

Public Sector Performance and Public Spending Efficiency: An International Comparative Analysis Using the DEA Approach on a Panel of 40 Countries

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Abstract:

Objective: This article evaluates the efficiency of public expenditure allocation to optimize the overall performance of the public sector. Conducted on a panel of forty countries stratified by income level, this study highlights the crucial dimension of expenditure quality. This issue, which remains marginally explored in recent empirical literature, takes on a particular urgency in a context of structural and perpetual growth of global public budgets.

Methods: Methodological rigor rests on Data Envelopment Analysis (DEA), a non-parametric approach highly suitable for estimating relative technical efficiency scores from annual data covering the 2015-2025 period. Furthermore, the integration of the Malmquist productivity index captures the dynamic trajectory of public sector performance and disentangles efficiency variations from technological shifts.

Results: Empirical estimations reveal substantial technical inefficiency over the entire period, characterized by a disconnect between the hierarchy of scores and countries' income levels. Counterintuitively, middle-income economies, particularly those in the lower-middle bracket, display a better average optimization of their budgetary resources compared to high-income countries. The latter suffer from diminishing marginal returns, attributable to the relative hypertrophy of their public sector.

Conclusions: The study advocates for a strategic realignment and a structural reconfiguration of budgetary allocation rather than quantitative expansion for high- and middle-income countries. For low-income economies, strengthening institutional quality proves imperative to guarantee increased resilience against exogenous macroeconomic shocks.

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1. Introduction

Nowadays, the global public sector is characterized by increasing budgetary constraints, constantly rising sovereign debt, increasingly pressing social needs, and challenges that have been exacerbated by recent international macroeconomic polycrises (IMF, 2024; Afonso et al., 2024). In this shifting context, a substantial body of literature dedicated to the analysis of economic development has long approached public finances exclusively from the perspective of the size and composition of budgetary allocations, thereby neglecting the explicit analysis of the quality of public expenditure. Emilie et al. (2021) explain the scarcity of contributions on this dimension by the complexity inherent in the very definition of the concept of quality. Indeed, the authors associate this notion with a multitude of interdependent governmental economic objectives related, among others, to efficiency, equity of allocations, economic growth, macroeconomic stabilization, and sustainable development. Following this line of thought, the present work focuses specifically on the dimension of effectiveness and examines the relative efficiency of public expenditure through a rigorous set of public sector performance indicators.

The performance indicators utilized in this study refer to the fundamental and structural components of the public sector, namely education, health, infrastructure, and public administration. In this regard, Gupta et al. (1998) highlighted the positive and crucial contribution of the education and health sectors to human capital accumulation, a major determinant that stimulates long-term economic growth while promoting collective well-being. More specifically, education increases the future productivity of the labor force as well as a country's innovation capacity, establishing itself as a fundamental investment for growth. At the same time, an efficient health system mitigates mortality risks and actively contributes to increasing life expectancy (Mushkin, 1962). As for infrastructure and public administration, they largely condition the attractiveness of domestic and foreign direct investments, business support, the reduction of production costs and, ultimately, the quality of life of populations. However, contemporary empirical literature argues that the regular increase in budgetary allocations to these sectors does not mechanically guarantee a proportional improvement in the performance of public services. It is therefore imperative to evaluate the technical efficiency of the resources committed relative to the outputs obtained.

Beyond these purely sectoral dimensions, this research draws inspiration from the pioneering work of Afonso and Schuknecht (2005) and Baciú and Botezat (2014) by integrating key macroeconomic indicators to accurately reflect the overall performance and economic stability of the analyzed states. The evaluation thus encompasses the unemployment rate, the inflation rate, the GDP growth rate, and GDP per capita. The unemployment rate constitutes a critical indicator of labor market stability and social inclusion, while the inflation rate reflects price

stability, preserving household purchasing power and strengthening confidence in the currency. Furthermore, the GDP growth rate measures the dynamics of the wealth produced, whereas GDP per capita provides information on the level of economic development and the average standard of living. According to Shaheen et al. (2023), the joint analysis of these four macroeconomic aggregates offers a robust synthesis of a country's stability, ideally complementing traditional sectoral analysis.

Historically, the analysis of the state's role in the economy has raised profound theoretical controversies between classical and Keynesian visions. Classical theory stipulates that any state intervention through public expenditure or taxation ultimately generates major economic distortions and a crowding-out effect detrimental to private investment. This premise has notably been empirically confirmed by Afonso and Furceri (2010) in the case of European countries, highlighting a negative relationship between state size and economic growth. Conversely, Keynesian theory argues that a stimulus through public expenditure or the manipulation of revenues makes it possible to revitalize aggregate demand via the fiscal multiplier mechanism (Kosarade & Motukula, 2022). Our study follows this Keynesian logic, while the choice of intervention sectors is theoretically validated by endogenous growth models. Indeed, founding authors such as (Aschauer, 1989; Barro, 1990; Lucas, 1988) consider capital expenditure and human capital formation as the true drivers of economic growth and long-term development.

From this perspective, the main objective of this work is to evaluate, through the non-parametric method of Data Envelopment Analysis (DEA), the efficiency with which public resources are converted into overall performance, for a sample of forty countries stratified by income level over an eleven-year period.

Particular emphasis is placed on the Malmquist productivity index in order to dynamically capture the evolution of this performance over time. Through this modeling, our research aims to answer two central questions: what is the efficiency level of public expenditure for each country in the sample, and how does this efficiency evolve dynamically over time?

The major contribution of this study lies in its integrated multisectoral approach. Indeed, existing literature frequently confines itself to isolated sectoral analyses (Bardey & Pichetti, 2004; Konte et al., 2022; Mallaye & Gadam, 2021) or is limited solely to social sectors (Jayasuriya & Wodon, 2007; Richard & Nyakundi, 2019; Sikayena et al., 2022), failing to include economic sector indicators directly affected by budgetary choices.

