



Modelling Economic Policy Issues

Health vs. wealth? A managerial effectiveness analysis of the COVID-19[☆]Claudio Thieme^a , Víctor Giménez^b, Diego Prior^b, Emili Tortosa-Ausina^c *^a Department of Management, Universidad Diego Portales, Av. Santa Clara 797, Huechuraba, Santiago de Chile, Chile^b Department of Business, Universitat Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain^c Department of Economics, IIDL and Ivie, Universitat Jaume I, Campus del Riu Sec, 12071, Castelló de la Plana, Spain

ARTICLE INFO

JEL classification:

C61
H51
I18

Keywords:

Composite indicators
COVID-19
Data envelopment analysis
Managerial effectiveness
Robust conditional convex frontier models

ABSTRACT

This study evaluates the effectiveness of 104 countries in managing the COVID-19 pandemic during the period 2020–2022. We integrate health and economic outcomes through a bidimensional approach combining excess mortality and GDP variation indicators. The estimation method defines directional distance functions within a robust conditional Benefit-of-the-Doubt framework that incorporates the dynamic perspective of Mastromarco and Simar (2015). Results show that joint managerial effectiveness improved progressively while health and economic orientations behaved orthogonally, challenging structural trade-off assumptions, with nearly 90% of countries adopting balanced strategies by 2022, reflecting institutional adaptation rather than deliberate optimization. Quantile regression analysis reveals dynamic effectiveness determinants varying by phase: hospital capacity and participatory legitimacy proved critical in 2020, vaccine introduction and distributive configurations marked the transition in 2021, while government effectiveness and long-term strategic orientation emerged as central factors in 2022. By 2022, traditional instruments such as stringency and mass vaccination display diminishing or null marginal returns, while state effectiveness and a long-term orientation become the primary correlates of sustained performance.

1. Introduction

The COVID-19 pandemic represented an unprecedented crisis that critically challenged governmental capacity to protect both public health and economic stability simultaneously. In 2020, the virus infected over 84 million individuals and resulted in more than 1.8 million fatalities worldwide (World Health Organization [WHO], 2021). The economic ramifications were equally severe, with global GDP contracting by 3.1% in 2020 — the most significant recession since World War II (World Bank, 2021) — and a global loss of 114 million jobs (International Labor Organization, ILO, 2021). This dual crisis compelled governments worldwide to implement emergency measures to safeguard public health and mitigate economic damage, testing health systems, governance

[☆] All authors thank Ana Rodríguez Álvarez as well as other participants at the 9th International Workshop on Efficiency in Education, Health, and other Public Services (Madrid, October 2023) for helpful comments. We are particularly grateful to two anonymous reviewers, whose comments contributed to improve the overall quality of the article. Emili Tortosa-Ausina acknowledges financial support by MCIN/AEI/10.13039/501100011033 (Ministerio de Ciencia e Innovación, Spain, PID2020-115450GB-I00 and PID2024-159788NB-I00) and Generalitat Valenciana, Spain (CIPROM/2022/50). Víctor Giménez and Diego Prior acknowledge financial support from AGAUR, reference 2021SGR00719. The usual disclaimer applies.

* Correspondence to: Department of Economics, Universitat Jaume I, Campus del Riu Sec, 12071, Castelló de la Plana, Spain.

E-mail addresses: claudio.thieme@udp.cl (C. Thieme), victor.gimenez@uab.es (V. Giménez), diego.prior@uab.es (D. Prior), tortosa@uji.es (E. Tortosa-Ausina).

<https://doi.org/10.1016/j.eap.2026.05.002>

Received 7 March 2025; Received in revised form 13 January 2026; Accepted 2 May 2026

Available online 19 May 2026

0313-5926/© 2026 The Author(s). Published by Elsevier B.V. on behalf of The Economic Society of Australia (Queensland) Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

structures, and social safety nets globally, and creating an urgent need to understand and evaluate the efficacy of governmental responses in managing these interrelated challenges.

From the onset of the pandemic, governments implemented a variety of measures and strategies aimed at containing virus spread while attempting to mitigate the resulting economic impact. These interventions, ranging from the imposition of lockdowns and mobility restrictions to the implementation of economic support programs, had significant repercussions on both public health and economic activity (Gordon et al., 2021). The resulting variability in outcomes, with some nations successfully containing virus spread while maintaining economic stability, and others experiencing severe consequences in both dimensions, underscores the critical importance of comprehensive analysis that simultaneously considers health and economic aspects of pandemic management.

A central question in pandemic management concerns whether there is an inevitable trade-off between preserving lives and protecting economic activity. Some research suggests such a trade-off is unavoidable. Acemoglu et al. (2021) developed models showing how different lockdown strategies produce varying impacts on health and the economy, suggesting tension between these objectives. Similarly, Andersen et al. (2020) analyzed Scandinavian policy approaches, finding distinct economic and health outcomes that pointed to possible trade-offs.

However, a growing body of evidence challenges this presumed dichotomy. Alvelda et al. (2020) argue that saving lives and saving the economy are not conflicting goals if managed correctly, contending that strategies prioritizing public health can ultimately lead to better economic outcomes by enabling faster and more sustainable economic reopening. More recent research reinforces this perspective: Feng et al. (2023) and Storm (2023) find no robust empirical evidence supporting an inescapable trade-off between stringent health measures and economic performance. Storm (2023) demonstrates how Denmark, Finland, and Norway successfully contained both mortality rates and GDP contraction through proactive policies, while the United Kingdom and the United States experienced high mortality and significant economic contractions, despite substantial fiscal stimulus. Feng et al. (2023) identify a negative correlation between economic recession magnitude and COVID-19 mortality rates among OECD countries, suggesting more effective health emergency management is associated with lower economic costs.

These conflicting findings likely stem from differences in study design, time periods examined, and the complexity of pandemic responses that evolved over time. The apparent contradiction may reflect that the relationship between health and economic outcomes depends critically on the timing, design, and implementation quality of interventions rather than representing a crucial structural constraint. Hence, the interplay between health and economic factors during the pandemic might underscore the necessity for integrated approaches to policy formulation, acknowledging the intrinsic link between population health and economic well-being.

Despite extensive literature examining the impacts of COVID-19 on public health and economic outcomes, significant gaps persist. First, while numerous studies analyze health or economic outcomes independently, few simultaneously evaluate both dimensions to determine whether governments faced genuine trade-offs or were able to optimize the two objectives. Second, existing pandemic management assessments rarely incorporate contextual factors that enable fair cross-country comparisons. Third, previous studies focus on composite effectiveness indicators without decomposing the pure managerial component from structural advantages conferred by development level, health infrastructure, or population characteristics.

In this scenario, our study attempts to contribute in three ways to these literatures and address the gaps identified, from both methodological as well as more substantive perspectives. First, we develop a bi-dimensional assessment framework using robust conditional Benefit-of-the-Doubt models with directional distance functions. Unlike previous approaches that aggregate health and economic outcomes into a single composite score, our method simultaneously evaluates three orientations: joint effectiveness (what we will refer to as a good output–bad output perspective, GOBO), health-focused effectiveness (bad output perspective, BO), and economy-focused effectiveness (good output, GO). This innovation allows us to empirically test whether the health-economy trade-off represents a structural constraint or a management choice, and to quantify countries' strategic orientation toward health versus economic priorities.

Second, we introduce a two-stage analytical framework that first conditions effectiveness scores on contextual factors (HDI, cardiovascular disease prevalence, island status, population age structure, and time) using the conditional efficiency approach of Daraio and Simar (2005) and Daraio and Simar (2007), and then isolates pure managerial effectiveness in a second stage—following Bădin et al. (2012). This methodological innovation applies conditional robust directional distance functions within a Benefit-of-the-Doubt framework, extending it with the temporal approach of Mastromarco and Simar (2015). As a result, it is possible to disentangle government management quality from structural advantages, providing fairer cross-country comparisons than existing studies. To our knowledge, this represents the first application of conditional robust directional BoD models to pandemic management evaluation.

Third, we conduct a comprehensive analysis of effectiveness determinants across the performance distribution using quantile regressions. This approach, considered in previous activity analysis studies such as Abdelsalam et al. (2014), Matallín-Sáez et al. (2019) and Abdelsalam et al. (2025), reveals that optimal strategies vary by performance level and crisis phase. For instance, hospital capacity proved critical in the 2020 shock phase, particularly for medium and high performers. In contrast, government effectiveness and long-term orientation became decisive in the 2022 consolidation phase. We analyze four categories of determinants: economic resources (inequality, public debt, unemployment, hospital beds), policy instruments (stringency, vaccination), governance quality (six Worldwide Governance Indicators), and cultural dimensions (six Hofstede dimensions). By examining these factors across three quantiles and three years, we provide nuanced insights into how different determinants matter at different stages of crisis management and performance levels. These insights would remain obscured in aggregate analyses.¹

¹ Beyond policy interventions, people may react to news and events elsewhere, increasing spontaneous social distancing, or be less willing to work (Krueger et al., 2022). The literature identifies at least: (i) cultural factors; (ii) installed governance capacities; and (iii) the level of economic and social inequality in a country, which we systematically examine in our second-stage analysis.

In summary, and building upon the preceding discussion, we set out the following three specific objectives that this article seeks to address:

- (i) Is there empirical evidence of a structural trade-off between health and economic effectiveness, or do these dimensions operate independently? We test this by examining correlations between GOBO, GO, and BO orientations and analyzing the distribution of countries' strategic focus (GO-BO differential) across three years.
- (ii) How do policy instruments (stringency and vaccination) associate with managerial effectiveness in jointly minimizing negative health outcomes and maximizing economic performance? We assess whether these instruments show consistent effects or diminishing returns over the evolution of the pandemic.
- (iii) Which exogenous factors (economics, governance dimensions, cultural characteristics) explain variation in managerial effectiveness across countries and performance levels? We employ quantile regressions to identify how determinants differ between low, medium, and high performers and across crisis phases (2020–2022).

Some previous research has applied operations research (OR) methods to analyze different issues related to the COVID-19 pandemic; examples include the recent contributions by Akpan et al. (2024), Caulkins et al. (2023), Chen and Lin (2025), Duggan et al. (2024) and Giménez et al. (2024), among others. However, no contributions have explicitly considered OR methods to *jointly* evaluate both dimensions to analyze the effectiveness of pandemic management at the national level from a more comprehensive perspective. One related study is that of Chen et al. (2023), who focused explicitly on the issue of social distancing, proposing a different methodology based on stochastic modeling of COVID-19 rather than efficiency analysis, but these authors did not decompose managerial effectiveness from contextual factors.

In this regard, our approach also extends existing work considering OR methods in several ways. For instance, unlike Giménez et al. (2024), who constructed a single composite indicator of pandemic management, we evaluate three complementary orientations to test trade-off hypotheses. In addition to this, whereas the focus is usually on either health outcomes or economic impacts, we integrate both dimensions while controlling for contextual heterogeneity, and we do this by combining robust partial frontiers, conditional models, and dynamic temporal perspectives within a directional distance framework. This allows us to better handle both desirable and undesirable outputs with negative data. Finally, we use quantile regression techniques, to consider inequality, governance, and cultural variables to examine explanatory factors for both management effectiveness and the health and economic emphasis of countries' strategies.

Our findings can be explored in three main dimensions. First, joint managerial effectiveness improved progressively between 2020 and 2022, with health and economic dimensions behaving orthogonally—challenging the narrative of an inevitable trade-off. The persistent absence of correlation between health-oriented and economy-oriented effectiveness confirms that the two dimensions operate independently. Second, countries converged toward balanced strategies, with nearly 90% adopting intermediate approaches by 2022, reflecting adaptation to sociopolitical constraints rather than deliberate optimization. Third, effectiveness determinants evolved dynamically across crisis phases, showing some stylized facts: (i) hospital capacity proved critical in 2020; (ii) vaccine coverage became essential in 2021, with inequality showing paradoxical positive effects in less developed countries; (iii) by 2022, government effectiveness and long-term orientation dominated, while stringency and vaccination showed diminishing returns. These results suggest that managerial effectiveness in prolonged crises depends on states' ability to reconfigure institutional and cultural capacities according to emergency phases rather than static resources.

