

New governance composite indicator: a quality and reliability-based approach

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ABSTRACT

Composite indicators simplify the representation of complex realities without losing generality, attracting the attention of researchers from various fields, including operational research. Despite their advantages, many composite indicators fail with regard to quality and reliability, e.g., governance composite indicators. This study proposes an innovative quality-reliability approach for constructing composite indicators, which can be applied to represent the multidimensional governance of the 20 largest economies in the world. The composite indicator obtained showed high explanatory power (correlation of 0.85 with GDP per capita), absence of countries with discrepant scores (0% bivariate outliers), high informational power (retention of 90% of input data), and high discriminant power (well-distributed scores). Finally, the countries' uncertainty of 0.20 positions in the ranking guarantees that the composite indicator has a stable internal structure, and the results are reliable and valuable for guiding investors and public managers on making investments and/or prioritizing institutional reforms.

KEYWORDS. multidimensional problems; governance indicators; composite indicators; ordered weighted averaging.

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1. Introduction

Operational research has specialized in several areas, such as the construction of composite indicators [Fusco, 2015], [Rogge 2018], [Figueira et al. 2023]. Composite indicators are tools that simplify the representation and communication of complex and multifaceted realities, known as multidimensional phenomena [Libório et al. 2023]. In turn, governance is a multidimensional construct that a single indicator cannot measure since it involves aspects such as corruption control, government effectiveness, rule of law, quality of the business environment, regulatory quality, and voice and accountability [Kaufmann et al. 2011], [Pinar 2015], [Barbier and Burgess 2021].

Given their impact on political and investment decisions [Gani, 2007], [Torfing and Ansell 2020], this relevance makes constructing governance composite indicators a critical process. Due to the lack of a perfect method, the OECD [2008] guide for constructing composite indicators recommends checking the quality of the results. The guide particularly suggests analyzing the quality of the results using robustness tests (uncertainty and sensitivity) and linkage with a conceptually significant variable [OECD 2008]. The first test checks how much the classification/score of results varies due to changes in the normalization function, sub-indicator weights, and aggregation schemes [Nardo et al. 2005]. The second test verifies the composite indicator's ability to capture the multidimensional phenomenon concept [Libório et al. 2021].

Although they offer concise representations of good governance without loss of generality, governance composite indicators have limitations in verifying the quality of the results. Governance composite indicators found in the literature do not adequately perform uncertainty analysis and link to other variable tests [Oino 2019], [Belenesi et al. 2021], [Feyisa et al. 2022]. This is a significant limitation given the repercussions of governance composite indicators on political and investment decisions [Bellos and Subasat 2012], [Torfing and Ansell 2020].

This study explores this gap and develops an approach to constructing a composite indicator based on quality and reliability. This approach presents two novelties. It considers informational power, discriminant power, and the proportion of atypical measures to be complementary quality and reliability tests. Furthermore, it uses the quality and reliability test results as a criterion for selecting the weights of the ordered weighted average operator.

These new features prevent composite governance indicators such as low quality and reliability from being used in decision-making. They provide a broader view of the quality and reliability of composite indicators. They remove subjectivity from the process of defining the weights of the ordered weighted averaging (OWA) operator. These contributions are evidenced by applying the approach to the analysis of multidimensional governance in the 20 largest economies in the world.

In addition to this introduction, this research is organized as follows. Section 2 explores the literature on governance composite indicators, including the methods used and quality tests performed. Section 3 presents the materials and methods used in constructing and testing the quality and reliability of the governance composite indicator. Section 4 presents and discusses the results, indicating the advantages and disadvantages of the new governance composite indicator. Finally, Section 5 presents the conclusions, research limitations, and lines of future investigation.

2. Multidimensional Governance

The concept of good governance has been widely explored in the political and academic environment for quite some time, given its close relationship with economic development [Kohler-Koch and Rittberger 2006], [Thomas 2010]. There are different definitions of governance. The World Bank [1994] defines good governance as the bureaucracy shaped by a professional ethos, an executive branch of government responsible for its actions, a strong participation of civil society in public affairs, and everyone behaving under the rule of law. Other concepts are even broader

and consider different stakeholders, and others are more focused, such as the behavior of public agents [Cruz and Marques 2017].