Moreover, apprehending public sector performance through a single indicator proves reductive given the multidimensionality of the domains covered. By way of illustration, educational performance cannot be summarized by the enrollment rate alone; it must imperatively integrate the quality of teaching and the

completion rate. To overcome this limitation, we opted for the construction of a composite index per sector, aggregating several representative variables, an approach in perfect alignment with the most recent methodological developments.

The remainder of this work is structured as follows: the first section is dedicated to a thorough review of the theoretical and empirical literature on public expenditure efficiency and public sector performance; the second section outlines the chosen non-parametric methodology as well as the nature of the data selected for the estimations; while the third section presents and discusses in detail the empirical results obtained.

2. Literature Review

The analysis of public finances has long been dominated by a substantial and well-developed body of literature focused primarily on the overall size and sectoral composition of national budgets. Nevertheless, a more recent paradigm shifts the scientific debate toward the quality and efficiency of public expenditure, replacing the traditional question regarding the volume of resources (how much to spend) with a strategic reflection on allocative optimization (how to spend). From this perspective, the evaluation of efficiency becomes an institutional obligation, as governments are accountable to taxpayers for the rational use of public funds. This conceptual revival is illustrated by successive waves of major empirical studies, recently supplemented by analyses incorporating post-pandemic macroeconomic shocks and fiscal consolidation imperatives (Afonso et al., 2024).

In the field of large-scale modeling, Emilie et al. (2021) conducted a major empirical analysis on a panel of 192 countries covering the 1990-2015 period, utilizing the Stochastic Frontier Analysis (SFA) approach to evaluate expenditure quality in developing countries. To overcome sectoral heterogeneity, the authors construct a composite indicator using Principal Component Analysis (PCA), aggregating education (via the gross enrollment rate, pupil-teacher ratio, and average and expected years of schooling), health (under-five, infant, and maternal mortality rates, and life expectancy), and infrastructure (access to electricity, potable water, and the proportion of paved roads), supplemented by GDP per capita for the economic dimension. By calculating a one-dimensional composite index using a geometric mean, their results highlight high efficiency scores for Europe and North America, contrasting with an average score of 0.71 for Africa and South Asia, while confirming a positive correlation between a country's income level and its fiscal efficiency. This finding of a structural divergence based on the level of development is corroborated by the recent work of Nguyen et al. (2023), who demonstrate that the introduction of digital governance reforms significantly reduces these efficiency gaps in emerging economies. In a similar sectoral perspective, Herrera and Ouedraogo (2018) performed an international

benchmarking exercise for the World Bank, evaluating the efficiency of expenditure on education, health, and infrastructure. Using robust performance indicators, such as PISA/TIMSS scores for education or the estimated public capital stock for infrastructure, they identify an average production efficiency of 0.60 in infrastructure, 0.80 in education, and 0.90 in health for developing countries, scores that are systematically lower than those of advanced economies. At the level of integrated economic zones, Baciú and Botezat (2014) examined the allocative efficiency of new European Union member states between 2000 and 2009. Using the DEA approach, they construct a synthetic public sector performance (PSP) index encompassing sectoral variables (education, health, administration) and Musgravian variables (real GDP growth and the Human Development Index). Their findings reveal that while new Eastern European entrants initially display lower efficiency scores than older members, this gap tends to narrow over the period, with relative efficiency driven by social sectors (health and education) to the detriment of a structurally less efficient public administration.

For advanced countries, Afonso et al. (2019) enriched this approach by evaluating the interactions between taxation and expenditure efficiency for 36 OECD countries over the 2003-2017 period. By combining the DEA method and the Malmquist productivity index, the authors incorporate multidimensional outputs (PISA scores, cardiovascular survival rates, corruption indicators, and the Gini index) against public expenditure as a percentage of GDP. Their simulations indicate that OECD countries could theoretically reduce their inputs by 32% to 34% for an identical level of output, while the dynamic Malmquist analysis highlights a decline in total factor productivity and technological progress between 2007 and 2017, while validating the deleterious impact of direct taxes on public performance.

The analysis of the optimal size of the state and the temporal trajectory of efficiency is also the subject of major contributions. Shaheen et al. (2023) tested this relationship on a panel of 19 Asian countries (1996-2015) via the DEA approach, measuring a PSP index backed by six sectoral and macroeconomic pillars against total expenditure as a percentage of GDP. Their results validate the hypothesis of superior performance for intermediate-sized governments, while observing an upward trajectory of the performance index between 2008 and 2015 for the entire sample, with the notable exceptions of Tajikistan and Ukraine.

This temporal dynamic aligns, at the subnational level, with the study by Khan and Murova (2015) covering the fifty US states between 1992 and 2012. Applying an input-oriented DEA model under constant and variable returns to scale, the authors use Gross State Product (GSP) as the output against expenditures on education, transport, health, and social protection. Their

estimations highlight a continuous erosion of efficiency from 1992 to 2008, followed by a phase of technological recovery extending to 2012.

Finally, the trade-off between methodological orientations is further explored by Yadava and Neog (2022) in their examination of 19 Indian states (2006-2015). By exploiting the DEA methodology, the authors reveal major disparities and identify Maharashtra, Manipur, and Nagaland as the most efficient territories. The originality of their work rests on the dual optimization perspective: the input orientation suggests that a theoretical reduction of 57.88% in public expenditure is possible at a constant level of performance, while the output orientation demonstrates a potential improvement margin of 14.16% in public services without additional budgetary injections. These bivalent models are in direct line with the developments of Martinez and Silva (2024), who advocate the systematic use of dynamic DEA windows to neutralize specification biases in international efficiency comparisons.

A critical examination of this rich literature highlights three major methodological and conceptual limitations that our present study endeavors to overcome.