The paper proceeds as follows. Following this introduction, Section 2 outlines the methodology used in our study. Section 3 comprehensively describes the data utilized. In Section 4, we present our empirical results, followed by an in-depth discussion of these findings in Section 5. Finally, Section 6 concludes the paper by summarizing our key findings and elucidating their implications for public policy.

2. Methodology

2.1. Effectiveness composite indicator

The COVID-19 pandemic has precipitated an intense debate across social, political, and health sectors regarding the balance between virus containment measures and their potential negative impact on economic growth. This discourse reflects the complex interplay between public health interventions and economic outcomes, as highlighted in our introduction. Despite extensive discussion, no universal consensus has emerged on the optimal balance between these two crucial aspects of pandemic management. Consequently, countries implemented diverse strategies based on their specific priorities, resources, and contextual factors.

To address this complexity and provide a more nuanced understanding of pandemic management effectiveness, we propose a composite indicator that simultaneously integrates the health and economic dimensions, as a necessary prerequisite for evaluating the effectiveness of pandemic management, which is the central objective of this study. This approach allows us to evaluate the overall effectiveness of different national strategies while accounting for the potential synergies and *trade-offs* between public health measures and economic performance. By developing this composite indicator, we aim to offer a more comprehensive assessment of pandemic management that goes beyond the traditional dichotomy of health versus economy, incorporating the multifaceted nature of the crisis response.

Therefore, in order to assess the effectiveness of pandemic management in a set of countries on the basis of a composite indicator (CI), a methodology is needed that assesses both dimensions with sufficient flexibility. One widely used alternative in the literature

for constructing a CI from a set of indicators is Benefit of Doubt (BoD) (Cherchye et al., 2007, 2008; De Witte and Rogge, 2011; Despotis, 2005; Gaaloul and Khalfallah, 2014; Melyn and Moesen, 1991; Morais and Camanho, 2011; Stumbriene et al., 2019; Zanella et al., 2013). BoD models are a variant of the non-parametric frontier models used to measure efficiency (Cooper et al., 2007) where only outputs are considered. Their main advantage is that the weight assigned to each of the indicators is endogenous and individualized for each unit evaluated, which gives them great flexibility and adaptability in the evaluation of the different strategies implemented by the countries analyzed.

However, a particular feature in the evaluation of pandemic management is the use of indicators with certain characteristics that must be considered from a technical point of view. The first characteristic is the presence of indicators whose behavior improves by decreasing their value. This is common in the health field where it is desirable to minimize, for example, the number of deaths. Therefore, from a methodological point of view, the model must be able to handle simultaneously indicators to be maximized and others to be minimized. One methodological approach is to use directional distance functions (DDF) (Färe and Grosskopf, 2000), which are widely applied to evaluate environmental efficiency where good outputs to be maximized coexist alongside bad outputs to be minimized (Chung et al., 1997; Oh, 2010; Picazo-Tadeo et al., 2005; Zanella et al., 2013). The second characteristic is the negative data associated with economic growth. The use of negative variables implies modifying the BoD models slightly.

As a consequence of these two characteristics of the indicators, in this paper we employ a BoD-DDF model capable of dealing with negative data. For its formulation we assume, for K countries, we have information on a set of M indicators to maximize $y \in R_+^M$, as well as H indicators to minimize $b \in R_+^H$. The CI of any country, under a cross-sectional approach, can be estimated through the following DDF (Oh, 2010; Sueyoshi and Goto, 2010):

$$D(y, b) = \max(\beta \mid (y + \beta g_y, b - \beta g_b)) \quad (1)$$

The above DDF determines respectively the maximum possible simultaneous increase and decrease (represented by β) for the indicators y and b over the vector $g = (g_y, g_b)$. g defines the desirable directions for improvement for both types of indicators. In our case, we use the vector of $M + H$ components $g = (y, b)$ as suggested by Chung et al. (1997). Various methods can be used to calculate $D(y, b)$. In this study we use a non parametric frontier model based on Oh (2010), although without inputs to be coherent with a BoD formulation. $D(y, b)$ is calculated by solving the following linear program for each country analyzed under the assumption $g = (y, b)$ (Mandal and Madheswaran, 2010):

$$\begin{aligned} \text{Max } CI^o &= \beta \\ \text{s.t.} \quad & \sum_{k=1}^K \lambda_k y_{km} \geq y_m^o + \beta |y_m^o| & m = 1 \dots M \\ & \sum_{k=1}^K \lambda_k b_{kh} \leq b_h^o - \beta |b_h^o| & h = 1 \dots H \\ & \sum_{k=1}^K \lambda_k = 1 \\ & \beta \geq 0 \\ & \lambda_k \geq 0 & k = 1 \dots K \end{aligned} \quad (2)$$

where y_{km} represents the indicator m to be maximized for country k , and b_{kh} the indicator h to be minimized for country k ; y_m^o , b_h^o are the observed levels of each indicator, respectively, for the country evaluated. β is the maximum simultaneously achievable increase/decrease in the indicators to be maximized/minimized. Note that in the case of a country that has managed the pandemic in both dimensions effectively, $\beta = 0$. In general, $\beta \times 100$ represents the maximum percentage by which indicators can be increased/decreased. In other words, a value of $\beta = 0$ indicates full efficiency, while higher values reflect increasing levels of inefficiency. This can be then interpreted as a “performance gap” that quantifies how far a country is from best-practice performance. The absolute value on the right side of the constraints was incorporated following the proposal by Kerstens and Van de Woestyne (2011) for the treatment of negative data in DDF models.

Regarding the technical assumptions of our proposal, unlike Chung et al.’s (1997) proposal, our technique assumes that it is possible to reduce bad outputs without requiring a reduction in the level of good outputs (i.e., our assumption is that bad outputs are ‘strongly disposable’ rather than ‘weakly disposable’). In the framework of the BoD composite indicators, this assumption is not exceptional, as it seems to be in line with what was proposed in Zanella et al. (2015) and developed later in Oliveira et al. (2019). The main advantage of this technological assumption is that, in the frontier, negative slopes connecting efficient DMUs are avoided.

One criticism of non-parametric frontier models is their high sensitivity to the presence of outliers. This problem can be particularly important when the data used are provided by the countries themselves, as is the case with the database we use. To mitigate its impact, Cazals et al. (2002) developed order- m models. They can be calculated either from the probabilistic formulation or by an approximation based on a simpler Monte-Carlo algorithm with convergent results (Daraio and Simar, 2005; D’Inverno and De Witte, 2020). In this paper we adopt the latter approach, which consists of performing B rounds of computation (where B is sufficiently large). In each round b ($b = 1, \dots, B$), draw a sample with replacement from m countries and calculate (2) obtaining CI_b^o . Finally, the robust composite indicator CI^o is calculated as the arithmetic average of the different CI_b^o :

$$CI^o = \frac{1}{B} \sum_{b=1}^B CI_b^o \quad (3)$$

The key reference for developing robust directional distance functions is Simar and Vanhems (2012).

2.2. Environmental factors and temporal approach

An additional circumstance when assessing countries is their different environmental conditions. The effectiveness of governmental management of the COVID-19 pandemic may have been influenced by different national characteristics. The incorporation of environmental factors (z) in non-parametric frontier models has been widely discussed in the literature, and various methodological alternatives are found (Muñiz et al., 2006). The most recent approach is to use conditional models (Daraio and Simar, 2007, 2005). The conditional models evaluate the units by comparing them with those that have similar environmental conditions, obtaining a fairer evaluation that is adjusted to their environment.

In our case, we rely on a panel dataset covering three years. To incorporate the temporal dimension into the conditional model, we follow the approach of Mastromarco and Simar (2015), who propose treating time as an additional conditional variable. With the aim of simplifying both the exposition and the mathematical notation, we consider in our setting that the vector of environmental variables z includes a *time* variable.² Mastromarco and Simar (2015) treat time as a continuous variable, given that they work with a large panel dataset. However, they suggest considering the *time* variable as an ordinal variable when data are available for only a few years, as is our case. They also emphasize that, under such conditions, the results would be equivalent to conducting year-by-year individual evaluations. It should be noted that their framework aims to identify changes over time in the frontier (technological change) and in the distribution of efficiencies (catching-up), as well as the impact of environmental factors on both. In our application, we adopt their proposal for incorporating the temporal dimension into the conditional analysis previous to the calculation of the *managerial effectiveness* and the determination of its drivers, which constitutes the main objective of this study. For this reason, we diverge from their methodology in some respects — for instance, by applying order- m partial frontiers instead of order- α , or by not computing technological change or catching-up — in order to remain focused on our research objective and to keep the length and scope of the paper within reasonable limits.

To adapt the cross-sectional methodology to a conditional and temporal approach based on the proposal by Mastromarco and Simar (2015), we calculate for each of the variables z (including the *time* variable as previously mentioned) a bandwidth h as described by Li and Racine (2008) for a particular kernel $k(\cdot)$ with bounded support (an Epanechnikov kernel in our case). We follow the approach proposed by Bădin et al. (2010), using a generalized product kernel function, since we have mixed data (continuous and discrete variables) in our data set (see De Witte and Kortelainen, 2013, for details). Subsequently, when the sample is drawn with replacement of size m in the order- m algorithm described in Section 2.1, a higher probability of being drawn is assigned to those units (countries) with similar environmental and time conditions to the one evaluated. The probability of being drawn country i is given by $\frac{k((z - z_i)/h)}{\sum_{j=1}^K k((z - z_j)/h)}$, thus obtaining the conditional composite indicator for unit o (CCI^o).³ A recent application, using a conditional robust directional BoD approach, similar to ours, is included in D’Inverno et al. (2025).

2.3. Managerial effectiveness

Once the conditional effectiveness CI has been obtained (CCI^o), we must differentiate how much of its value is attributable to environmental factors z and how much to country management or, in other words, managerial effectiveness (ME). The intuitive idea is that the part of effectiveness that is not attributable to environmental factors is attributed to elements that can be controlled by management.⁴ Bădin et al. (2012) developed a suitable methodology for its calculation, which consists of capturing the marginal relation of z on CCI^o using a non-parametric regression. The residual of the regression can be interpreted as a measure of managerial effectiveness, since it would include that part of CCI^o not explained by z . This information can be used to rank the countries according to their management. The regression to be estimated is as follows:

$$CCI = \mu(z) + \sigma(z)\varepsilon \quad (4)$$

where $\mu(z)$ is the average relation of the environmental factors on effectiveness; $\sigma(z)$ provides additional information about the dispersion of the distribution of the effectiveness coefficients as a function of the environmental factors; ε is the error (managerial effectiveness).

If ε and z have a very low correlation, the error can be interpreted as the pure managerial effectiveness, and as a proxy for it otherwise. The ME for one unit o is given by:

$$ME^o = \varepsilon^o = \frac{CCI^o - \mu(z)}{\sigma(z)} \quad (5)$$

To facilitate interpretation, the values of managerial effectiveness (ε_i) were multiplied by -1 . Consequently, the ε distribution is characterized by $\mathbb{E}(\varepsilon|Z = z) = 0$ and $\mathbb{V}(\varepsilon|Z = z) = 1$. A large (positive) value of ε is synonymous with good *managerial effectiveness*. A small (negative) value is synonymous with poor managerial effectiveness. For the estimation of $\mu(z)$ and $\sigma(z)$ we use nonparametric local constant models and bandwidths calculated by the usual least squares cross validation — LSCV — (Pagan and Ullah, 1999). An example of the application of this method can be found in Cordero et al. (2017).

² The implication of introducing time as an additional environmental variable is the expansion of the matrix of z values, adding a column representing time and as many additional rows as the number of DMUs analyzed multiplied by the number of years minus one.

³ Keeping in mind that the observed DMU corresponds to a country and a year.