The emphasis on good governance has advanced with the increase in foreign direct investments and the assets of international investors abroad. This movement increased investors' interest in increasing the quality of governance in the countries that receive their investments to ensure risk reduction [Khodary 2016], [Oman and Arndt 2010]. For these reasons, good governance has become crucial for sustainable development and establishing trust between institutions based on the transparency of transactions and the accountability of decisions [Cruz and Marques 2017], generating a high demand for governance indicators [Gisselquist 2014], and consequently, a proliferation of governance measures, such as the Worldwide Governance Indicators [Kaufmann et al. 2011], Country Policy and Institutional Assessment [World Bank. [2010], Transparency International's Corruption Perceptions Index [Thompson and Shah 2005], and Freedom House's Freedom in the World [Giannone 2010].

These measures aggregate several indicators into a synthesis measure, called composite indicators or indices, which capture and simplify the understanding and comparison of multiple facts or dimensions of a complex and multidimensional concept [Nardo et al. 2005], [OECD 2008], [Greco et al. 2019]. In this sense, it is possible to say that governance is a multidimensional construct, and its synthesis into a unidimensional measure requires the construction of a composite indicator [Mitra 2013]. In this sense, composite indicators compress and preserve the information necessary to understand countries' governance, enabling analysis of development priorities, construction of scientific knowledge, and even influencing dominant groups [Gisselquist 2014]. Furthermore, composite indicators quantitatively estimate countries' governance quality, enabling comparisons and decision-making [Oman and Arndt 2010].

2.1. Governance composite indicators

Most of governance composite indicators are constructed using the principal component analysis helping decision-makers to understand the relationship between governance and the performance of institutions and financial markets [Oino 2019], [Belenesi et al. 2021], [Feyisa et al. 2022], [Rashid et al. 2024] the achievement of private investments [Falchetta et al. 2021], the flow of foreign investments [Nxumalo and Makoni 2021], [Bouchoucha 2022], the efficiency of the health system [Vātavu et al. 2022], [Hadipour et al. 2023], the growth of investments in specific sectors, such as renewable energy [Kassi and Dong 2023] or even to identify countries' government styles [Zahariadis et al. 2023]. Another frequently used method to construct governance composite indicators is the simple additive weighting, offering insights into governance assessment [Khodary 2016], irrigation governance ratings [Akuribaet al. 2020], and adherence to best corporate governance practices [Velázquez and Barba 2019].

The index nomenclature is an interesting point about the composite indicators that use the six indicators from the World Governance Indicators. The same sub-indicators are used to represent governance [Nxumalo and Makoni 2021], institutional quality [Rashid et al. 2024], and governance quality [Kassi and Dong 2023]. Using the World Governance Indicators sub-indicators as a measure of institutional quality is not new and has been addressed in several studies [Kaufmann et al. 2011], [Barbier and Burgess 2021]. Another interesting point to be observed is the diversity of objectives and areas of application of the constructed composite indicators. This and the other points highlighted so far reinforce the importance of constructing governance composite indicators and the need to guarantee the quality and reliability of these measures.

One important gap in the governance composite indicators is the absence of uncertainty analysis and the link with external variables to test the results' quality. This absence raises doubts about the applicability of governance measurements and their role in signaling which countries are more attractive for investment.

3. Materials and methods

The development of this research is divided into collecting data from the governance sub-indicators, building the composite indicator using OWA, testing the quality and reliability of the composite indicator, and choosing the governance composite indicator.

3.1. Collection of data from governance sub-indicators

The governance sub-indicators used in the composite indicator followed the Worldwide Governance Indicators structure. This structure includes six sub-indicators: control of corruption, government effectiveness, rule of law, quality of the business environment, regulatory quality, and voice and responsibility. The gross domestic product per capita indicator was used to test the linkage of the composite indicator, given its proven correlation with governance indicators in several countries [Azam and Emirullah 2014], [Marino et al. 2016], [Al-Naser and Hamdan 2021].

Data on governance sub-indicators and gross domestic producer per capita for 2021 were extracted from the World Bank Databank (<https://databank.worldbank.org/>). For example purposes, the 20 largest economies of that year were selected. These data and the calculations of the governance composite indicator are available at doi: 10.17632/wbk4vxm7mp.1.

