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ANALYSIS OF PUBLIC EXPENDITURE EFFICIENCY IN THE EDUCATION AND HEALTH SECTORS IN EAST JAVA PROVINCE: A STOCHASTIC FRONTIER ANALYSIS APPROACH

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A B S T R A C T

Human resource development through the education and health sectors require optimal fiscal governance; however, an increase in budget allocation does no automatically guarantee linear outcome achievements. This study aims t measure and analyze the technical efficiency of public expenditures in educatio and health sectors across eight cities in East Java Province (Surabaya, Malang Batu, Kediri, Blitar, Madiun, Mojokerto, and Pasuruan) during the 2014–202 period. Utilizing a quantitative explanatory research design, this study applie the Stochastic Frontier Analysis (SFA) method with a Cobb-Douglas log-linea production function specification based on panel data (80 observations). Th input variables include sector expenditure, GRDP per capita, total populatio (education control), and the number of medical personnel and health facilitie (health control), with the Education Index and Life Expectancy serving as outpu variables. The results indicate a contrasting efficiency trend between the tw sectors. Education spending efficiency showed a consistent upward trajector from an average of 26.88% in 2014 to 82.61% in 2023, where population siz significantly influenced the output, indicating economies of scale. Conversely health spending efficiency fluctuated sharply and declined drastically during th COVID-19 pandemic (2020–2021), with economic capacity (GRDP per capita and medical personnel availability acting as significant determinants. At th regional level, performance asymmetry occurred: Surabaya excelled i education efficiency but was less efficient in health, whereas Mojokert consistently achieved high efficiency in both sectors. Policy implication highlight the urgency of shifting toward results-based budgeting rather tha merely expanding nominal budget allocations.

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1. INTRODUCTION

Human resource development represents a strategic pillar in regional economic transformation, with the education and health sectors acting as primary determinants (Bykova et al., 2024). Within the framework of regional autonomy, city governments possess significant fiscal discretion to manage public expenditures to improve the quality of basic services. Budgets allocated to the education and health sectors are no longer merely routine

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expenditure items; rather, they serve as long-term investment instruments expected to stimulate labor productivity and accelerate regional economic growth. In East Java Province, this financial commitment is reflected in the steady annual increase in budget allocations for education and health functions within city budgets. However, this expanding fiscal capacity raises a crucial governance question regarding optimization: does a higher volume of budget absorption automatically correlate linearly with improved human capital outcomes (Habbe, 2021)?

Phenomena in the field often reveal a disconnection between the quantity of budgetary inputs and the quality of resulting outcomes. Empirical realities indicate that several cities with high per capita expenditures in education and health paradoxically experience stagnating Human Development Index (HDI) growth. Conversely, some regions with fiscal constraints manage to achieve public service targets more optimally. This disparity implies the presence of technical inefficiency in converting budgetary resources into tangible basic service outputs. Technical inefficiency is a critical issue, as any budgetary waste at the local level constrains the fiscal space required for other priority development programs. Consequently, evaluating budgetary performance solely through administrative compliance and accounting absorption is no longer sufficient; the focus must shift toward measuring technical efficiency to assess how optimally maximum outputs can be generated from a given combination of expenditure inputs.

Prior studies examining the efficiency of public spending have predominantly relied on non-parametric approaches, such as Data Envelopment Analysis (DEA). While DEA offers flexibility by not requiring a specific functional form, it suffers from a fundamental limitation: it treats all deviations from the frontier line as pure inefficiency, failing to account for stochastic shocks or measurement errors. This limitation is particularly critical when analyzing local government financial data in Indonesia, which is frequently influenced by exogenous factors beyond the government's control, such as macroeconomic fluctuations or global health crises.

To bridge this methodological gap, this study employs a parametric Stochastic Frontier Analysis (SFA) approach based on panel data for the 2014–2023 period. Through the SFA method, deviations in budgetary performance can be precisely decomposed into two components: pure technical inefficiency effects and random error effects (such as the impacts of pandemics or national policy shifts). The utilization of panel data spanning a ten-year horizon (2014–2023) in this research aims not only to measure the relative efficiency levels among cities in East Java but also to analyze the dynamics of efficiency changes over time (time-varying efficiency). This longitudinal analysis is vital to capturing shifts in local fiscal behavior before, during, and after the global health crises that occurred over the past decade.