First, although notable advances have been made in sectoral analysis, the majority of existing studies tend to compartmentalize efficiency evaluation, focusing either in isolation on social sectors or on disengaged macroeconomic aggregates, thereby omitting the systemic interdependence between budgetary allocation and overall economic stability.

Second, the near-systematic omission of quality indicators within sectoral *outputs*, such as reducing educational performance to the enrollment rate alone, biases the evaluation of the public sector's actual performance.

Third, international comparative analyses often suffer from a homogeneity bias by applying uniform efficiency frontiers to economies with fundamentally asymmetric production structures.

Our approach diverges from this literature by proposing an integrated, two-dimensional (static and dynamic) multisectoral modeling framework. By constructing qualitative composite indices per sector and rigorously stratifying our panel of forty countries according to World Bank income groups over the transitional 2015-2025 period, this study neutralizes structural heterogeneity biases. It thus offers an unprecedented dynamic mapping of efficiency trajectories, allowing the identification of whether public performance gains result from technical catch-up (the catch-up effect) or a shift in the global technological frontier.

3. Methodology

In order to rigorously evaluate the efficiency of public expenditure and model the overall performance of the public sector, this study deploys a sequential empirical strategy structured into three fundamental steps.

The first step is dedicated to the construction of a multidimensional performance index, subsequently utilized as an output in our efficiency model. To this end, a series of sectoral indices is previously calculated via Principal Component Analysis (PCA). PCA stands out as a rigorous quantitative method widely recommended in the literature, as it allows for the formation of a composite indicator capturing the maximum amount of information (variance) from a set of initially collinear variables. The general functional form for generating the scores of the first principal component is written as follows:

$$PC_1 = a_{11}(X_1) + a_{12}(X_2) + a_{13}(X_3) + \dots + a_{1n}(X_n) \quad (1)$$

Where:

PC_1 is the variable score on the first principal component, a_{1n} is the weight of variable "n" in the calculation of the first principal component and X_n is the value of the variable "n".

Prior to this extraction, we verified the relevance of the PCA by testing the correlation between the different intra-sectoral variables, yielding highly significant results for all sectors. Referring to the Kaiser criterion, the eigenvalues of the first principal component amount to 1.88 for education, 1.90 for health, and 2.91 for administration, respectively.

Regarding the economic sector, the eigenvalues are 1.09 for performance and 1.14 for stability. Since all these values strictly exceed unity, the statistical validity of our sectoral indices is fully justified.

Our global multidimensional indicator is then aggregated using the geometric mean of these sectoral indices. The choice of this aggregation method is based on contemporary methodological standards adopted by major international institutions, such as the OECD or the UNDP (notably for the calculation of the Human Development Index).

The fundamental advantage of the geometric mean lies in its penalizing nature; unlike the arithmetic mean, it limits perfect substitutability among dimensions. Thus, a low performance in a given public sector (for instance, health) automatically impacts the composite index and cannot be artificially compensated for by an exceptional result in another domain. The geometric mean formula is presented as follows:

$$I_c = \sqrt[\sum P_s]{\prod I_s^{P_s}} \quad (2)$$

Including I_c the composite index, I_s sector indices and P_s the weights allocated to sectors.

The second step constitutes Data Envelopment Analysis (DEA). A substantial body of literature adopts the DEA approach for estimating the efficiency of public expenditure. The construction of the efficiency frontier in the DEA model

is carried out with reference to scale assumptions. Two scale assumptions are commonly used: constant returns to scale (CRS) (Charnes et al., 1978) and variable returns to scale (VRS) (Banker et al., 1984). Following Bouzouita and Vierstraete (2011), constructing the production frontier under the assumption of constant and then variable returns to scale allows us to decompose technical efficiency into pure technical efficiency, that is, independent of the size of the DMUs, and scale efficiency.

In the context of our work, it appears appropriate to measure public expenditure efficiency under the assumption of variable returns to scale. Regarding public sector performance, the assumption of variable returns to scale is better suited for efficiency evaluation (Mihaljevic Kosor et al., 2019).

If we consider n DMUs (or different countries) in our set of observations, a given DMU_j , ($j = 1, \dots, n$) uses quantities x_{ij} of inputs $i = 1, \dots, m$, to produce r different outputs y_{rj} ($r = 1, \dots, s$).

Following the model of Banker et al. (1984), the VRS model with variable returns to scale (VRS) model, it is possible to estimate the technical efficiency θ of the reference DMU k using linear programming. The functional form of the model for a given DMU DMU_k with x_{ik} inputs production y_{rk} output is as follows:

$$\begin{aligned}
 & \text{Min}_{\theta, \lambda, s^-, s^+} e_k = \theta - \varepsilon (\sum_{i=1}^m s_i^- + \sum_{r=1}^s s_r^+) & (3) \\
 \text{u. c} \quad & \sum_{j=1}^n \lambda_j x_{ij} + s_i^- = \theta x_{jk} & \text{pour tout } i = 1, \dots, m \\
 & \sum_{j=1}^n \lambda_j y_{rj} - s_r^+ = y_{rk} & \text{pour tout } r = 1, \dots, s \\
 & \sum_{j=1}^n \lambda_j = 1 \\
 & \lambda_j, s_i^-, s_r^+ \geq 0 \quad \forall i, j, r
 \end{aligned}$$

With s_i^+ being the vector of slack variables associated with outputs, s_i^- the vector associated with inputs, and ε a quantity sufficiently small so that the maximization of slack variables remains a secondary objective relative to the minimization of the coefficient θ . λ is the weight coefficient of the input and output, which allows determining the production frontier. The latter is reached when $\theta = 1$ and all slack variables are equal to zero. In other words, each country with a score of $\theta = 1$ and a slack variable value of zero is deemed

efficient. For any $\theta < 1$, the DMU will be declared (relatively) inefficient. The constraint $\sum_{j=1}^n \lambda_j = 1$ allows for the determination of a piecewise linear production frontier with variable returns to scale.