3.2. OWA operator

The new governance composite indicator based on quality and reliability was constructed through OWA [Yager 1988]. OWA has a high potential for application in the construction of composite indicators, being used to represent the security of energy supply [Badea et al. 2011], human development [Leon-Castro et al. 2021], quality of life [Shu et al. 2022], child well-being from a health perspective [Ribeiro et al. 2024] and public infrastructure of cities [Fusco et al. 2024].

Initially proposed by Yager [1988], OWA offers versatility in directing composite indicator scores upwards or downwards, enabling decision-makers to emphasize positive or negative aspects of the multidimensional phenomenon [Libório et al. 2024]. The emphases adopted can assume different intensities based on the regulation of the level of compensation between sub-indicators, which offers multiple solutions for representing the multidimensional phenomenon [Libório et al. 2022], [Ekel et al. 2019].

In the present research, regulating compensation levels between sub-indicators and their direction allows, for example, to emphasize governance's positive or negative aspects in different intensities. This intensity and direction of emphasis are regulated based on the decision-maker's level of optimism or orness degree, which offers multiple solutions for representing the same multidimensional phenomenon [Libório et al. 2022]. The S-CI-OWA software was used to build and test the quality of OWA's solutions [Ribeiro et al. 2024]. The software can be run in the browser via the link: <https://ci-owa.shinyapps.io/ci-owa-v1/>.

Five steps are necessary to construct a composite indicator by OWA [Yager and Kacprzyk 2012], starting from the sub-indicator normalization as follows:

$$\Omega_{\lambda} = \frac{\lambda_{\omega} - \min(\lambda_{\omega})}{\max(\lambda_{\omega}) - \min(\lambda_{\omega})} \quad (1)$$

where ω_{λ} is the value of the sub-indicator λ for the country ω , $\max(\omega_{\lambda})$ and $\min(\omega_{\lambda})$ are the maximum and minimum values of the sub-indicator λ among all countries ψ .

In steps two and three, the normalized sub-indicators are transposed and ordered from largest to smallest. The OWA weights are defined according to the sub-indicators order in the fourth step. Finally, in the fifth step, the composite indicator is constructed by the following expression:

$$\text{OWA}(\Omega_1, \Omega_2, \dots, \Omega_{\rho}) = \sum_{\lambda=1}^{\rho} \beta_{\lambda} \alpha_{\lambda} \quad (2)$$

where α_{λ} corresponds to the λ -th highest value among $\Omega_1, \Omega_2, \dots, \Omega_{\rho}$ and the weights β_{λ} meet the conditions $\beta_{\lambda} \in [0,1]$ and $\sum_{\lambda=1}^{\rho} \beta_{\lambda} = 1$.

3.3. Quality and reliability tests

Uncertainty analysis and linkage with external variables were used as quality and reliability tests following the OECD's [2008] guide. The study also tests the proportion of atypical measurements, informational power, and discriminating power to increase methodology rigor.

The uncertainty analysis checks the composite indicator's internal structure stability. It measures the average change in the ranking of countries across composite indicators constructed in different ways [Greco et al. 2019]. Simple Additive Weighting was chosen as the alternative composite indicator due to its ease of operationalization and popularity among researchers in the field [El Gibari et al. 2019]. For this, equal weights are assigned in equation (2), and then the following function is applied to test the uncertainty of rankings:

$$\Phi = \frac{1}{\delta} \sum_{\omega=1}^{\delta} |K_{OWA_{\omega}} - K_{CI_{\omega}}| \quad (3)$$

where Φ corresponds to the average change in the ranking of countries ω between the OWA and alternative composite indicators and $K_{OWA_{\omega}}$ and $K_{CI_{\omega}}$ are the ranking of the ω -th countries of the OWA and alternative composite indicators.