Based on this background, this study aims to measure the technical efficiency of public expenditures in the education and health sectors across city governments in East Java Province using the SFA method. Furthermore, this research is directed toward identifying the environmental determinants that influence this technical inefficiency. The findings of this study are expected to provide an empirical contribution to the local public finance literature and serve as a strategic tool for local policymakers in formulating a more efficient and targeted results-based budgeting system.

2. LITERATURE REVIEW

2.1. Public Expenditure and Regional Human Resource Development

The dynamic of regional development heavily relies on human resource enhancement as a strategic pillar for economic transformation (Mathur, 1999). Within the framework of regional autonomy, city governments possess significant fiscal discretion to manage public spending, particularly in prioritizing the education and health sectors as the primary determinants of basic service quality. Theoretically, public expenditure in these sectors is designed as a long-term investment to optimize human capital. However, an increase in budget allocations does not automatically guarantee linear outcome achievements. This phenomenon creates an empirical gap, shifting the focus of fiscal evaluation from mere administrative budget absorption to the analysis of relative performance and dynamic changes in efficiency over time (Septriani et al., 2026).

2.2. The Concept of Technical Efficiency in the Public Sector

Technical efficiency in public service delivery measures the capacity of local governments to optimize maximum outcomes from a given set of inputs. When applied to the public sector, inefficiencies manifest as a structural disconnect where substantial sector expenditures fail to generate optimal public service outcomes. In evaluating this performance, analyzing technical inefficiency becomes crucial to understanding the structural gaps in public management (Ruggiero et al., 1995). Rather than assuming uniform performance, evaluating efficiency allows for the detection of performance asymmetry across different regions and sectors, showing why certain cities excel in one public dimension but lag in another.

2.3. Methodological Framework: Stochastic Frontier Analysis (SFA)

To empirical analyze the efficiency of public spending, this study utilizes a parametric Stochastic Frontier Analysis (SFA) approach. Unlike deterministic frameworks like Data Envelopment Analysis (DEA) which assume all deviations from the frontier are caused by pure inefficiency, the SFA framework incorporates a composite error term. By utilizing SFA, deviations in

budgetary performance can be precisely decomposed into two distinct components: pure technical inefficiency effects and random error or stochastic shocks.

When specified for panel data, the SFA production frontier can be formulated using a Cobb-Douglas log-linear functional form:

$$\ln Y_{it} = \beta_0 + \sum \beta_k \ln X_{kit} + v_{it} - u_{it}$$

Where:

- Y_{it} represents the public service outcome (output) for city i at time t.
- X_{kit} denotes the vector of budgetary inputs and environmental control factors.
- β represents the structural coefficients to be estimated.
- v_{it} is the symmetric random error term representing statistical noise and exogenous stochastic shocks.
- u_{it} is the non-negative error term representing technical inefficiency, which is explicitly estimated as a *time-varying efficiency* component to capture efficiency dynamics over time.

2.4. Conceptualization of Variables and Environmental Determinants

The evaluation of technical efficiency in this framework is categorized into two distinct public sectors, using specific input-output indicators and environmental control variables observed over a ten-year horizon (2014–2023) across eight cities in East Java Province:

Education Sector Framework

- Input Variable: Alocated public expenditure for the education sector.
- Output Variable: Education Index
- Environmental Control Variable: Total population, which serves to control for demographic scale and potential economies of scale in urban service delivery.