⁴ The notion of managerial effectiveness resembles to the concept of the Solow residual (Solow, 1957) within a macroeconomic framework.

3. Data, sample and variables

To synthesize the interrelationship between health and economy in the robust composite indicator, we select two variables: one representing the health dimension and another, the economic dimension. According to the literature, the most widely used variable for measuring a country's health performance in this type of study is the total number of deaths per million inhabitants (Giménez et al., 2024). This variable, by its nature, represents an adverse outcome to be minimized, so it can be methodologically treated as a *bad output* type variable.

However, this indicator presents several limitations. First, there are inconsistencies in the definition of a COVID-19 death, which can vary between countries (García-Basteiro et al., 2020). Second, COVID-19 deaths may be underreported due to lack of testing, especially at the beginning of the pandemic (Greer et al., 2023). Third, it does not capture the indirect impact as it does not consider deaths caused indirectly by the pandemic, such as those resulting from health system saturation. Therefore, a better alternative is to use excess deaths for each year, calculated as the number of reported deaths minus the number of expected deaths. This indicator captures both direct and indirect impacts while being less sensitive to differences in testing and reporting practices. Furthermore, by comparing figures with a baseline period, the differences between countries in registration practices are mitigated (Beaney et al., 2020). However, the crude excess death figure gives us an idea of the scale, but is less comparable between countries because their population sizes and expected annual deaths may vary greatly. For this reason, to improve comparisons between countries, we measure excess mortality as the percentage difference between the number of reported deaths and the projected number. This metric is called the *p*-score and is expressed for each year as:

$$p\text{-score}_t = \frac{\text{Reported deaths}_t - \text{Forecasted deaths}_t}{\text{Forecasted deaths}_t} \times 100 \quad (6)$$

This indicator was calculated using the latest available observations for each year (Mathieu et al., 2020).

The choice of the excess deaths *p*-score indicator as a health variable aligns with recent academic literature. This approach has been taken by Torres et al. (2024), among others. These studies have shown the robustness and reliability of the excess mortality *p*-score as a measure of the pandemic's impact, which further justifies its use in our composite indicator.

In contrast, the variable that generally represents a country's economic performance is the percentage change in GDP (Law et al., 2022), which should be maximized as it is considered a *good output*. The use of GDP variation as the main economic indicator aligns with the literature on evaluating the impact of COVID-19 (Dorn et al., 2023; Gagnon et al., 2023).

In summary, in this study we consider that a country's performance in managing the crisis resulting from the pandemic is measured by its capacity to minimize deaths, on one hand, and maximize wealth, on the other. By focusing on excess deaths and GDP change, our study captures both the health and economic dimensions of the pandemic's impact. This dual approach allows for a more comprehensive evaluation of countries' performance in crisis management, considering both immediate health outcomes and broader economic consequences. Likewise, it offers a balanced perspective on the trade-offs that policymakers faced between protecting public health and maintaining economic stability.

The literature on evaluating the effectiveness of COVID-19 pandemic management suggests a wide range of variables that can be used to condition evaluation models to the specific environment of each country (Brown, 2023; Brown et al., 2025; Cuschieri et al., 2022). After carefully considering the different available options, we selected four environmental variables for our conditional model: (i) the Human Development Index (HDI); (ii) the cardiovascular mortality rate; (iii) island status; (iv) the percentage of population over 65 years old; and (v) the year under analysis (in our case we created a panel from 2020 to 2022). These variables were chosen not only for their demonstrable relevance in the aforementioned studies, but also because they represent independent and complementary dimensions that can influence pandemic management.

The Human Development Index reflects a country's overall level of economic, educational, and health development, thereby justifying structural differences in infrastructure and health monitoring capacities (Mgammal, 2024). The cardiovascular mortality rate captures the prevalence of preexisting conditions that can exacerbate the levels of COVID-19 (Yang et al., 2020). Island status, as an expression of a higher proportion of maritime borders, can influence a country's ability to control its borders and, consequently, the spread of the virus (Brown et al., 2025).⁵ A country's age structure, measured as the percentage of the population aged 65 and older, is associated with greater biological and health vulnerability related to ageing and, as such, with higher COVID-19 mortality (Brown, 2023). Finally, the dynamics of these variables are considered by including the year as a contextual conditioning factor (Mastromarco and Simar, 2015). These control variables enable a more contextualized evaluation of countries' effectiveness in pandemic management by considering structural factors of economic, educational, health, and demographic development, as well as geographical characteristics beyond the immediate control of governments.

In our study, we evaluated the management performance of 104 countries across all continents during 2020, 2021, and 2022. Table 1 presents the descriptive statistics for the variables used in the conditional efficiency model for the sample of countries included in this study.

⁵ As rightly pointed out by a reviewer, the contrasting experiences of Japan and the UK could suggest that including this variable as a contextual factor might be problematic. Although the literature is not conclusive, some contributions have shown that some islands benefitted from such status, but sometimes in combination with other variables. For instance, Barrett and Poot (2023) found that island nation had about 740–780 fewer recorded deaths per million population than other countries, and about 80 to 90 fewer excess deaths. However, they also found that being an island nation might only be helpful when the geographic advantage was combined with other variables. For instance, in the case of New Zealand, the country indeed benefitted greatly from being an island nation, but other variables such as institutional quality also played a relevant role (see also Rodríguez-Pose and Burlina, 2021). Other contributions such as Brown et al. (2025), found that countries with more sea borders had lower excess mortality rates, a result consistent across different model specifications, and that could partly reinforce the relevance of being an island to reduce excess mortality. Hence, we consider that the island status, rather than problematic, has potential as a contextual variable.

Table 1
Descriptive statistics of model variables (2020–2022).

Variable	Year	N	Mean	Std. Dev.	Min.	Max.
GDP growth (%)	2020	104	−6.220	6.106	−32.900	7.200
	2021	104	6.711	5.174	−4.900	37.500
	2022	104	4.723	5.280	−28.800	19.800
Excess mortality (p-score)	2020	104	11.221	13.272	−20.381	53.208
	2021	104	16.472	12.751	−6.470	56.981
	2022	104	14.474	9.431	−4.751	56.860
Human Development Index (HDI)	2020	104	0.828	0.087	0.645	0.969
	2021	104	0.828	0.089	0.631	0.969
	2022	104	0.837	0.083	0.649	0.967
Cardiovascular mortality rate (×100k)	2020	104	234.287	132.116	79.370	724.417
	2021	104	234.287	132.116	79.370	724.417
	2022	104	234.287	132.116	79.370	724.417
Population aged ≥65 (%) (z_3)	2020	104	12.768	6.412	1.248	28.918
	2021	104	13.020	6.515	1.304	29.217
	2022	104	13.282	6.607	1.391	29.403
Isle (Island status)	No	83	–	–	–	–
	Yes	21	–	–	–	–

Note. GDP = Gross Domestic Product; HDI = Human Development Index. For *Isle*, only sample sizes are reported: No = 83 (79.8%), Yes = 21 (20.2%).

Regarding the bad output (p-score, excess mortality), the mean increased from 11.22% in 2020 to 16.47% in 2021, then declined to 14.47% in 2022, suggesting a deterioration in the second year of the pandemic followed by some moderation. The extreme values were notable: minimum values of −20.38% in 2020 (Seychelles), −6.47% in 2021 (Seychelles), and −4.75% in 2022 (Antigua and Barbuda); maximum values of 53.21% in 2020 (Ecuador), 56.98% in 2021 (Peru), and 56.86% in 2022 (Bolivia).

Regarding the good output (*GDP_Growth*, GDP variation), the sample reflects an average contraction of −6.22% in 2020, a strong rebound of 6.71% in 2021, and expansion of 4.72% in 2022. The extremes illustrate this heterogeneity: in 2020, the lowest growth was −32.9% (Maldives) and the highest was 7.2% (Ireland); in 2021, −4.9% (Fiji) and 37.5% (Maldives); in 2022, −28.8% (Ukraine) and 19.8% (Fiji).

Among the environmental variables, the HDI is high and stable: means of 0.828 (2020 and 2021) and 0.837 (2022), with low dispersion. The maximum values consistently correspond to Norway (≈ 0.97), while the minimum values correspond to Guatemala in 2020 (0.645) and Namibia in 2021–2022 (≈ 0.63 –0.65). The cardiovascular mortality rate per 100,000 inhabitants shows an average of 234.29 with notable variability; Japan exhibits the lowest rate (79.37) and Uzbekistan the highest (724.42) across all three years. The age structure (% of population ≥65 years) increases gradually from 12.77% (2020) to 13.28% (2022), with Japan at the maximum (≈ 28.92 –29.40) and Qatar at the minimum (≈ 1.25 –1.39); the dispersion reveals substantial demographic differences between countries. Finally, the “island” dummy variable shows that 21 of the 104 countries (20.2%) are island nations.

This descriptive analysis provides insight into the variability of both outcome variables and control variables across different countries and regions. The stark contrasts observed between countries and continents underscore the importance of considering these contextual factors when evaluating the effectiveness of pandemic management strategies.

3.1. Explanatory variables of pandemic managerial effectiveness

To identify the explanatory factors of pandemic managerial effectiveness, four dimensions of variables were considered: (i) economic and resource endowment variables (Gini coefficient, public debt, unemployment, hospital bed availability), (ii) public health policy measures (stringency and vaccines), (iii) governance (5 Worldwide Governance Indicators), and (iv) cultural factors (six Hofstede dimensions).

Regarding the economic and resource endowment dimension, inequality emerged as a factor that can affect governments' capacity to manage the pandemic. In countries where the gap between rich and poor is wide, the most vulnerable population groups — such as informal workers and marginalized communities — were the most affected by the pandemic and had the least access to healthcare services and economic support. The lack of social protection and unequal access to resources exacerbated health and economic inequalities during the pandemic (Matei, 2024). However, the results will indicate whether the above prevailed or whether the negative correlation of this index with wealth and development indicators was more significant.

The percentage of public debt is used to capture differences in fiscal space and the ability to mount counter-cyclical responses: countries entering the crisis with lower debt burdens deployed broader stimulus, while high pre-existing debt constrained the scope and speed of support (Benmelech and Tzur-Ilan, 2020; Chudik et al., 2021). The unemployment rate is included as a proxy for labor-market stress and socioeconomic vulnerability. At the bivariate level, unemployment correlates positively with COVID-19 mortality across countries, warranting consideration (Brown, 2023). Finally, the availability of beds per 1000 inhabitants is a direct measure of installed hospital capacity and showed meaningful associations with pandemic performance. A worldwide analysis identifies hospital beds per 100,000 as an independent predictor in the full model and documents a non-linear, protective pattern, with mortality decreasing beyond roughly 50 beds/100,000 (Brown, 2023).

Table 2
Descriptive statistics of the second stage (2020–2022).