The link with an external variable checks the composite indicator explanatory power. In other words, it signals the composite indicator's ability to capture the concept of the multidimensional phenomenon by applying Spearman's [1904] correlation as follows:

$$\rho = \frac{\text{cov}[K_{OWA_{\omega}}, K_{\epsilon_{\omega}}]}{\sigma_{K_{OWA_{\omega}}} \sigma_{K_{\epsilon_{\omega}}}} \quad (4)$$

where ϵ_{ω} is to the external variable, $\text{cov}[K_{OWA_{\omega}}, K_{\epsilon_{\omega}}]$ is the covariance of the rank of OWA_{ω} and ϵ_{ω} , $\sigma_{K_{OWA_{\omega}}}$ e $\sigma_{K_{\epsilon_{\omega}}}$ correspond to the standard deviations of the OWA_{ω} and ϵ_{ω} ranks, respectively.

The informational power measures the information extracted from the sub-indicators by the composite indicator. It signals the composite indicator's internal reliability by the following function:

$$\text{ave} = \frac{1}{\rho} \sum_{\lambda=1}^{\rho} \left(\frac{\text{cov}(OWA_{\omega}, \epsilon_{\lambda\omega})}{\sqrt{OWA_{\omega}} \times \sqrt{\epsilon_{\lambda\omega}}} \right)^2 \quad (5)$$

where $\text{cov}(OWA_{\omega}, \epsilon_{\lambda\omega})$ corresponds to the covariance matrix of OWA_{ω} and ϵ_{ω} .

The discriminating power informs the dispersion of the composite indicator scores, signaling how difficult is to distinguish countries scores. This tests is performed by the Shannon's [1948] entropy index:

$$\mathbf{H}' = -\frac{1}{\ln \delta} \sum_{\omega=1}^{\delta} OWA_{\omega} \ln OWA_{\omega} \quad (6)$$

where $\mathbf{H}'$ is the Shannon diversity of information, and $\ln$ corresponds to the Neperian logarithm.

The proportion of atypical measures test informs the degree of compatibility of the composite indicator scores with the external variable scores, allowing the identification of countries where the governance composite indicator presents an atypical relationship with the gross domestic product per capita. The test is calculated using Mahalanobis's [1930] distance, which allows for identifying bivariate outliers through the following functions:

$$\mathbf{B} = \frac{1}{\delta} \sum_{\omega=1}^{\delta} \begin{cases} 1 & \text{if } \psi^2 \leq \eta_{\omega}^2 \\ 0 & \text{if } \psi^2 > \eta_{\omega}^2 \end{cases} \quad (7)$$

where ψ^2 is the chi-square distribution with degrees of freedom equal to the number of decision-making units and η^2 is the Mahalanobis distance, obtained as follows:

$$\eta^2 = (OWA_{\omega} - \epsilon_{\omega})^v \times \gamma^{-1} \times (OWA_{\omega} - \epsilon_{\omega}) \quad (8)$$

where v represents the matrix transpose, and γ corresponds to the covariance matrix of ϵ_{ω} .

3.4. Choosing the direction and intensity of emphasis of the composite indicator

Adjusting the direction and intensity of the emphasis of the indicator composed of no OWA implies the possibility of obtaining $(n - 1) \times 2 + 1$ representations of governance. In the present case, eleven composite indicators can be constructed from the six sub-indicators of the World Governance Indicators. Therefore, by comparing the quality and reliability tests of these eleven composite indicators, it is possible to choose one to represent the countries' governance.

However, identifying the composite indicator to be used is a difficult task due to the multi-criteria nature of the problem. To facilitate this identification, the results of each test were standardized. This standardization allows identifying which tests the composite indicator performed below or above the average of the other composite indicators. Then, the standardized values were classified as good, neutral, and poor. The neutral class includes values up to 20% below and above zero, while the good and poor classes include values below and above this range.

Figure 1 presents the tests' results for all possible negative and positive emphases. The negative or positive sign allows one to quickly identify which tests each composite indicator performed below or above the average of the eleven. In turn, colors allow us to identify which composite indicators better represent governance.

