1.620
BEFF	0.04	0.021	1.91	0.059	-0.015	0.081
GDPPC	-0.153	0.346	-0.44	0.659	-0.841	0.534
Taxes	1.335	0.386	3.46	0.001	0.57	2.10
Transfers	-14.08	21.38	-0.66	0.512	-56.49	28.33
PODENS	-0.46	0.483	-1.05	0.296	-1.33	0.41
Constant	1.671	3.524	0.47	0.636	-5.319	8.66

(Std. err. adjusted for 102 clusters in code_provinces)

Number of instruments used in the two-stage system GMM: 8 namely (L1.BEFF, L2.BEFF, L3.BEFF, BEFF, Taxes, Transfers, POPDENS and Constant)

Number of group: 102 provinces

Arellano-Bond test for autocorrelation of the first-differenced residuals
H0: no autocorrelation of order 1 z=-2.0298 Prob(|z|)= 0.0424
H0: no autocorrelation of order 2 z=1.5069 Prob(|z|)= 0.1318

Sargan-Hansen test of the overidentifying restrictions
H0: overidentifying restrictions are valid
2-step moment functions, 2-step weighting matrix $\chi^2(1) = 1.5152$ $Prob(\chi^2) = 0.2183$
2-step moment functions, 3-step weighting matix $\chi^2(1) = 1.9648$ $Prob(\chi^2) = 0.1610$

Table 8 reports the results of the two-step system GMM estimation, which confirm the results obtained in the previous subsection through the method of instrumental variables (two-stage least squares). As can be seen, we emphasized that the number of instruments (8) is lesser than the number of provinces (102). The Arellano-Bond test for autocorrelation of the first-differenced residuals indicates there to be no omitted dynamics or omitted lags for the regressors. The Sargan-Hansen test of overidentifying restrictions indicates the results obtained through the two-step system GMM to be consistent. Therefore, the two-step system GMM with a doubly corrected robust variance estimate is able to deal with the problem of omitted variables bias.

5.3 Policy implications

Our findings highlight the importance of good institutions and policy interventions aimed at promoting a healthy lifestyle, providing sane and clean urban and rural environments, and guaranteeing an efficient and affordable health system for all in order to achieve an acceptable level of overall well-being. To attain this goal, different resources may be useful. First, medical associations representing the views of doctors, nurses and hospital staff are calling for increased investment in the health sector in order to improve the efficiency of the public health care service. This means increasing the number of health facilities and the availability of equipment, hiring more medical professionals and promoting training programs for health personnel. Second, patients, citizens and their stakeholders are demanding greater access to health services in both urban and rural areas. For the sake of equity and sustainability, the central government must subsidise the cost of health services for low-income people, and drastic budget constraints for health care workers must be balanced by increased performance and efficiency in the delivery of health services. Third, citizens must also be made aware of the necessity to adopt a healthy lifestyle for good health, and the government must encourage them to do so by promoting campaigns on healthy eating, regular physical activity and the impact of lifestyle upon health. Finally, an adequate mental health care service is also fundamental for guarranteeing the well-being of citizens. Indeed, investment in mental health programs is of paramount importance, especially after two years of forced closures due to the COVID-19 pandemic, during which specialists reported a huge increase in mental disorders. Overall, health and health system must be understood not only as the result of medical procedures, but also as the result of external influences such as nutrition, environmental pollution, personal lifestyle and education.

Our findings may be applied and generalized first in European countries and in other different contexts, e.g., in underdeveloped and developing countries with different institutional structures and different population needs because health is a constitutional right in almost all countries worldwide and necessary to achieve a higher level of well-being.

6 Conclusion

In a context of weak institutions caused by inefficient public administration, especially in the health care sector, an effective and efficient public health system undoubtedly contributes to citizens' well-being. Everyone has the constitutional right to good health, being a fundamental and basic need. In this study, public health efficiency was measured by means of bootstrap data envelopment analysis, while the well-being index results were assessed by aggregating indicators linked to the local characteristics of the territories. The public health efficiency scores and well-being index show high variability among neighbouring provinces. An interesting finding of this study is that the decentralized 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 relevance of our findings by predicting the increase in human resources in society determined by the positive effect of an effective and efficient public health system on overall 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 indices WIAG (0.53) and WIGH (0.24) in each province per year.

The added value of this work is exploiting, for the first time, a panel data which is 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. Discussions are being carry out in Italy on how to implement the national health system to achieve its constitutional objectives in a sustainable and equitable way and, by consequence, improve the well-being of its 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 the use of 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 in a production process, and the relative well-being achieved as an outcome, and investigate the relationship between health expenditure and well-being by means of non-parametric analyses that take reverse causation into account.

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