Variable	Year	N	Mean	Std.Dev.	Min	Max
Economic and resource endowment						
Gini Index (income)	2020	104	0.532	0.095	0.331	0.739
Gross public debt (% GDP)	2020	104	72.611	41.451	1.000	258.400
Gross public debt (% GDP)	2021	104	71.750	47.711	1.900	360.900
Gross public debt (% GDP)	2022	104	66.388	40.807	2.100	248.300
Unemployment rate (IMF, %)	2020	91	8.870	5.417	1.700	29.200
Unemployment rate (IMF, %)	2021	91	8.309	5.401	1.900	34.300
Unemployment rate (IMF, %)	2022	91	7.367	5.463	1.300	33.500
Hospital beds (per 1000 pop.)	2020	87	3.796	2.316	0.430	12.720
Measures (stringency and vaccines)						
Stringency Index	2020	97	51.844	10.419	12.466	71.366
Stringency Index	2021	97	55.031	10.437	9.151	73.649
Stringency Index	2022	97	23.479	9.137	10.905	56.298
Vaccines (doses per 100 pop.)	2021	104	131.655	48.901	21.810	226.640
Vaccines (doses per 100 pop.)	2022	104	41.753	30.277	2.550	139.470
Governance indicators (WGI)						
Control of corruption (CC)	2020	104	0.377	0.983	−1.345	2.236
Government effectiveness (GE)	2020	104	0.444	0.846	−1.205	2.284
Political stability (PV)	2020	104	0.262	0.735	−1.699	1.589
Rule of law (RL)	2020	104	0.384	0.900	−1.251	2.019
Regulatory quality (RQ)	2020	104	0.474	0.833	−1.486	2.205
Voice and accountability (VA)	2020	104	0.341	0.890	−1.778	1.720
Control of corruption (CC)	2021	103	0.047	1.010	−1.622	2.333
Government effectiveness (GE)	2021	103	0.044	0.995	−2.221	1.960
Political stability (PV)	2021	104	0.023	0.962	−2.519	1.878
Rule of law (RL)	2021	103	0.015	1.012	−1.877	2.013
Regulatory quality (RQ)	2021	103	0.034	1.002	−2.343	1.887
Voice and accountability (VA)	2021	102	0.007	1.022	−2.062	1.609
Cultural dimensions (Hofstede)						
Power distance	2020	85	64.365	22.767	11.000	100.000
Individualism	2020	85	42.635	22.229	6.000	91.000
Achievement motivation	2020	85	46.800	18.963	5.000	100.000
Uncertainty avoidance	2020	85	69.718	22.589	8.000	100.000
Long-term orientation	2020	73	46.966	23.024	7.000	93.000
Indulgence	2020	71	45.093	20.605	4.000	97.321

Notes: Descriptive statistics for variables used in the second stage (2020–2022). Some series are not available for all years (e.g., hospital beds 2021 and 2022; cultural dimensions: last available year). N counts vary by indicator/year according to source availability.

Regarding public health policy measures, we considered two variables that are vital at different points in time: the stringency index and the number of vaccine doses per 100 inhabitants in year t . The inclusion of the stringency index and the vaccination rate is justified by their widespread use in the comparative literature on COVID-19 performance. The former, developed by the Oxford COVID-19 Government Response Tracker, has been recurrently used as a standardized indicator of the intensity of non-pharmaceutical interventions, enabling cross-national comparisons of the impact of school closures, mobility restrictions, and lockdown measures (Hale et al., 2021). In parallel, the number of vaccine doses administered per 100 inhabitants constitutes a central variable from 2021 onwards, as it reflects the effective immunization coverage in each country and its capacity to reduce mortality and alleviate pressure on health systems.

Similarly, governance was also a relevant factor in governments' pandemic response, as it can explain states' capacity to make rapid and effective decisions and coordinate efforts across different sectors and levels of government. In some countries, the lack of leadership and coordination hindered the governmental response, while others successfully implemented measures thanks to effective governance (Abdou, 2021).

Finally, cultural factors, understood as differences in practices and beliefs, can influence the adoption of preventive measures and the population's willingness to follow them. For example, in some countries mask wearing was regarded as a culturally accepted practice, while the practice met with resistance in others (Cao et al., 2020; Kumar, 2021).

Table 2 presents the descriptive statistics of the second-stage variables considered in this study.

Inequality as measured by the Gini index for 2020 exhibits an average of 0.532 and a wide range (0.331–0.739), reflecting marked heterogeneity across countries. Regarding fiscal conditions, gross public debt (% of GDP) shows high and highly dispersed levels: a mean of 72.6% in 2020, 71.8% in 2021, and a decline to 66.4% in 2022, with long tails indicating extreme cases.

The labor market gradually improves following the initial shock: the average unemployment rate falls from 8.87% in 2020 to 8.31% in 2021 and 7.37% in 2022. Hospital capacity (beds per 1000 inhabitants) appears as a stable structural characteristic

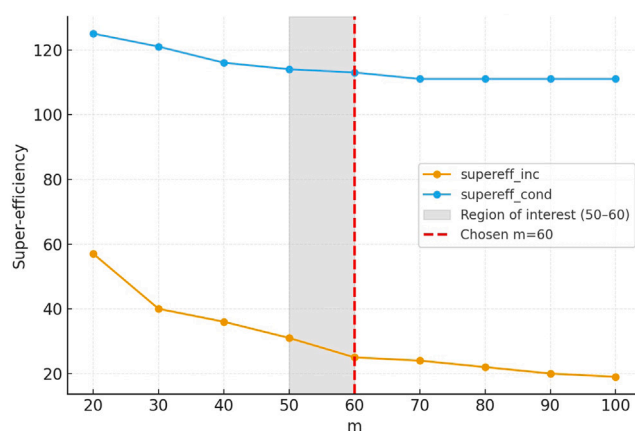


Fig. 1. Elbow plot for super-efficiency (m selection).

The plot shows the number of super-efficient observations for both unconditional and conditional models across different values of m . The gray shaded region (50–60) indicates the range of interest, with $m = 60$ selected as the optimal value (red dashed line) where the decrease in super-efficient observations stabilizes for the conditional model. This value balances robustness against outliers while maintaining sufficient discrimination among units.

throughout the period: a constant mean of 3.73 across all three years. In contrast, policy severity (Stringency Index) increases in 2021 and relaxes substantially in 2022: 51.84 in 2020; 55.03 in 2021; and 23.48 in 2022.

The Worldwide Governance Indicators (WGI) remain relatively stable around slightly positive values, with high dispersion across countries. In 2020, the average values are for control of corruption 0.377, 0.444 for government effectiveness, 0.262 for political stability, 0.384 for rule of law, 0.474 for regulatory quality, and 0.341 for voice and accountability. In 2021, low-magnitude oscillations are observed (e.g., effectiveness = 0.376; voice = 0.459), while in 2022 the averages return close to their 2020 levels (e.g., control of corruption = 0.375; effectiveness = 0.430; voice = 0.343), always with wide ranges (≈ -1.9 to 2.4 points depending on the indicator).

This study utilizes data from multiple sources. The baseline data for cumulative excess mortality (annual p-score), cardiovascular mortality rate, income Gini coefficient, and annual average stringency index were obtained from Our World in Data (Roser et al., 2020). To consider the cultural aspects of each country, Hofstede's six dimensional model (Hofstede, 2001; Hofstede and Hofstede, 2005); information is available at www.hofstede-insights.com. Government quality perceptions, corresponding to 2020, come from the WGI, available at www.govindicators.org. Finally, general government debt and GDP percentage change data were obtained from the International Monetary Fund (IMF), accessible at <https://www.imf.org/external/datamapper>.

4. Results

This study seeks to answer three central research questions: (i) How did countries' managerial effectiveness evolve during the 2020–2022 period in COVID-19? (ii) Was there a trade-off between health and economic dimensions during each year of this period? and (iii) What economic, cultural, and governance factors explain the observed differences in managerial effectiveness?

To address these questions, models described in Section 2 were estimated, which requires setting in advance the values of the parameters B and m . In accordance with the recommendation of Daraio and Simar (2005), the number of bootstrap replications was set at $B = 200$, and the partial frontier size was established at $m = 60$, a value corresponding to the point where the decrease in the number of super-efficient observations stabilizes (see Fig. 1).

Under this approach, *managerial effectiveness* is conceptualized as the residual efficiency attributable to governments' management capacity in facing the pandemic, after controlling for the movements of the contextual factors (z), including time. Thus, three model orientations were defined: (i) a model oriented toward the desirable output (GO orientation, in our case economy orientation) — the economic dimension, measured through GDP percentage change; (ii) a model oriented toward the undesirable output (BO orientation, in our case health orientation) — the health dimension, represented by cumulative excess mortality; and (iii) a joint model that simultaneously integrates both dimensions (GOBO orientation, in our case a balanced economy-health orientation). As previously noted, for greater comprehension, the opposites of these indices were calculated. In this way, positive values indicate high managerial effectiveness, while low or negative values reflect management deficiencies. It should be emphasized that there are alternative approaches to the one chosen for determining the direction vector used to calculate the DDF. Wang et al. (2019) present the main alternatives based on the use of an endogenous directional vector that optimizes a specific criterion. In particular, they highlight two alternatives for cases in which the objective is not the measurement of economic efficiency. The first consists of determining the directional vector that reaches the efficient frontier as quickly as possible, while the second consists of identifying the directional vector associated with the largest potential improvement.

Table 3
Managerial effectiveness by orientation and year (2020–2022).

Indicator	2020		2021		2022	
	Mean	SD	Mean	SD	Mean	SD
ME_{GOBO}	−0.318	0.387	0.139	0.324	0.176	0.301
ME_{GO}	0.109	2.202	0.296	3.036	−0.421	4.648
ME_{BO}	−0.965	4.780	−0.333	4.803	1.289	9.529
$GO - BO$	1.073	4.975	0.629	4.919	−1.709	9.313

Note: Values are means with standard deviations (SD). ME_{GOBO} = joint managerial effectiveness; ME_{GO} = economic orientation; ME_{BO} = health orientation; $GO - BO$ = difference between economic and health orientations (positive = economy focus, negative = health focus).

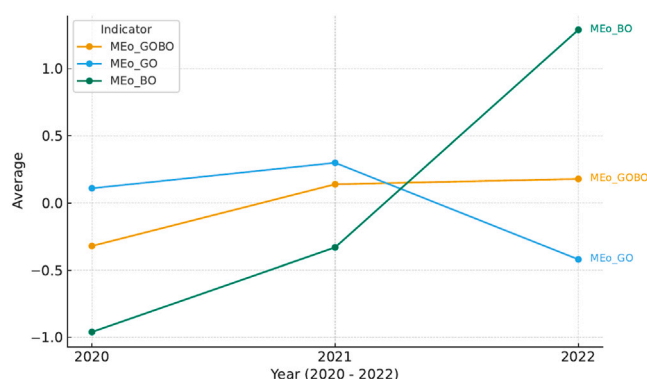


Fig. 2. Average evolution of ME_{GOBO} , ME_{GO} and ME_{BO} (2020–2022).

The figure shows the temporal evolution of managerial effectiveness across three orientations: joint effectiveness (ME_{GOBO} , orange line), economic orientation (ME_{GO} , blue line), and health orientation (ME_{BO} , green line). ME_{GOBO} demonstrates progressive improvement from negative to positive values. ME_{GO} exhibits volatility with initial improvement followed by decline in 2022. ME_{BO} shows the most dramatic transformation, moving from markedly negative values in 2020–2021 to strongly positive values in 2022, indicating improved health management effectiveness over time.

In our case, we decided to conduct the evaluation under the assumption of the three orientations mentioned above for several reasons: (i) other studies have adopted a similar approach (see for instance Arbona et al., 2022; Beltrán-Estevé et al., 2019); (ii) in our case, in which we consider only one good and one bad output, jointly with a convex linear frontier approach, the greatest/lowest potentials for improvement will be mainly associated with one of the orientations, GO or BO, and therefore the two criteria are implicitly being considered; (iii) the GOBO orientation also allows for a more balanced evaluation; (iv) it enables us to assess all units under the same perspective and quantifies the consequences of prioritizing one criterion over the other one; and (v) it simplifies both the interpretation and the mathematical complexity of the models, while providing similar results and simultaneously allowing for the evaluation of intermediate scenarios, such as the GOBO orientation, which do not necessarily coincide with the criteria of maximum/minimum distance to the frontier.

4.1. Temporal evolution of the managerial effectiveness

The results presented in Table 3 and Fig. 2 reveal relevant transformations in pandemic crisis management. The most notable finding corresponds to the dramatic change in ME_{BO} , which transitioned from markedly negative values in 2020 (−0.965) and 2021 (−0.333) toward broadly positive territory in 2022 (1.289). This transformation, accompanied by an unprecedented standard deviation in 2022 (9.529), shows both the magnitude of the change and the heterogeneity in national responses. The large standard deviation in ME_{BO} scores for 2022 reflects the divergent trajectories adopted by countries in the later stages of the pandemic, with some maintaining strict protocols while others relaxed their restrictions. Additionally, a few extreme cases contribute to this variability. This heterogeneity underscores that, as the pandemic progressed, countries increasingly diverged in their capacity or willingness to sustain effective health-oriented management.