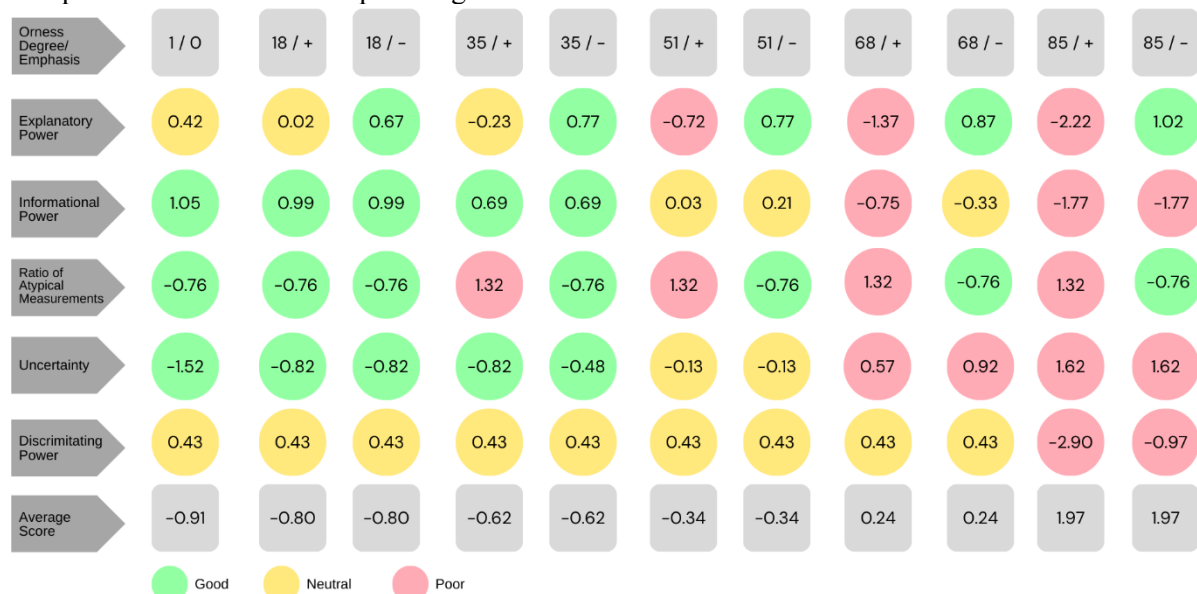


Figure 1. Results of sub-indicator quality tests. **Note:** Negative values in green represent tests in which lower values mean better results.

The panel of test results with standardized values reveals that the best composite indicators are those with the least emphasis. Among these, composite indicators with negative emphases or orness degrees of -18 and -35 offer the best governance representations. Among these, the composite indicator with an orness degree of -18 was chosen because it presents more non-zero β_λ weights. The greater the number of non-zero weights, the greater the data aggregated in the composite indicator. In other words, the composite indicator with an orness degree of -18 was chosen for its performance in quality and reliability tests and the quantity of aggregated data.

4. Results and discussions

Figure 2 shows the results of the quality and reliability tests of the governance composite indicator constructed by OWA. First, the explanatory power indicates that the composite indicator captures the concept of governance as it is strongly correlated (rho of 0.85) with the external variable gross domestic product per capita. This first result is the first evidence of the quality of the governance composite indicator, as well as being in line with the literature that relates

governance and the quality of institutions with the economic performance of countries [Azam and Emirullah 2014], [Marino et al. 2016], [Al-Naser and Hamdan 2021].

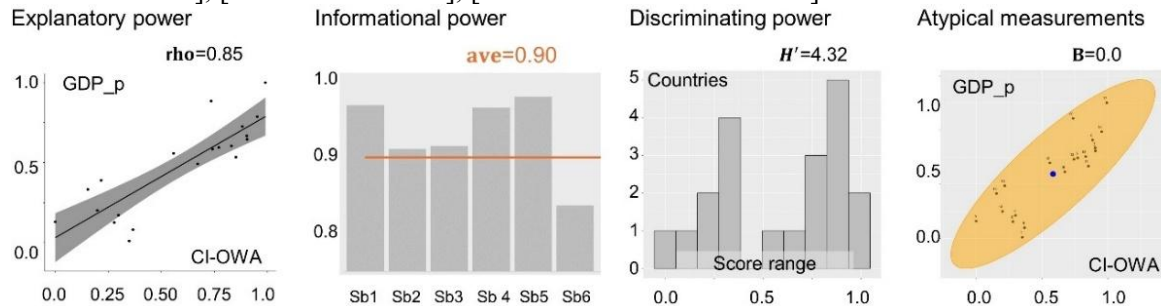


Figure 2. Quality and reliability of the governance composite indicator.