Finally, the last step introduces the Malmquist total factor productivity index (Malmquist, 1953). Generally speaking, time influences efficiency scores and the production frontier. Thus, the Malmquist index, through the DEA approach, allows for the decomposition of series in order to attribute changes in total factor productivity (TFP) to changes in efficiency and technology. The functional form of the index for a given country is as follows:

$$TFP_{t+1}(y_t, x_t, y_{t+1}, x_{t+1}) = \left[\frac{d_0^t(y_{t+1}, x_{t+1})}{d_0^t(y_t, x_t)} * \frac{d_0^{t+1}(y_{t+1}, x_{t+1})}{d_0^{t+1}(y_t, x_t)} \right]^{1/2} \quad (4)$$

With $d_0^t(y_s, x_s)$ being the output distance score using the frontier at year t and the inputs and outputs related to year s .

4. Data presentation:

The present empirical study relies on a panel of forty countries, whose selection aims to offer a global representation of different development trajectories. To guarantee cross-sectional comparability, the sample has been rigorously stratified according to the World Bank classification into four income categories: High Income, Upper-Middle Income, Lower-Middle Income and Low-Income countries. The detailed list of economies constituting this panel is presented in the table below.

Table 1. Our panel of countries by income level

High Income (HI)	Upper-Middle Income (UMI)	Lower-Middle Income (LMI)	Low Income (LI)
Australia AUS	Armenia ARM	Algeria DZA	Burkina Faso BFA
Austria AUT	Azerbaijan AZE	Egypt, Arab Rep. EGY	Burundi BDI
Canada CAN	Belarus BLR	Honduras HND	Congo, Dem. Rep. COD
France FRA	Brazil BRA	India IND	Gambia, The GMB
Italy ITA	Iran, Islamic Republic IRN	Morocco MAR	Liberia LBR
Kuwait KWT	Libya LBY	Sri Lanka LKA	Madagascar MDG
Poland POL	Malaysia MYS	Uzbekistan UZB	Mali MLI
Qatar QAT	Russian Federation RUS	Vietnam VNM	Sudan SDN
United States USA	Turkey TUR	Zambia ZMB	Syrian Arab Republic SYR
United Kingdom GBR	South Africa ZAF	Jordan JOR	Afghanistan AFG

The analysis covers a decadal period, theoretically extending from 2015 to 2025. Data relating to health, administration, as well as macroeconomic stability and performance are extracted from the World Bank's *World Development Indicators*

(WDI) database. Those pertaining to the educational sector come from the UNESCO Institute for Statistics (UIS), while the indicator for public expenditure and infrastructure is drawn from the World Bank's Public Finance Statistics. On an operational level, in order to circumvent the lack of availability of certain data for the very last years (2024-2025) and to ensure econometric robustness, the efficiency evaluation was conducted by considering key observation points at the beginning (2015) and at the end of the consolidated period (2023), with occasional missing observations completed by linear extrapolation.

The single *input* (input variable) selected to model the efficiency frontier corresponds to **total public expenditure expressed as a percentage of GDP**. This aggregate encompasses both current expenditure (operational expenditure, transfers, debt service) and capital expenditure (public investment), thereby capturing the overall budgetary effort deployed by governments to provide public goods and services.

Expressing this indicator as a proportion of national wealth neutralizes the size effect of economies, an indispensable condition for international comparative analysis. The descriptive analysis reveals that the budgetary effort follows a hierarchy structurally correlated with the level of development: the group of high-income countries dedicates the largest share of its GDP to public expenditure, followed by upper-middle-income economies, and then by the poorest countries.

This configuration empirically corroborates Wagner's Law in our sample, positing that advanced economies, benefiting from strong growth and complex social needs, tend to disproportionately increase the size of their public sector.

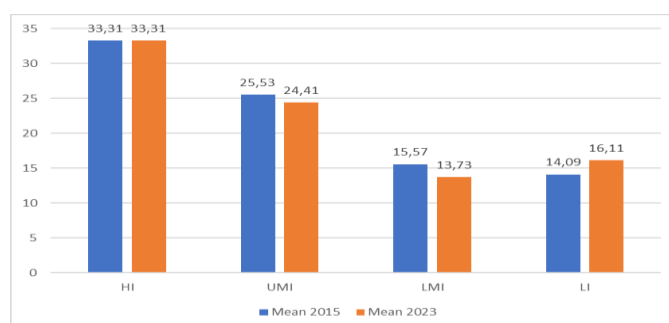


Fig. 1. Public spending as a percentage of GDP by income level

Regarding the outputs (output variables), the overall performance of the public sector is captured through the construction of sectoral sub-indices reflecting the state's key areas of intervention.

The first domain is **education**, universally recognized by endogenous growth theorists (Barro, 1990; Lucas, 1988) as the primary driver of human capital accumulation and long-term economic development.

To capture the quality of this sector beyond simple enrollment rates, we constructed a composite index aggregating two fundamental variables: The upper secondary completion rate (capturing the capacity of the educational system to lead a cohort to the end of the cycle) and the mean years of schooling (reflecting the human capital stock of the population).

Descriptive statistics highlight an overall improvement in the sector over the period. Nevertheless, a structural divide persists: in 2023, the completion rate in high-income countries (87.71%) remains more than four times higher than that of low-income countries (21.54%), a gap in accumulation of nearly eight years of schooling that has practically not narrowed.