Considering the aggregations at the continental level (see Fig. 3), Asia experienced the most pronounced transformation in ME_{health} , with a superlative improvement between 2021 and 2022 that contrasts with the more gradual behavior observed in North America. Africa and South America, for their part, maintained persistently negative levels, suggesting structural difficulties in implementing effective health policies. Europe showed a moderate evolution with stabilization in the 2021–2022 period.

The ME_{GOBO} had a progressive but less dramatic recovery, evolving from −0.318 in 2020 toward modest positive values in 2021 (0.139) and 2022 (0.176). North America and Europe stood out for their recovery trajectories, transitioning from the worst performance in 2020 to the best in 2022, while improvement in Africa was considerably less pronounced.

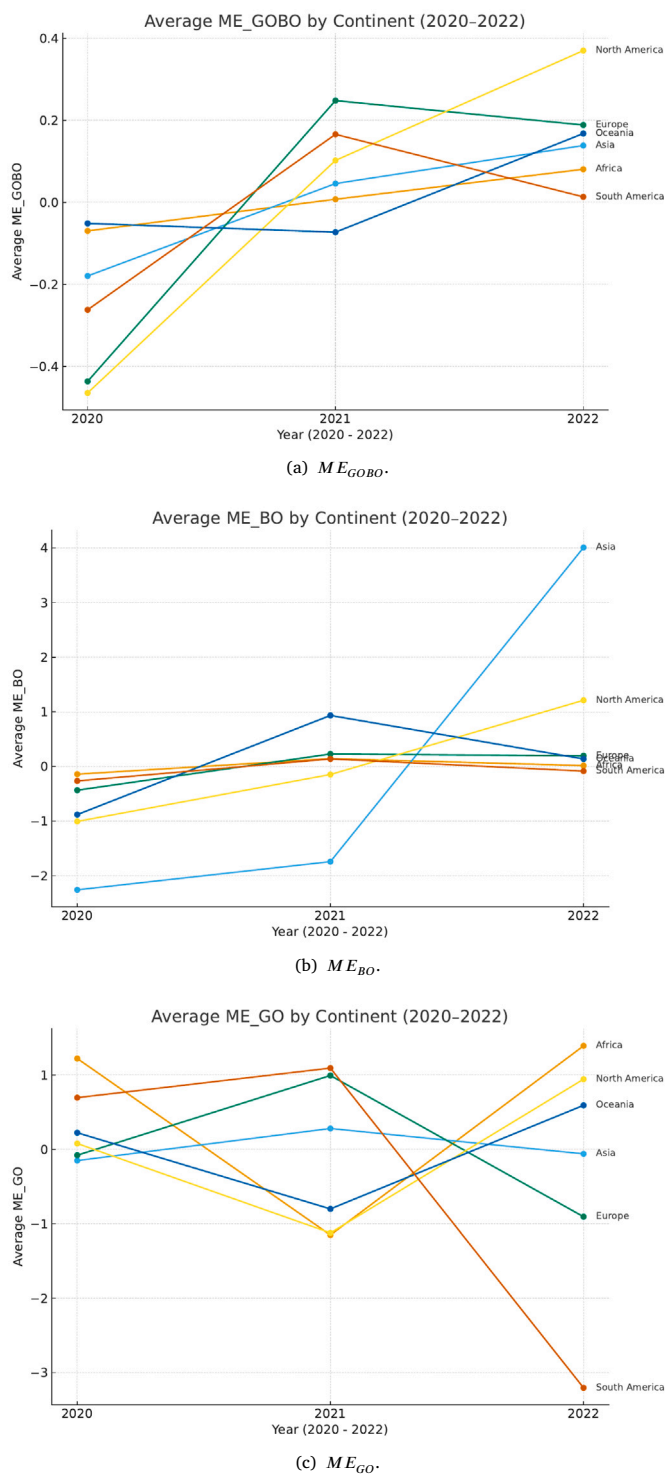


Fig. 3. Average evolution of the *managerial effectiveness* by continent (2020–2022), per orientation: (a) proportional (*GOBO*), (b) bad outputs (*BO*) and (c) good outputs (*GO*).

The ME_{GO} exhibited the greatest volatility among all analyzed dimensions. After a modest but positive start in 2020 (0.109) and an improvement in 2021 (0.296), it experienced a collapse toward negative values in 2022 (−0.421). This volatility, reflected in increasing standard deviations (from 2.202 to 4.648), was particularly evident in South America, with a significant improvement in 2021 followed by an abrupt decline in 2022. Africa, North America, and Oceania presented a “V”-shaped pattern with marked contractions in 2021.

The $GO-BO$ ($ME_{GO} - ME_{BO}$) differential synthesizes the reconfiguration of managerial priorities. The positive values in 2020 (1.073) and 2021 (0.629) demonstrate an initial emphasis on the economic dimension, which reversed dramatically in 2022 (−1.709), signaling a shift toward health priorities. Asia presented the most extreme transition (from 2.108 in 2020 to −4.068 in 2022), followed by South America (from values close to unity to −3.120), while Europe showed a more moderate evolution but in the same direction.

4.2. Trade-off analysis

To test the trade-off hypothesis, two complementary approaches were applied: (i) analysis of the distribution of the focus index, defined as the difference between ME_{GO} and ME_{BO} , where positive values indicate bias toward the economy and negative values toward health; and (ii) examination of the correlations between the three ME orientations. To classify country-year orientation between health and economics, we define the orientation index Δ as the difference between economic efficiency and health efficiency. Following established practices that interpret ± 0.5 standard deviations as a band of indifference/minimum significant change (Norman et al., 2003) and standard deviation classification schemes with a central class of ± 0.5 standard deviations (Brewer and Pickle, 2002), we consider three categories: (i) “balanced” if $|\Delta| \leq 0.5$ standard deviations; (ii) “economy-oriented” if $\Delta > 0.5$ standard deviations; and (iii) “health-oriented” if $\Delta < -0.5$ standard deviations. This approach is analogous to defining a region of practical equivalence (Lakens et al., 2018).

The application of the ± 0.5 standard deviation criterion to classify national approaches reveals more nuanced patterns than a simple economy-health dichotomy. In 2020, 75.7% of countries adopted a balanced approach, a proportion that increased to 79.6% in 2021 and reached 90.3% in 2022. This convergence toward balance occurred paradoxically while the mean differential shifted toward negative values and the balance range itself evolved (−0.488, 1.737 in 2020; −3.224, 1.592 in 2022).

As can be observed in Fig. 4, one clear element is the transition from a large number of countries with an economic focus in 2020 to only three countries in this category in 2022. In contrast, cases with a health focus persisted, although remaining a minority (7.8% in 2020, 9.7% in 2021, 6.8% in 2022), including unprecedented extreme values in 2022 such as Paraguay (−28.870) and Estonia (−26.654). This asymmetry suggests that the political and social costs of prioritizing the economy over health were unsustainable during the pandemic.

The continental analysis confirms the general trend with relevant regional distinctions. Africa transitioned from greater initial heterogeneity toward convergence, with 75% adopting a balanced approach in 2022. Asia showed the clearest consolidation, with 88.5% of countries balanced in 2022 compared to 57.7% in 2020. Europe maintained the greatest stability, with balance predominating from the beginning (82.9% in 2020, 95.1% in 2022). Oceania presented the most dramatic evolution, from the coexistence of diverse approaches in 2020 toward total convergence in balance by 2022.

4.2.1. Correlations and evidence of orthogonality

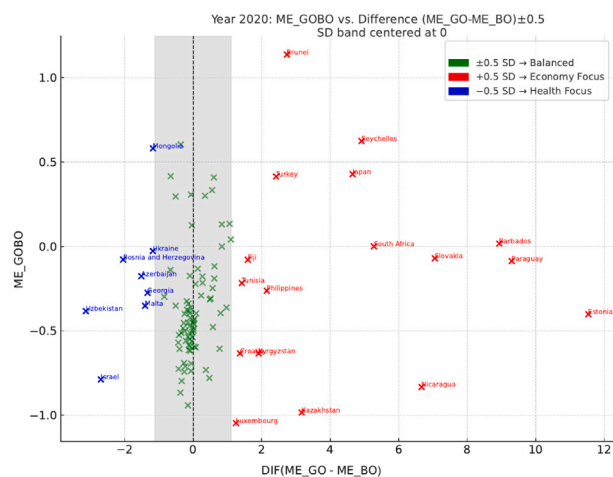
Table 4 provides crucial evidence regarding the nature of the *trade-off*. The correlation between ME_{GOBO} and ME_{GO} , while consistently positive and significant, weakens progressively ($r = 0.412$ in 2020, $r = 0.232$ in 2022, $p < 0.05$), suggesting a gradual decoupling between integrated management and economic orientation. Conversely, the correlation between ME_{GOBO} and ME_{BO} evolves from non-significance in 2020 ($r = 0.149$) toward a positive association in 2022 ($r = 0.276$, $p < 0.01$), indicating the growing integration of health considerations into comprehensive management frameworks.

The most theoretically significant finding is the persistent absence of correlation between ME_{GO} and ME_{BO} ($r = 0.086$, 0.076, 0.071 for 2020, 2021, 2022 respectively). This empirical orthogonality confirms that the two dimensions operate independently, suggesting that excellence in one dimension does not predetermine performance in the other, either positively or negatively.

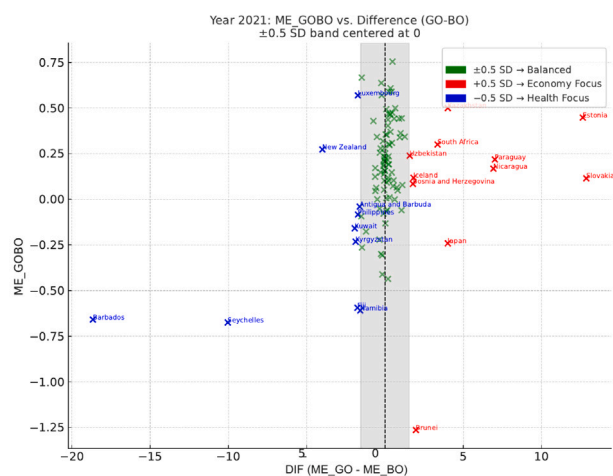
4.2.2. Determinants of managerial effectiveness, 2020–2022

The analysis using quantile regressions reveals that the determinants of joint managerial effectiveness (ME_{GOBO}) exhibit some dynamics, with association patterns that vary both across years and across segments of the performance distribution (see Table 5). This temporal and distributional heterogeneity provides evidence of the adaptive mechanisms that operated during different phases of the pandemic crisis.

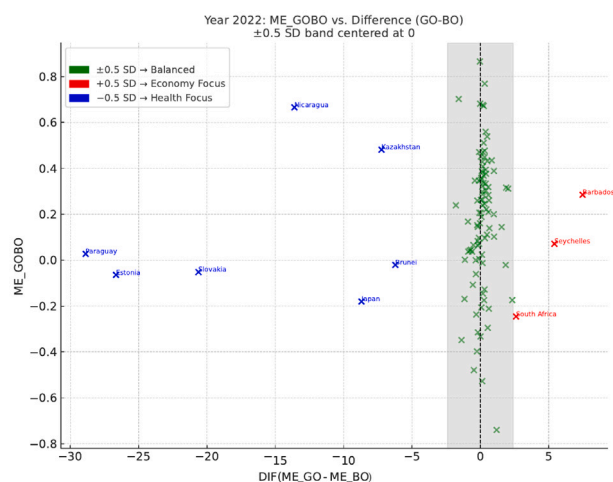
Year 2020: installed capacity and institutional tensions after the initial shock. During the first year of the pandemic, pre-existing hospital capacity emerges as the most robust factor, with positive and highly significant coefficients in the middle ($\tau = 0.50$: 0.091, $p < 0.001$) and high ($\tau = 0.75$: 0.145, $p < 0.001$) quantiles. This finding suggests that health infrastructure endowment constituted a critical asset for countries with better joint performance, enabling them to absorb the health shock without excessively compromising economic activity. Simultaneously, the stringency index (*Stringency*) presents a marginally significant negative association at the median (−0.010, $p < 0.10$), foreshadowing the limits of generalized interventions when the objective transcends pure epidemiological containment.