The informational power measured by the average variance extracted indicates that the governance composite indicator retained a significant proportion of the information from the six sub-indicators. A bird of 0.90 means that only 10% of the information in the input data was lost in weighting and aggregating the sub-indicators, the second being evidence of the quality of the governance composite indicator.

The ease of distinguishing countries' governance composite indicator scores is the third evidence of the quality and reliability of the governance composite indicator. The discriminating power graph reveals that the countries' scores are well distributed among the score classes, making it easier for the decision-maker to differentiate between countries.

The fourth piece of evidence for the quality and reliability of the composite indicator is observed in the bivariate outliers graph. The graph shows that all points or countries are within the orange ellipse, indicating the absence of atypical measurements. In other words, no country presented a governance composite indicator score incompatible with gross domestic product per capita.

The fifth and definitive evidence of the quality of the new governance composite indicator is presented in Table 1. The average variation of countries in the ranking was 0.2 positions, indicating that the composite indicator has a stable internal structure and that the scores are reliable.

Table 1. Ranking, scores, and uncertainty of the governance composite indicator.

Country	Rank	Scores	Uncertainty
Switzerland	1	0.99	0
Netherlands	2	0.95	0
Canada	3	0.91	-1
Australia	4	0.90	1
Germany	5	0.88	0
Japan	6	0.85	0
United Kingdom	7	0.83	0
France	8	0.77	0
South Korea	9	0.74	-1
United States	10	0.74	1
Spain	11	0.68	0
Italy	12	0.56	0
Indonesia	13	0.37	0
India	14	0.36	0
China	15	0.30	0
Brazil	16	0.29	0
Turkiye	17	0.22	0

Mexico	18	0.21	0
Russian Federation	19	0.16	0
Iran	20	0.00	0

The results show that ranking uncertainty occurs only among the ten best-positioned countries with scores above 0.70. Furthermore, the composite indicator score presents an important variation between the twelfth and thirteenth countries in the ranking. This variation is easily identified in the discriminant power graph (Figure 2), which distinguishes the countries into two blocks.

The first block comprises European countries, including Canada, the United States, Australia, Japan, and South Korea. These countries have scored 3.4 times higher than those in the second block. Countries in the second block score 0.24 and are easily identified on the map in Figure 3.



Figure 3. Map of the quality of country institutions by the governance composite indicator.

The results confirm that developed countries score higher in the governance composite indicator than developing countries. Such results corroborate the importance of improving these indicators in the countries' development process by correcting possible flaws in their governance mechanisms. A deeper analysis of the components of the generated indicators can help locate weaknesses in the governance dimensions assessed.

5. Conclusions

Governance composite indicators offer valuable information on the performance of institutions and financial markets, achievement of private investments, foreign investments, health system efficiency, growth of investments in specific sectors, or even identifying countries' government styles. However, the lack of tests that ensure the quality and reliability of these composite indicators can lead to inaccurate interpretations of mistaken decisions.

In this sense, the OWA method and quality tests were presented in this study to ensure the quality and reliability of a new governance composite indicator. The research stresses the quality of this new governance composite indicator through five tests: uncertainty analysis, the proportion of atypical measurements, explanatory power (link with external variable), informational power, and discriminating power.

The new governance composite indicator correlated 0.85 with the gross domestic product per capita, showing its ability to capture the concept of governance and institutional quality. No country presented a score on the governance composite indicator that was discrepant with its gross domestic product per capita, indicating the absence of atypical measurements. Ninety percent of

the information in the six sub-indicators was retained in the composite indicator, signaling low information loss. The scores are well divided into the ten classes of the composite indicator, signaling that it is easy for the decision maker to distinguish countries' governance. Finally, and most importantly, the uncertainty analysis shows that countries varied by an average of 0.2 positions in the ranking, ensuring that the internal structure of the composite indicator is stable and that the results are reliable.

The results obtained by the application proposed in this study can be helpful for policymakers, international development organizations, and financial institutions. The potential for new studies to construct governance composite indicators and measure their results' quality is vast. With increasingly abundant and available data, this tool is a great ally in the search for sustainable development and in maintaining and improving good governance practices.

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