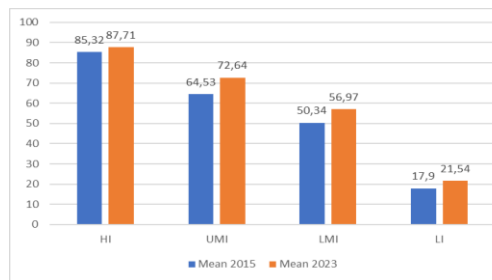


Fig. 2. Upper secondary school completion rates by income level

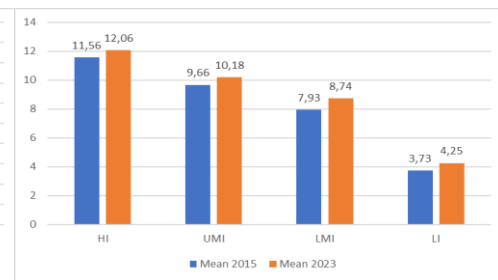


Fig. 3. Mean number of years of schooling by income level

The second sub-index concerns **health**, which the literature emphasizes as constituting, along with education, a fundamental investment Mushkin (1962). An efficient health system directly increases the labor force by reducing disability and premature mortality. This sectoral index aggregates life expectancy at birth and the infant mortality rate (per 1,000 live births). Graphical trends reveal clear improvements across all income groups. These advances reflect the effectiveness of public health policies regarding access to care, the development of medical infrastructure, and mass vaccination campaigns, measures that have significantly reduced infant mortality in developing countries.

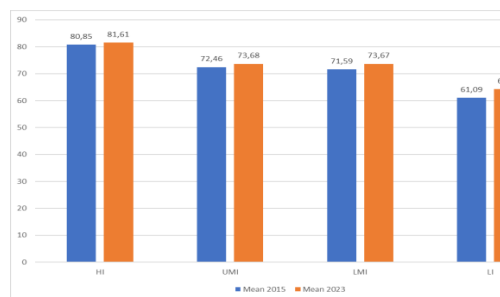


Fig. 4. Life expectancy at birth by income level

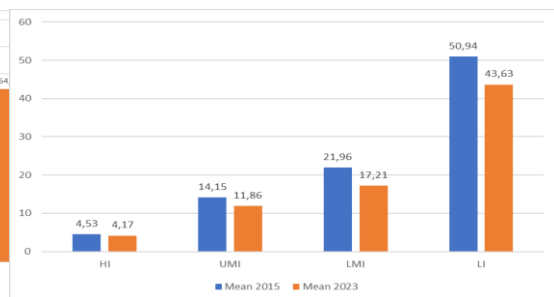


Fig. 5. Infant mortality rate per 1000 births by income level

The third domain evaluates the budgetary impact on **infrastructure**. Following Emilie et al. (2021), public investment in infrastructure generates massive positive externalities, catalyzing the attractiveness of private capital. Access to electricity, selected here as the primary proxy, directly impacts industrial productivity and the functioning of fundamental social services.

The data reveal remarkable performance, particularly for lower-middle-income countries, which record a jump from 81.05% to 94.60% in access over the period, the result of massive rural electrification programs in Asia and Africa. Conversely, the low-income group lags worryingly behind, with more than half of its population (51.2%) still lacking this basic service in 2023.

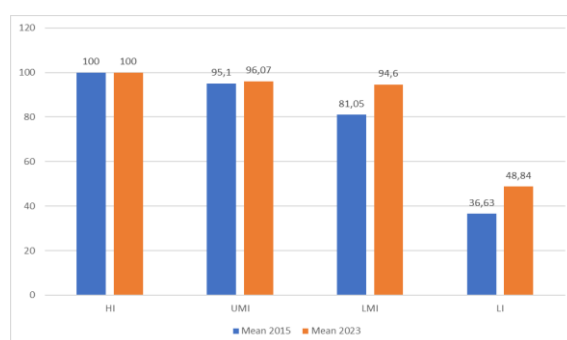


Fig. 6. Access to electricity as a percentage of the population by income level

The fourth domain, public **administration**, is evaluated via three indicators from the World Bank's Worldwide Governance Indicators (WGI): control of corruption, bureaucratic quality, and the rule of law. In agreement with Afonso and Schuknecht (2005), these dimensions are essential for assessing a state's capacity to formulate and implement sound policies. The strong collinearity inherent in these variables justifies their systematic aggregation into a single sub-index to avoid any estimation bias.

Finally, drawing inspiration from the work of Baciu and Botezat (2014), the economic dimension of public action is captured through two pillars: **stability** (measured by the inflation rate and GDP per capita) and **economic performance** (captured by the unemployment rate and the GDP growth rate).

The descriptive analysis of these aggregates highlights the profound wealth asymmetries (GDP per capita) between rich and poor nations. In 2023, the inflation rate reached record levels, particularly in low-income economies, a direct consequence of post-COVID-19 pandemic inflationary shocks and global geopolitical fragmentation.

On the employment front, although a decline in youth unemployment is observed in three of the groups, middle-income economies face a persistent challenge:

despite sustained macroeconomic growth (GDP), this dynamic is not sufficiently inclusive to absorb demographic pressure on the labor market, leading to structurally high youth unemployment rates.