(a) 2020.



(b) 2021.



(c) 2022.

Fig. 4. Orientation between health and economy (2020–2022).

Table 4

Pearson correlations between managerial effectiveness orientations by year.

	ME_{GOBO}	ME_{GO}	ME_{BO}
2020			
ME_{GOBO}	1.000	0.412***	0.149
ME_{GO}		1.000	0.086
ME_{BO}			1.000
2021			
ME_{GOBO}	1.000	0.426***	0.202*
ME_{GO}		1.000	0.076
ME_{BO}			1.000
2022			
ME_{GOBO}	1.000	0.232*	0.276**
ME_{GO}		1.000	0.071
ME_{BO}			1.000

Note. Values are Pearson's r . Non-significant results are reported without stars.* $p < .05$.** $p < .01$.*** $p < .001$.**Table 5**

Quantile regressions of managerial effectiveness by year (2020–2022).

Parameter	2020			2021			2022		
	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$	$\tau = 0.25$	$\tau = 0.50$	$\tau = 0.75$
Economics and resources allocation									
Intercept	−0.472	0.061	1.086*	0.173	0.195	−0.371	1.303**	0.154	0.475
Gini index	0.566	0.412	−0.619	0.679	1.069**	1.326**	−1.115**	−0.468	−1.106*
Public debt (% PIB)	0.000	0.001	0.000	−0.002***	0.000	0.000	0.001	0.001	0.000
Unemployment rate (IMF, %)	−0.006	−0.011	−0.019	0.004	−0.005	−0.010	0.006	−0.006	0.005
Hospital beds per 1000	0.031	0.091***	0.145***	–	–	–	–	–	–
Public health strategies									
Stringency	−0.001	−0.010*	−0.010	−0.011**	−0.003	0.000	0.003	0.003	−0.004
Vaccines (doses per 100)	–	–	–	0.003**	0.000	−0.001	−0.003*	−0.004**	−0.003
Institutional structure (WGI)									
Control of corruption (CC)	0.168	0.270*	0.687***	0.022	0.076	0.037	0.046	0.061	−0.053
Government effectiveness (GE)	0.249	0.247	−0.150	0.069	0.141	−0.042	0.293**	0.189	0.010
Political stability (PV)	−0.158*	−0.339***	−0.140	0.040	−0.043	−0.061	0.106	0.012	0.126
Rule of law (RL)	−0.088	−0.222	−0.723**	0.103	−0.110	0.016	−0.318*	−0.038	0.062
Regulatory quality (RQ)	−0.361**	−0.332*	0.109	−0.177*	−0.056	0.062	0.018	0.014	0.080
Voice and accountability (VA)	0.151*	0.273**	0.161	0.020	0.019	−0.013	−0.008	−0.067	−0.137
Cultural structure (Hofstede)									
Distance to power	0.000	0.004	0.007**	0.001	−0.002	0.000	−0.002	0.000	0.003
Individualism	−0.001	−0.001	−0.003	0.000	0.001	0.001	−0.004*	−0.003	0.000
Achievement motivation	−0.002	−0.002	−0.001	−0.001	−0.002	−0.004**	0.001	0.003	0.006**
Uncertainty avoidance	−0.002	−0.005**	−0.018***	−0.001	−0.002**	0.006**	−0.007***	−0.004	−0.005**
Long-term orientation	0.001	−0.005*	0.000	0.002	0.002	0.001	−0.001	0.005**	0.006*
Indulgence	−0.002	−0.002	0.000	−0.004**	−0.004**	0.001	−0.004*	0.001	0.006*
Pseudo- R^2	0.165	0.164	0.263	0.239	0.197	0.258	0.254	0.235	0.208
Mean absolute error	0.2409	0.2059	0.3032	0.1764	0.1516	0.1697	0.2298	0.1870	0.2411

Notes: Vaccines = doses per 100 inhabitants.

* Significance coefficients: $p < .05$.** Significance coefficients: $p < .01$.*** Significance coefficients: $p < .001$.

At the institutional level, a paradoxical pattern emerges. While the voice and accountability dimension (VA) is positively associated with effectiveness in the low and middle quantiles (0.151, $p < 0.10$; 0.273, $p < 0.01$), indicators traditionally linked to state capacity — such as political stability (PV) and regulatory quality (RQ) — show significant negative coefficients. This apparent contradiction suggests that under conditions of radical uncertainty, participatory legitimacy and decisional flexibility may have been more valuable than rigid institutional structures.

Culturally, uncertainty avoidance exhibits a negative gradient that intensifies toward the high tail of the distribution, reaching its maximum level at $\tau = 0.75$ (-0.018 , $p < 0.001$). This result is consistent with the hypothesis that cultures with high risk aversion faced greater difficulties in implementing adaptive responses in contexts of incomplete information and accelerated change.

Year 2021: vaccine transition and reconfiguration of priorities. The mass introduction of vaccines reconfigures the landscape of determinants. Vaccine coverage (doses per 100 inhabitants) emerges as a positive and significant factor in the low quantile (0.003 , $p < 0.01$), suggesting that early immunization particularly benefited countries with lower relative effectiveness, enabling them to close performance gaps. Simultaneously, the stringency index maintains its negative association, now significant at $\tau = 0.25$ (-0.011 , $p < 0.01$), reinforcing evidence of diminishing returns from generalized restrictions.

In 2021 (corresponding to the vaccine transition) the Gini coefficient turns positive and statistically significant at $\tau = 0.50$ (1.069 , $p < 0.01$) and $\tau = 0.75$ (1.326 , $p < 0.01$), consistent with targeted reopenings and priority allocation of scarce resources that yielded larger marginal gains in our joint effectiveness metric among mid- to high-performing countries. We do not claim that inequality is inherently beneficial; we interpret this 2021 association as a transitional pattern arising from those selective reopenings and priority allocations.

Public debt shows a negative association at the lower quantile ($\tau = 0.25$, $p < 0.001$), consistent with tighter fiscal space constraining countercyclical support. Cultural dimensions show substantial reconfiguration. Indulgence presents consistent negative levels in the low quantiles (-0.004 , $p < 0.01$), while uncertainty avoidance reverses its sign at $\tau = 0.75$, becoming positive (0.006 , $p < 0.01$). This reversal suggests that, with established protocols and available vaccines, cultures with greater propensity for normative compliance better capitalized on standardized interventions.

Year 2022: consolidation phase and the costs of inequality. The coefficient on the Gini index reverses sign and becomes negative at the lower and upper quantiles (-1.115 , $p < 0.01$ at $\tau = 0.25$; -1.106 , $p < 0.10$ at $\tau = 0.75$), suggesting that structural inequality ceased to operate as a facilitator of differentiated responses and instead became a drag on sustainable recovery. In parallel, vaccination exhibits negative and statistically significant associations at the lower and middle quantiles (-0.003 , $p < 0.10$; -0.004 , $p < 0.01$), a result consistent with saturation — where marginal increases in coverage no longer translate into improvements in the joint effectiveness metric — and/or with inverse endogeneity (greater deployment in settings with poorer performance). Taken together with prior evidence on the role of institutions, these patterns indicate that, in 2022, institutional quality and effective coverage (rather than additional doses per se), along with the reduction of distributive gaps, were key drivers of sustained effectiveness.

In the cultural domain, the complexity persists. Uncertainty avoidance maintains negative coefficients at $\tau = 0.25$ (-0.007 , $p < 0.001$) and $\tau = 0.75$ (-0.005 , $p < 0.01$), while achievement motivation emerges positively in the high tail (0.006 , $p < 0.01$), suggesting that results-oriented management styles characterized the best-performing countries in the consolidation phase.

The identified patterns reveal an evolution consistent with three phases of institutional adaptation: (i) a shock phase (2020) when installed capacity and participatory legitimacy dominate over procedural rigidity; (ii) a transition phase (2021) characterized by the primacy of technological innovation (vaccines) and a certain paradoxical advantage of unequal socioeconomic configurations; and (iii) a consolidation phase (2022) when state executive capacity and long-term strategic orientation emerge as critical determinants, while traditional intervention instruments show evident exhaustion. Collectively, effectiveness in managing prolonged crises does not depend on a static set of capacities, but rather on the ability to reconfigure priorities and mobilize different institutional and cultural resources according to the specific phase of the challenge faced.

5. Discussion of results

Our results are threefold. First, joint *managerial effectiveness* (*ME_GOBO*) improves progressively between 2020 and 2022, with the economic and health dimensions behaving orthogonally, challenging the narrative of an inevitable trade-off between health and economy. Second, the convergence toward balanced strategies — around 90% of countries in 2022 — reflects adaptation to sociopolitical constraints rather than deliberate optimization. Third, the determinants of effectiveness exhibit a profoundly dynamic nature, with clear transitions between crisis management phases that demand differentiated institutional and cultural capacities.

5.1. Health vs. the economy: does a structural trade-off exist?

Comparative evidence indicates that, although strict measures entail activity costs in the short term, there is no mechanical link between “saving lives” and “destroying the economy” when rapid and well-designed responses are implemented (Brauner et al., 2021; Haug et al., 2020). Macroeconomic analyses with multinational data show that GDP evolution in 2020–2022 depends on both epidemic dynamics and the timing and mix of policies, without a linear *trade-off* between health and economic outcomes. Furthermore, countries that opted for early elimination strategies achieved, on average, lower excess mortality and better macroeconomic trajectories than those that followed mitigation strategies (Maggetti and Trein, 2022).⁶

⁶ It is important to note that orthogonality in efficiency measures does not imply the absence of health-economic tensions in practice. Policymakers often face decisions where health measures impose economic costs or vice versa. Our findings suggest, however, that such trade-offs are not deterministic: effective policy design can help mitigate them, allowing countries to perform well on both dimensions simultaneously.

5.2. Dynamic determinants of effectiveness: empirical evidence from quantile regression

The analysis using quantile regressions (see Table 5) reveals a temporal evolution consistent with three distinct phases of pandemic management, each characterized by specific configurations of critical determinants.

Shock phase (2020): installed capacity as critical buffer. Hospital capacity emerges as the most robust determinant in 2020, with particularly pronounced levels in the middle and high quantiles ($\tau = 0.50$: 0.091; $\tau = 0.75$: 0.145, $p < 0.001$). This finding is consistent with literature documenting how the availability of hospital beds allowed certain countries to absorb the initial shock without their health systems collapsing (Cavalieri et al., 2025). The marginally significant negative association of the *stringency index* at the median suggests that from the first year, there were already limits to the effectiveness of generalized restrictions when the objective transcends mere epidemiological containment (Haug et al., 2020). The observed institutional pattern — with voice and accountability positive but regulatory quality and political stability negative — reflects tensions inherent to management under radical uncertainty, in line with evidence that privileges participatory legitimacy and adaptive flexibility over rigid procedural structures in initial phases (Da Silva, 2023). The strong association with uncertainty avoidance in the high quantile (-0.018 , $p < 0.001$) reinforces this interpretation.

Vaccine transition phase (2021): reconfiguration of capacities and distributive paradoxes. The introduction of vaccines marks a turning point: their positive association in the low quantile (0.003, $p < 0.01$) is consistent with global estimates that attribute substantial mortality reduction and facilitation of economic recovery to vaccines (Watson et al., 2022). Simultaneously, the persistence of negative association from the stringency index, now significant at $\tau = 0.25$, confirms diminishing returns of Non-Pharmaceutical Interventions (NPIs). The positive association of the Gini index with effectiveness in the middle and high quantiles (1.069 and 1.326, $p < 0.01$), though counter-intuitive, is coherent with the negative correlation of the Gini index with GDP per capita and HDI: in 2021, less developed and more unequal countries would have achieved greater relative improvements by incorporating vaccination and relaxing restrictions, with possible support from dual structures and labor informality. The sign reversal of uncertainty avoidance at $\tau = 0.75$ (0.006, $p < 0.01$) suggests that, with established protocols and available technology, cultures with greater normative adherence better capitalized on standardized interventions (Brown and Jones, 2025).

Consolidation phase (2022): primacy of state capacity and exhaustion of traditional instruments. In 2022, government effectiveness emerges as the primary determinant in the low quantile (0.293, $p < 0.01$), while long-term orientation gains relevance at the median (0.005, $p < 0.01$), suggesting that sustained execution and strategic planning become critical once the acute phase is overcome (Da Silva et al., 2023). The reversal of the Gini index association — now negative at the extremes (-1.115 at $\tau = 0.25$, $p < 0.01$; -1.106 at $\tau = 0.75$, $p < 0.10$) — indicates that structural inequality shifts from being an enabler of differentiated responses to an impediment to sustainable recovery. The negative coefficients for vaccines in 2022 (-0.003 and -0.004 , $p < 0.10$ and $p < 0.01$) do not imply ineffectiveness, but rather *saturation*: after critical coverage thresholds, marginal variation does not translate into additional improvements in joint performance, a pattern consistent with diminishing or null marginal returns in late phases (Brauner et al., 2021).

All coefficients are interpreted as conditional associations rather than causal effects. Results may reflect plausible endogeneity — e.g., reactive vaccination/testing in lower-performing settings and time-varying confounding — so we avoid causal language and frame the 2021 pattern as transitional rather than structural.

5.3. Implications for public policy

Evolutionary capacities vs. static resources. The transition from dependence on installed capacity (2020) toward primacy of government effectiveness (2022) suggests that prolonged crises demand capacity portfolios that evolve with the phases of the emergency.

Diminishing returns and precision over intensity. The evidence of diminishing returns from *stringency* and vaccination underscores that intensity must give way to precision, privileging focused and adaptive interventions over sustained generalized measures.

Distributional heterogeneity and differentiated policy. The variation of effects across quantiles indicates that optimal policies differ according to relative position in the performance distribution, suggesting differentiated strategies rather than universal prescriptions.

Culture as contingent modulator. Non-monotonic association of cultural dimensions — particularly, the reversal of uncertainty avoidance — challenge cultural determinisms and suggest that the fit between cultural characteristics and crisis phase is more relevant than values *per se*.

6. Conclusions

This study offers evidence on the evolution of *managerial effectiveness* during the COVID-19 pandemic in 104 countries (2020–2022), enabling us to move beyond the idea of an inevitable trade-off between health and economy. The progressive improvement in joint effectiveness (*ME joint*), together with the empirical orthogonality between health and economic dimensions, confirms that both spheres can be managed simultaneously without advances in one necessarily implying setbacks in the other.

Second, the results show a clear convergence toward balanced strategies: in 2022, around 90% of countries adopted intermediate approaches, with no cases of extreme economic prioritization. This pattern reflects not so much deliberate optimization as adaptation to sociopolitical constraints and the costs of sustaining unilateral approaches, especially those that privileged economy over health.

Third, quantile regressions identify the dynamic nature of effectiveness determinants. In the shock phase (2020), hospital capacity and participatory legitimacy were key to containing the initial impact. In the vaccine transition (2021), immunization coverage emerged as a critical factor for closing gaps in lagging countries, while inequality was positively associated with relative improvements in less developed contexts. Finally, in the consolidation phase (2022), government effectiveness and long-term orientation consolidated as central determinants, while inequality became a burden and vaccines showed diminishing returns once critical coverage thresholds were reached.

Collectively, the evidence suggests that effective management of prolonged crises depends less on a static set of resources and more on state capacity to reconfigure priorities and mobilize instruments according to the emergency phase. Executive capacity — proxied by government effectiveness — emerges as long-term strategic asset, while cultural variables do not operate deterministically, but as contingent modulators that can become advantages or limitations depending on the moment in the crisis cycle.

Looking toward future global crises, the results highlight three main lessons: (i) invest in adaptive institutional capacities beyond physical infrastructure; (ii) design policies with focused precision, avoiding generalized high-intensity measures with diminishing returns; and (iii) consider distributional heterogeneity, differentiating strategies according to countries' relative position in the performance distribution. In summary, the pandemic demonstrated that *managerial effectiveness* does not lie in avoiding the trade-off between health and economy, but in managing it dynamically through flexible institutional arrangements, quality regulation, and long-term strategic planning.

From a methodological perspective, a promising avenue for future research would be, on the one hand, to explore additional endogenous choices of the directional vector g and examine their impact on distance measures, as well as on alternative ways of identifying the trade-offs between good and bad outputs. On the other hand, it would be worthwhile to consider the incorporation of weight restrictions, for example when certain preferences among outputs can be elicited from an expert panel.

CRedit authorship contribution statement

Claudio Thieme: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Víctor Giménez:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Diego Prior:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Emili Tortosa-Ausina:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Investigation, Funding acquisition, Conceptualization.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.eap.2026.05.002>.

References

- Abdelsalam, O., Fethi, M.D., Matallín, J.C., Tortosa-Ausina, E., 2014. On the comparative performance of socially responsible and Islamic mutual funds. *J. Econ. Behav. Organ.* 103, S108–S128.
- Abdelsalam, O., Mollah, S., Tortosa-Ausina, E., El-Masry, A.A., 2025. Do political connections matter for bank efficiency in times of crisis? *Int. J. Finance Econ.* 30 (1), 602–625.
- Abdou, A.M., 2021. Good governance and COVID-19: The digital bureaucracy to response the pandemic (Singapore as a model). *J. Public Aff.* 21 (4), e2656.
- Acemoglu, D., Chernozhukov, V., Werning, I., Whinston, M.D., 2021. Optimal targeted lockdowns in a multigroup SIR model. *Am. Econ. Rev.: Insights* 3 (4), 487–502.
- Akpan, I.J., Shanker, M., Offodile, O.F., 2024. Discrete-event simulation is still alive and strong: evidence from bibliometric performance evaluation of research during COVID-19 global health pandemic. *Int. Trans. Oper. Res.* 31 (4), 2069–2092.
- Alvelda, P., Ferguson, T., Mallery, J., 2020. To Save the Economy, Save People First. Technical Report 18, Institute for New Economic Thinking.
- Andersen, A.L., Hansen, E.T., Johannesen, N., Sheridan, A., 2020. Pandemic, Shutdown and Consumer Spending: Lessons from Scandinavian Policy Responses to COVID-19. Technical Report, arXiv preprint, arXiv:2005.04630.
- Arbona, A., Giménez, V., López-Estrada, S., Prior, D., 2022. Efficiency and quality in Colombian education: An application of the metafrontier Malmquist-Luenberger productivity index. *Socio-Econ. Plan. Sci.* 79, 101122.
- Bădin, L., Daraio, C., Simar, L., 2010. Optimal bandwidth selection for conditional efficiency measures: A data-driven approach. *European J. Oper. Res.* 201 (2), 633–640.

- Bădin, L., Daraio, C., Simar, L., 2012. How to measure the impact of environmental factors in a nonparametric production model. *European J. Oper. Res.* 223 (3), 818–833.
- Barrett, P., Poot, J., 2023. Islands, remoteness and effective policy making: Aotearoa New Zealand during the COVID-19 pandemic. *Reg. Sci. Policy Pract.* 15 (3), 682–705.
- Beane, T., Clarke, J.M., Jain, V., Golestaneh, A.K., Lyons, G., Salman, D., Majeed, A., 2020. Excess mortality: the gold standard in measuring the impact of COVID-19 worldwide? *J. R. Soc. Med.* 113 (9), 329–334.
- Beltrán-Estevé, M., Giménez, V., Picazo-Tadeo, A.J., 2019. Environmental productivity in the European Union: A global Luenberger-metafrontier approach. *Sci. Total Environ.* 692, 136–146.
- Benmelech, E., Tzur-Ilan, N., 2020. The Determinants of Fiscal and Monetary Policies During the COVID-19 Crisis. Working Paper 27461, National Bureau of Economic Research, Cambridge, MA.
- Brauner, J.M., Mindermann, S., Sharma, M., Johnston, D., Salvatier, J., Gavenčák, T., Stephenson, A.B., Leech, G., Altman, G., Mikulik, V., et al., 2021. Inferring the effectiveness of government interventions against COVID-19. *Science* 371 (6531), eabd9338.
- Brewer, C.A., Pickle, L., 2002. Evaluation of methods for classifying epidemiological data on choropleth maps in series. *Ann. Assoc. Am. Geogr.* 92 (4), 662–681.
- Brown, P.A., 2023. Country-level predictors of COVID-19 mortality. *Sci. Rep.* 13, 9263.
- Brown, D., Dattilo, M., Rockey, J., 2025. Explaining international differences in excess mortality due to Covid-19. *Sci. Rep.* 15, 13879.
- Brown, B., Jones, C., 2025. Adaptive leadership of schools in Australia during the Covid-19 pandemic: lessons for future crises. *Sch. Leadersh. Manag.* 45 (2), 153–173.
- Cao, C., Li, N., Liu, L., 2020. Do national cultures matter in the containment of COVID-19? *Int. J. Sociol. Soc. Policy* 40 (9/10), 939–961.
- Caulkins, J., Grass, D., Feichtinger, G., Hartl, R., Kort, P., Kuhn, M., Prskawetz, A., Sanchez-Romero, M., Seidl, A., Wrzaczek, S., 2023. The hammer and the jab: Are COVID-19 lockdowns and vaccinations complements or substitutes? *European J. Oper. Res.* 311 (1), 233–250.
- Cavaliere, M., Fontana, S., Guccio, C., Lisi, D., Martorana, M.F., Pignataro, G., Romeo, D., 2025. Measuring hospital care resilience: A systematic literature review. *Eur. J. Health Econ.* 1–37, (forthcoming).
- Cazals, C., Florensa, J.-P., Simar, L., 2002. Nonparametric frontier estimation: a robust approach. *J. Econometrics* 106, 1–25.
- Chen, S.-P., Lin, Y.-R., 2025. Measuring the efficiency of administrative divisions in combating the COVID-19 pandemic in Taiwan: an empirical study. *Int. Trans. Oper. Res.* 32 (2), 1064–1087.
- Chen, K., Pun, C.S., Wong, H.Y., 2023. Efficient social distancing during the COVID-19 pandemic: Integrating economic and public health considerations. *European J. Oper. Res.* 304 (1), 84–98.
- Cherchye, L., Lovell, C.K., Moesen, W., Van Puyenbroeck, T., 2007. One market, one number? A composite indicator assessment of EU internal market dynamics. *Eur. Econ. Rev.* 51 (3), 749–779.
- Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., Saisana, M., Saltelli, A., Liska, R., Tarantola, S., 2008. Creating composite indicators with DEA and robustness analysis: the case of the Technology Achievement Index. *J. Oper. Res. Soc.* 59 (2), 239–251.
- Chudik, A., Mohaddes, K., Pesaran, M.H., Raissi, M., Rebucci, A., 2021. A counterfactual economic analysis of Covid-19 using a threshold augmented multi-country model. *J. Int. Money Finance* 119, 102477.
- Chung, Y.H., Färe, R., Grosskopf, S., 1997. Productivity and undesirable outputs: a directional distance function approach. *J. Environ. Manag.* 51 (3), 229–240.
- Cooper, W., Seiford, L., Tone, K., 2007. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*, second ed. Springer US, New York.
- Cordero, J.M., Pedraja-Chaparro, F., Pisaflores, E.C., Polo, C., 2017. Efficiency assessment of Portuguese municipalities using a conditional nonparametric approach. *J. Prod. Anal.* 48 (1), 1–24.
- Cuschieri, S., Pallari, E., Hatzayianni, A., Sigurvinsdottir, R., Sigfusdottir, I.D., Sigurdottir, Á.K., 2022. Mortality comparisons of COVID-19 with all-cause and non-communicable diseases in Cyprus, Iceland and Malta: lessons learned and forward planning. *Public Health* 202, 52–57.
- Da Silva, M., 2023. Explainability, public reason, and medical artificial intelligence. *Ethical Theory Moral Pract.* 26 (5), 743–762.
- Da Silva, N.S., de Araújo, N.K., Dos Santos, K.A., de Souza, K.S.C., de Araújo, J.N.G., Cruz, M.S., Parra, E.J., Silbiger, V.N., Luchessi, A.D., 2023. Post-Covid condition and clinic characteristics associated with SARS-CoV-2 infection: a 2-year follow-up to Brazilian cases. *Sci. Rep.* 13 (1), 13973.
- Daraio, C., Simar, L., 2005. Introducing environmental variables in nonparametric frontier models: A probabilistic approach. *J. Prod. Anal.* 24 (1), 93–121.
- Daraio, C., Simar, L., 2007. Conditional nonparametric frontier models for convex and nonconvex technologies: a unifying approach. *J. Prod. Anal.* 28 (1), 13–32.
- De Witte, K., Kortelainen, M., 2013. What explains the performance of students in a heterogeneous environment? Conditional efficiency estimation with continuous and discrete environmental variables. *Appl. Econ.* 45 (17), 2401–2412.
- De Witte, K., Rogge, N., 2011. Accounting for exogenous influences in performance evaluations of teachers. *Econ. Educ. Rev.* 30 (4), 641–653.
- Despotis, D.K., 2005. A reassessment of the human development index via data envelopment analysis. *J. Oper. Res. Soc.* 56 (8), 969–980.
- D’Inverno, G., De Witte, K., 2020. Service level provision in municipalities: A flexible directional distance composite indicator. *European J. Oper. Res.* 286 (3), 1129–1141.
- D’Inverno, G., Santos, J.V., Camanho, A.S., 2025. An innovative benefit-of-the-doubt approach for health system effectiveness: a global case study on amenable mortality. *Int. Trans. Oper. Res.* 32 (5), 2847–2877.
- Dorn, F., Lange, B., Braml, M., Gstrein, D., Nyirenda, J.L., Vanella, P., Winter, J., Fuest, C., Krause, G., 2023. The challenge of estimating the direct and indirect effects of COVID-19 interventions—Toward an integrated economic and epidemiological approach. *Econ. Hum. Biol.* 49, 101198.
- Duggan, J., Andrade, J., Murphy, T.B., Gleeson, J.P., Walsh, C., Nolan, P., 2024. An age-cohort simulation model for generating COVID-19 scenarios: A study from Ireland’s pandemic response. *European J. Oper. Res.* 313 (1), 343–358.
- Färe, R., Grosskopf, S., 2000. Theory and application of directional distance functions. *J. Prod. Anal.* 13 (2), 93–103.
- Feng, Q., Wu, G.L., Yuan, M., Zhou, S., 2023. Save lives or save livelihoods? A cross-country analysis of COVID-19 pandemic and economic growth. *J. Econ. Behav. Organ.* 197, 823–862.
- Gaaloul, H., Khalfallah, S., 2014. Application of the “benefit-of-the-doubt” approach for the construction of a digital access indicator: A revaluation of the “digital access index”. *Soc. Indic. Res.* 118 (1), 45–56.
- Gagnon, J.E., Kamin, S.B., Kearns, J., 2023. The impact of the COVID-19 pandemic on global GDP growth. *J. Jpn. Int. Econ.* 68, 101258.
- García-Basteiro, A., Alvarez-Dardet, C., Arenas, A., Bengoa, R., Borrell, C., Del Val, M., Franco, M., Gea-Sánchez, M., Otero, J.J.G., Valcárcel, B.G.L., et al., 2020. The need for an independent evaluation of the COVID-19 response in Spain. *Lancet* 396 (10250), 529–530.
- Giménez, V., Prior, D., Thieme, C., Tortosa-Ausina, E., 2024. International comparisons of COVID-19 pandemic management: What can be learned from activity analysis techniques? *Omega* 122, 102966.
- Gordon, D.V., Grafton, R.Q., Steinsham, S.I., 2021. Cross-country effects and policy responses to COVID-19 in 2020: The Nordic countries. *Econ. Anal. Policy* 71, 198–210.
- Greer, S.L., Dubin, K.A., Falkenbach, M., Jarman, H., Trump, B.D., 2023. Alignment and authority: Federalism, social policy, and COVID-19 response. *Health Policy* 127, 12–18.
- Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., Tatlow, H., 2021. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). *Nat. Hum. Behav.* 5, 529–538.
- Haug, N., Geyrhofer, L., Londei, A., Dervic, E., Desvars-Larrive, A., Loreto, V., Pinior, B., Thurner, S., Klimek, P., 2020. Ranking the effectiveness of worldwide COVID-19 government interventions. *Nat. Hum. Behav.* 4 (12), 1303–1312.