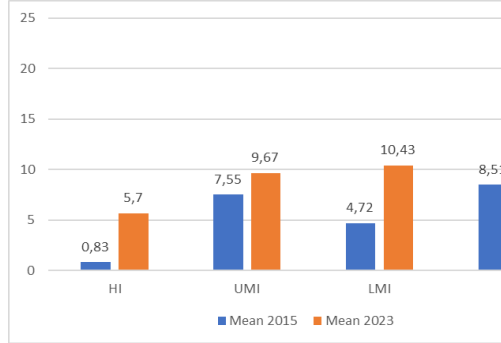


Fig. 7. Inflation rate by income level

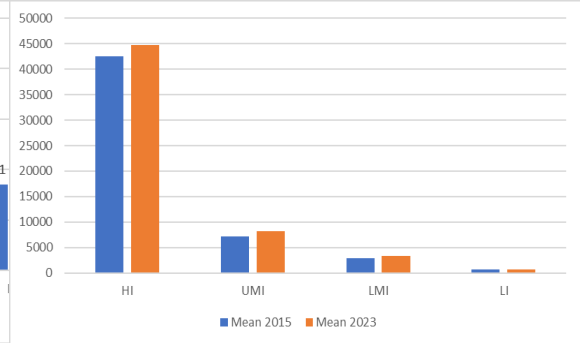


Fig. 8. GDP per capita by income level

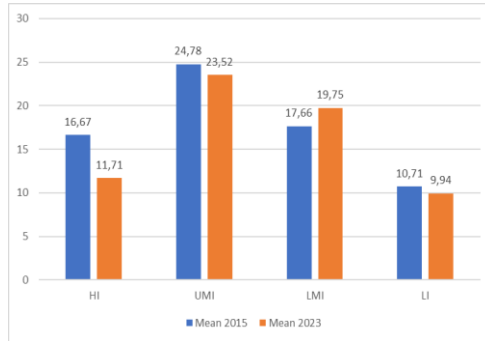


Fig. 9. Unemployment rate by income level

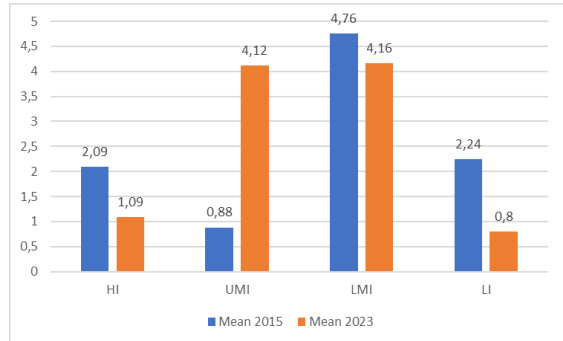


Fig. 10. GDP growth rate by income level

5. Results and discussion

This section is dedicated to the presentation, analysis, and discussion of the empirical results derived from our modeling. To provide a global, dynamic, and contextualized evaluation of public expenditure efficiency, our approach is structured around three complementary analytical axes. First, we present a static evaluation by examining the average technical efficiency scores calculated using the DEA-VRS approach, allowing us to map structural disparities across the four income groups over the 2015-2025 period. Second, we adopt a dynamic perspective by utilizing the Malmquist productivity index to decompose temporal trajectories and identify whether the observed variations stem from an operational catch-up effect or a shift in the technological frontier. Finally, we conduct a granular and disaggregated analysis of four specific economies,

representative of each development level, to confront our quantitative estimations with local institutional and budgetary realities.

5.1. Static Evaluation: Analysis of Technical Efficiency Scores (DEA)

The analysis of the efficiency frontier allows for the evaluation of states' capacity to optimize their public resources.

The table below presents the evolution of the average technical efficiency level by income group. Theoretically, in an input-oriented model, an efficiency score of α indicates that $(1 - \alpha)$ % of public expenditure could be saved without altering the achieved social and economic performance level. For instance, the overall average score of 0.82 in 2015 indicates that, for the entire sample, countries could have reduced their public expenditure by approximately 18% while maintaining an identical level of public service output.

Table 2. Annual evolution of efficiency scores by income group

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
HI	0.8794	0.9307	0.9189	0.8823	0.9483	0.6967	0.9609	0.9609	0.7768	0.8521	0.7219
UMI	0.9371	0.9628	0.9483	0.9342	0.9538	0.7605	0.9317	0.9317	0.89	0.9139	0.8835
LMI	0.9134	0.9527	0.9241	0.8922	0.9298	0.7817	0.889	0.889	0.9304	0.8898	0.8834
LI	0.5614	0.6562	0.5548	0.5119	0.5839	0.4676	0.4676	0.7133	0.5134	0.4684	0.4653
Groups (40 countries)	0.8228	0.8756	0.8365	0.8052	0.8540	0.7381	0.8123	0.8923	0.7777	0.7811	0.7885

The comparative analysis reveals a counterintuitive yet fundamental phenomenon: middle-income countries (both upper-middle and lower-middle) display structurally higher technical efficiency scores than high-income countries. This finding corroborates the seminal conclusions of Afonso and Schuknecht (2005), who demonstrate that countries with modest public sectors tend to exhibit better marginal efficiency than economies with massive public sectors, as the latter face diminishing marginal returns.

In terms of temporal trends, the series is marked by a drastic breaking point in 2020, a year in which nearly all groups reached their lowest efficiency level. This abrupt degradation is explained by the exogenous shock of the COVID-19 pandemic.

To counter the crisis, governments, particularly in advanced economies, deployed massive counter-cyclical fiscal policies (stimulus packages, emergency subsidies). This explosion of *inputs* (expenditure) did not translate into an immediate improvement in social and economic *outputs* (with growth and employment plummeting), mechanically generating sharp short-term technical inefficiency.

Finally, the low-income (LI) group stands out due to chronic underperformance. In 2023, this group could theoretically have reduced its expenditure by 49% at a constant performance level, compared to a potential reduction of only 7% for the lower-middle-income group.

Table 3. Annual evolution of efficiency scores for the group of low-income countries

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
AFG	0.607	0.739	0.645	0.59	0.677	0.522	0.522	0.726	0.532	0.482	0.479
BDI	0.332	0.392	0.34	0.303	0.354	0.282	0.382	0.405	0.327	0.298	0.296
BFA	0.462	0.566	0.49	0.445	0.538	0.443	0.443	0.563	0.499	0.461	0.454
COD	0.497	0.59	0.483	0.434	0.493	0.399	0.399	0.497	0.473	0.425	0.43
GMB	0.68	0.802	0.687	0.633	0.73	0.605	0.605	0.754	0.68	0.623	0.624
LBR	0.54	0.644	0.575	0.515	0.591	0.489	0.489	0.515	0.557	0.51	0.507
MDG	0.526	0.617	0.521	0.512	0.564	0.458	0.458	0.551	0.512	0.468	0.464
MLI	0.57	0.659	0.552	0.541	0.625	0.489	0.489	0.534	0.529	0.484	0.481
SDN	0.686	0.804	0.681	0.618	0.703	0.575	0.575	0.588	0.546	0.515	0.484
SYR	0.714	0.749	0.574	0.528	0.564	0.414	0.414	1	0.479	0.418	0.434

A disaggregated examination of this group reveals persistent physical inefficiency, although countries like Afghanistan, Gambia, and Sudan showed some stability at the beginning of the period before declining. This inefficiency, particularly pronounced in Sub-Saharan Africa, is extensively documented in the literature (Emilie et al., 2021; Herrera & Ouedraogo, 2018; Konte et al., 2022; Sikayena et al., 2022). It is generally attributable to poor institutional quality, structural capital absorption constraints, and sub-optimal management of public resources.

5.2. Analysis and discussion of Malmquist-DEA results

To capture temporal dynamics, the Malmquist index decomposes productivity evolution into two major dimensions: Technological change (techch), which measures the shift in the production frontier (innovation) and technical efficiency change (effch), reflects the catch-up effect or the capacity to optimize internal resources (itself decomposable into pure efficiency (pech) and scale efficiency (sech)).

A value greater than unity indicates a productivity gain, whereas a value below one reflects a regression.

Table 4. Summary Malmquist Indices

Transition	effch	techch	pech	sech	tfpch
2 (2015→2016)	1.084	0.936	1.009	1.075	1.015
3 (2016→2017)	0.972	1.035	1.030	0.944	1.006
4 (2017→2018)	1.000	1.052	1.045	0.957	1.052
5 (2018→2019)	1.030	0.951	0.963	1.070	0.979
6 (2019→2020)	0.871	1.047	0.937	0.930	0.912
7 (2020→2021)	1.092	0.977	1.076	1.014	1.067
8 (2021→2022)	0.821	1.260	0.823	0.998	1.034
9 (2022→2023)	1.058	0.913	1.099	0.963	0.966
10 (2023→2024)	0.950	1.039	0.956	0.994	0.987
11 (2024→2025)	0.980	1.006	1.034	0.948	0.986

The 2015-2019 period is characterized by an overall positive dynamic, driven by the continuous adoption of new technologies (techch > 1) and improved resource management (effch > 1). However, the 2019-2020 transition materializes the

pandemic shock with the sharpest degradation in the series ($tfpch = 0.912$). Crucially, this drop was driven by a collapse in efficiency catch-up ($effch = 0.871$), while the technological frontier continued to advance ($techch = 1.047$). This suggests that the crisis hindered the operational capacity of states to exploit their resources, without destroying the global technological potential.

The post-COVID recovery (2020-2021) is reflected in a notable rebound in efficiency ($effch = 1.092$). Furthermore, the recent period (2021-2022) reveals an exceptional technological peak ($techch = 1.260$). This surge can be interpreted as the result of accelerated digitalization of public services and the massive deployment of artificial intelligence in key sectors (health, education, administration).

Table 5. Malmquist Indices by Income Level

Income group	effch	techch	pech	dry	tfpch
High Income	0.974	1.035	0.993	0.980	1.008
Upper Middle Income	0.981	1.052	0.987	0.994	1.032
Lower Middle Income	1.005	1.018	1.009	0.996	1.023
Low Income	0.969	1.006	0.987	0.982	0.974

Analysis by income group highlights the notable performance of lower-middle-income (LMI) countries, which display the best overall progression ($tfpch = 1.023$). This group, which successfully managed its expenditure growth, maximizes its efficiency. Conversely, the weak dynamic progression of high-income (HI) countries is explained by social indicators (education, health) that are already close to their natural asymptotic limits, which mathematically restricts their margins for dynamic improvement.

5.3. Analysis of some countries according to their efficiency scores and their Malmquist indices

To illustrate the heterogeneity of the results, we examine four national profiles representative of each income stratum: Poland, Iran, Algeria, and Mali.

- ✓ *Poland (High Income)*: Ranked 2nd in its group, it displays a highly robust average score of 0.89, despite dedicating a significant share of its GDP (36%) to public expenditure. Its productivity ($TFP = 1.020$) is essentially driven by technological progress, illustrating the model of advanced economies where growth depends on innovation rather than capital accumulation.
- ✓ *Iran (Upper-Middle Income)*: Positioned 9th in its group, Iran achieves an efficiency score of 0.84, implying a potential expenditure reduction of 16%. The country allocates only 18% of its GDP to public expenditure; this fiscal moderation helps it maintain a relative efficiency comparable to that of rich nations. Its dynamic trajectory ($TFP = 1.015$) is also anchored in technological progress (1.035).
- ✓ *Algeria (Lower-Middle Income)*: Ranked 4th in its category, Algeria excels with an exceptional average score of 0.92. Although its income level is

lower than that of Iran or Poland, maintaining a moderate level of public expenditure (18% of GDP) combined with returns to scale allows it to optimize its position on the frontier. Its Malmquist index (1.019) reflects stable fiscal management ($\text{effch} = 1.001$) coupled with technological modernization ($\text{techch} = 1.018$).

- ✓ *Mali (Low Income)*: Ranked 4th in its group, Mali suffers from a very low efficiency score of 0.57, indicating a potential waste of 43% of the resources mobilized to achieve its current results. Although its expenditure weight is minimal (12% of GDP), its structural inefficiency leads to a regression in productivity ($\text{TFP} = 0.975$), primarily caused by poor resource allocation management and institutional weaknesses.

6. Conclusion and Recommendations

In a post-pandemic macroeconomic context characterized by the erosion of global fiscal space, the growing burden of sovereign debt, and the proliferation of exogenous shocks, the public action paradigm must imperatively shift from a volume-based logic (spending more) toward an efficiency requirement (spending better).