- Hofstede, G., 2001. *Culture's Consequences*, second ed. Sage, Thousand Oaks, CA.
- Hofstede, G., Hofstede, G.J., 2005. *Cultures and Organizations. Software of the Mind*, second ed. McGraw-Hill, New York.
- Kerstens, K., Van de Woestyne, I., 2011. Negative data in DEA: a simple proportional distance function approach. *J. Oper. Res. Soc.* 62 (7), 1413–1419.
- Krueger, D., Uhlig, H., Xie, T., 2022. Macroeconomic dynamics and reallocation in an epidemic: evaluating the 'Swedish solution'. *Econ. Policy* 37 (110), 341–398.
- Kumar, R., 2021. Impact of societal culture on Covid-19 morbidity and mortality across countries. *J. Cross-Cult. Psychol.* 52 (7), 643–662.
- Lakens, D., Scheel, A.M., Isager, P.M., 2018. Equivalence testing for psychological research: A tutorial. *Adv. Methods Pract. Psychol. Sci.* 1 (2), 259–269.
- Law, T.H., Ng, C.P., Poi, A.W.H., 2022. The sources of the Kuznets relationship between the COVID-19 mortality rate and economic performance. *Int. J. Disaster Risk Reduct.* 81, 103233.
- Li, Q., Racine, J.S., 2008. Nonparametric estimation of conditional CDF and quantile functions with mixed categorical and continuous data. *J. Bus. Econom. Statist.* 26 (4), 423–434.
- Maggetti, M., Trein, P., 2022. Policy integration, problem-solving, and the coronavirus disease crisis: Lessons for policy design. *Policy Soc.* 41 (1), 53–67.
- Mandal, S.K., Madheswaran, S., 2010. Environmental efficiency of the Indian cement industry: an interstate analysis. *Energy Policy* 38 (2), 1108–1118.
- Mastromarco, C., Simar, L., 2015. Effect of FDI and time on catching up: New insights from a conditional nonparametric frontier analysis. *J. Appl. Econometrics* 30 (5), 826–847.
- Matallín-Sáez, J.C., Soler-Dominguez, A., Tortosa-Ausina, E., 2019. Does active management add value? New evidence from a quantile regression approach. *J. Oper. Res. Soc.* 70 (10), 1734–1751.
- Matei, I., 2024. Assessing the impact of pandemic measures on economic growth in a globalizing world: A non-linear panel analysis. *Appl. Econ.* 56 (59), 8967–8990.
- Mathieu, E., Ritchie, H., Rodés-Guirao, L., Appel, C., Gavrilov, D., Giattino, C., Hasell, J., Macdonald, B., Dattani, S., Beltekian, D., Ortiz-Ospina, E., Roser, M., 2020. Excess mortality during the Coronavirus pandemic (COVID-19). *Our World Data* <https://ourworldindata.org/excess-mortality-covid>.
- Melyn, W., Moesen, W., 1991. Towards a synthetic indicator of macroeconomic performance: Unequal weighting when limited information is available. *Public Econ. Res. Pap.* 1–24.
- Mgammal, M.H., 2024. The impact of tobacco taxes, VAT, and affordability on the human development index: a global perspective on future economic trends. *Cogent Econ. Finance* 12 (1), 2429771.
- Morais, P., Camanho, A.S., 2011. Evaluation of performance of European cities with the aim to promote quality of life improvements. *Omega* 39 (4), 398–409.
- Muñiz, M., Paradi, J., Ruggiero, J., Yang, Z., 2006. Evaluating alternative DEA models used to control for non-discretionary inputs. *Comput. Oper. Res.* 33 (5), 1173–1183.
- Norman, G.R., Sloan, J.A., Wyrwich, K.W., 2003. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med. Care* 41 (5), 582–592.
- Oh, D.-h., 2010. A metafrontier approach for measuring an environmentally sensitive productivity growth index. *Energy Econ.* 32 (1), 146–157.
- Oliveira, R., Zanella, A., Camanho, A.S., 2019. The assessment of corporate social responsibility: The construction of an industry ranking and identification of potential for improvement. *European J. Oper. Res.* 278 (2), 498–513.
- Pagan, A., Ullah, A., 1999. *Nonparametric Econometrics*. In: *Themes in Modern Econometrics*, vol. 10, Cambridge University Press, Cambridge.
- Picazo-Tadeo, A.J., Reig-Martinez, E., Hernandez-Sancho, F., 2005. Directional distance functions and environmental regulation. *Resour. Energy Econ.* 27 (2), 131–142.
- Rodríguez-Pose, A., Burlina, C., 2021. Institutions and the uneven geography of the first wave of the COVID-19 pandemic. *J. Reg. Sci.* 61 (4), 728–752.
- Roser, M., Ritchie, H., Ortiz-Ospina, E., Hasell, J., 2020. Coronavirus Pandemic (COVID-19). *OurWorldInData.org*, Published online at *OurWorldInData.org*, Retrieved from <https://ourworldindata.org/coronavirus>.
- Simar, L., Vanhems, A., 2012. Probabilistic characterization of directional distances and their robust versions. *J. Econometrics* 166 (2), 342–354.
- Solow, R.M., 1957. Technical change and the aggregate production function. *Rev. Econ. Stat.* 39 (3), 312–320.
- Storm, S., 2023. Lessons for the age of consequences: COVID-19 and the macroeconomy. *Rev. Political Econ.* 35 (3), 823–862.
- Stumbriene, D., Camanho, A.S., Jakaitiene, A., 2019. The performance of education systems in the light of Europe 2020 strategy. *Ann. Oper. Res.* 288 (2), 577–608.
- Sueyoshi, T., Goto, M., 2010. Should the US clean air act include CO2 emission control? Examination by data envelopment analysis. *Energy Policy* 38 (10), 5902–5911.
- Torres, M.F., Garraza, M., Quintero, F.A., Luna, M.E., Navazo, B., Cesani, M.F., 2024. Decline in pubertal timing and its relationship with excess weight. A study of the secular trend in age at menarche in girls from La Plata district (Buenos Aires, Argentina). *Am. J. Hum. Biol.* 36 (8), e24074.
- Wang, K., Xian, Y., Lee, C.-Y., Wei, Y.-M., Huang, Z., 2019. On selecting directions for directional distance functions in a non-parametric framework: a review. *Ann. Oper. Res.* 278 (1), 43–76.
- Watson, O.J., Barnsley, G., Toor, J., Hogan, A.B., Winskill, P., Ghani, A.C., 2022. Global impact of the first year of COVID-19 vaccination: a mathematical modelling study. *Lancet Infect. Dis.* 22 (9), 1293–1302.
- Yang, J., Zheng, Y., Gou, X., Pu, K., Chen, Z., Guo, Q., Ji, R., Wang, H., Wang, Y., Zhou, Y., 2020. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: A systematic review and meta-analysis. *Int. J. Infect. Dis.* 94, 91–95.
- Zanella, A., Camanho, A., Dias, T.G., 2013. Benchmarking countries' environmental performance. *J. Oper. Res. Soc.* 64 (3), 426–438.
- Zanella, A., Camanho, A.S., Dias, T.G., 2015. Undesirable outputs and weighting schemes in composite indicators based on data envelopment analysis. *European J. Oper. Res.* 245 (2), 517–530.