This study contributes to this crucial debate by proposing a rigorous evaluation of public expenditure efficiency through the prism of the state's overall performance. By mobilizing a stratified panel of forty economies over the 2015-2025 decade, the added value of our approach lies in the construction of a multidimensional composite index (integrating human capital, infrastructure, institutional quality, and economic stability) coupled with a hybrid modeling framework that combines static evaluation (DEA-VRS) and dynamic analysis (Malmquist productivity index).

Our empirical investigations highlight a pronounced structural heterogeneity and reveal the paradox of wealth in public management. Counterintuitively, the analysis demonstrates that maximizing national wealth does not guarantee allocative efficiency.

Middle-income economies, particularly the lower-middle-income (LMI) group, significantly outperform high-income (HI) countries. This result empirically validates the law of diminishing marginal returns applied to the public sector (Afonso & Schuknecht, 2005): advanced nations, endowed with historically massive welfare states, reach a saturation point on their performance frontier. Consequently, they struggle to generate marginal social gains proportional to their massive capital injections. For illustrative purposes, in 2023, the theoretical potential for fiscal savings at a constant performance level amounted to 23% for high-income countries, compared to much narrower margins of 7% and 11% for middle-income countries. Conversely, low-income (LI) countries suffer from a chronic structural lag, with a potential resource wastage of around 49%.

The dynamic analysis enriches this interpretation by revealing that the lower-middle-income (LMI) group is the only one to achieve a net gain in total factor productivity over the decade. This finding is fundamental: it proves that the resilience of this group rests on a powerful managerial catch-up effect (allocative optimization and resource rationalization) rather than a mere technological leap. On a methodological level, this complementarity justifies the architecture of our study; isolating the observation of growth rates (Malmquist) would have obscured the abyssal inefficiencies of certain groups that only the static evaluation (DEA) allowed us to quantify.

In light of these results, our work formulates differentiated strategic implications for public policymakers and international institutions:

- ✓ *For high-income (HI) economies:* Fiscal expansion has reached its structural limits. The optimal strategy now requires targeted intersectoral reallocations and the modernization of the state apparatus (digitalization, artificial intelligence) to push back the technological frontier without increasing the tax burden.
- ✓ *For middle-income economies (UMI and LMI):* Although efficient in optimizing their resources, these nations risk stagnation if their growth is not translated into inclusive development. Urgency demands conditioning future expenditure on substantive reforms: strengthening the control of corruption and deploying active policies for the integration of youth into the labor market.
- ✓ *For low-income (LI) economies:* The classic injunction to increase fiscal effort is bound to fail if it is not accompanied by a prior cleanup of governance. The absolute priority must be the institutional securing of existing expenditure, improving public procurement transparency, and strengthening capital absorption capacity in the face of exogenous shocks.

Although our research offers robust evaluation tools, it is not without limitations, which are inherent to the deterministic nature of the DEA method (sensitivity to extreme values and lack of statistical inference regarding random noise).

Far from constituting a hindrance, these limitations outline the contours of a promising future research agenda. As an extension of this work, it will be appropriate to implement Bootstrap DEA resampling techniques to generate rigorous confidence intervals, and to adopt two-stage econometric procedures (the truncated models of Simar & Wilson, 2007) in order to accurately quantify the impact of environmental and institutional variables on endemic public sector inefficiency.

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عملکرد بخش عمومی و کارایی هزینه‌های عمومی: یک تحلیل تطبیقی بین‌المللی با استفاده از رویکرد DEA در یک گروه ۴۰ نفره از کشورها

چکیده

هدف: این مقاله کارایی تخصیص هزینه‌های عمومی را برای بهینه‌سازی عملکرد کلی بخش عمومی ارزیابی می‌کند. این مطالعه که بر روی گروهی از چهل کشور طبقه‌بندی شده بر اساس سطح درآمد انجام شده است، بُعد حیاتی کیفیت هزینه‌ها را برجسته می‌کند. این موضوع که در ادبیات تجربی اخیر به طور حاشیه‌ای مورد بررسی قرار گرفته است، در زمینه رشد ساختاری و دائمی بودجه‌های عمومی جهانی، فوریت خاصی پیدا می‌کند.

روش‌ها: دقت روش‌شناختی بر تحلیل پوششی داده‌ها (DEA) استوار است، یک رویکرد غیرپارامتری که برای تخمین نمرات کارایی فنی نسبی از داده‌های سالانه دوره ۲۰۱۵-۲۰۲۵ بسیار مناسب است. علاوه بر این، ادغام شاخص بهره‌وری مالمکویست، مسیر پویای عملکرد بخش عمومی را ثبت کرده و تغییرات کارایی را از تغییرات فناوری جدا می‌کند.

نتایج: تخمین‌های تجربی، ناکارآمدی فنی قابل توجهی را در کل دوره نشان می‌دهند که با عدم ارتباط بین سلسله مراتب نمرات و سطح درآمد کشورها مشخص می‌شود. برخلاف انتظار، اقتصادهای با درآمد متوسط، به ویژه آن‌هایی که در محدوده متوسط رو به پایین قرار دارند، در مقایسه با کشورهای با درآمد بالا، میانگین بهینه‌سازی بهتری از منابع بودجه خود نشان می‌دهند. کشورهای با درآمد بالا از کاهش بازده نهایی رنج می‌برند که ناشی از رشد نسبی بخش عمومی آن‌ها است.

نتیجه‌گیری: این مطالعه به جای گسترش کمی برای کشورهای با درآمد بالا و متوسط، از یک تنظیم مجدد استراتژیک و پیکربندی مجدد ساختاری تخصیص بودجه حمایت می‌کند. برای اقتصادهای کم‌درآمد، تقویت کیفیت نهادی برای تضمین افزایش تاب‌آوری در برابر شوک‌های کلان اقتصادی برون‌زا ضروری است.

کلمات کلیدی: DEA؛ کارایی؛ عملکرد بخش عمومی؛ هزینه‌های عمومی.