Health Sector Framework

- Input Variable: Alocated public expenditure for the health sector.
- Output Variable: Life Expectancy
- Environmental Control Variables: Regional economic capacity represented by GRDP per capita. alongside institutional supply factors, namely the number of medical personnel and health facilities

3 CONCEPTUAL FRAMEWORK

3.1 Technical Efficiency and the Input-Output Relationship in the Education Sector

The relationship between education expenditure and educational outcomes is often conditioned by demographic scale. In urban areas, a larger population can serve as a catalyst for efficiency through the mechanism of economies of scale. When a city government expands its education budget to build schools or hire teachers in a densely populated city, the fixed costs of public infrastructure are distributed across a larger number of student recipients, thereby reducing the per-capita cost of public service delivery. Conversely, if a city has a small population but high mandatory spending, it may experience high per-capita costs, leading to relative technical inefficiency. Based on these theoretical and empirical considerations, the following hypotheses are formulated:

H_{1a}: Public expenditure in the education sector significantly and positively defines the regional production frontier of the Education Index.

H_{1b}: Total population size acts as a significant environmental determinant that reduces technical inefficiency (generating economies of scale) in the delivery of urban education services.

3.2. Technical Efficiency and Determinants in the Health Sector

In the health sector, the conversion of public budgets into a higher Life Expectancy (Angka Harapan Hidup / AHH) does not occur in isolation. It is highly dependent on regional economic capacity and institutional supply factors. Higher GRDP per capita reflects a wealthier society with better nutrition, clean water access, and purchasing power for private healthcare, which structurally reduces the burden on public healthcare budgets and mitigates operational inefficiency.

Furthermore, institutional supply—represented by the availability of medical personnel and healthcare facilities—serves as the primary operational vehicle for budget execution. A well-funded healthcare budget cannot produce optimal public health outcomes if the city faces a structural shortage of doctors or hospital beds, which leads to budget bottlenecks and technical inefficiency. Therefore, the hypotheses for the health sector are proposed as follows:

H_{2a}: Public expenditure in the health sector significantly and positively defines the regional production frontier of Life Expectancy.

H_{2b}: GRDP per capita significantly influences the health production frontier and reduces technical inefficiency by strengthening regional economic capacity.

H_{2c}: The availability of medical personnel and health facilities acts as a significant institutional determinant that reduces technical inefficiency in public health service delivery.

3.3. Dynamics of Efficiency Over Time (Time-Varying Efficiency)

Public sector technical efficiency is susceptible to external macroeconomic disruptions and structural shocks. In a longitudinal setting spanning from 2014 to 2023, the behavior of local fiscal management cannot be assumed to be constant (time-invariant). The occurrence of the global health crisis (COVID-19 pandemic during 2020–2021) forced city governments to abruptly

reallocate budgets and deal with severe operational restrictions. While the education sector shifted toward digital/remote learning (which adjusted the operational cost structure), the healthcare sector faced extreme congestion and resource depletion. These temporal dynamics necessitate a time-varying assumption where efficiency levels change across different policy and economic cycles. Thus, the final hypotheses are:

H_{3a}: The technical efficiency of public expenditures in the education and health sectors among East Java cities exhibits significant time-varying dynamics over the 2014–2023 period.

H_{3b}: Exogenous stochastic shocks, specifically the COVID-19 pandemic, caused a significant structural decline in the technical efficiency of the health sector compared to the education sector.

4. METHODOLOGY

This study employs a quantitative explanatory research design to empirically analyze the technical efficiency of public expenditures in the education and health sectors across municipal governments. The empirical analysis utilizes a balanced panel dataset spanning a ten-year horizon from 2014 to 2023 ($T = 10$) across all eight municipal governments (cities) in East Java Province, Indonesia ($N = 8$), yielding a total of 80 observations. The cross-sectional units investigated include the cities of Surabaya, Malang, Batu, Kediri, Blitar, Madiun, Mojokerto, and Pasuruan. Secondary data for this longitudinal study were compiled and cross-referenced from the official statistical publications of the Central Bureau of Statistics (BPS-Statistics of Jawa Timur Province., 2023) and the regional financial reports managed by the Ministry of Finance.

To evaluate the dynamic properties of public spending performance, this study utilizes a parametric Stochastic Frontier Analysis (SFA) model instead of a deterministic non-parametric framework. By applying a panel SFA model, this research accounts for time-varying efficiency, thereby allowing the technical performance of local governments to fluctuate across changing policy and economic cycles over the observed decade. Following the foundational panel frontier framework, the deterministic core of the frontier is specified using a Cobb-Douglas log-linear production function due to its mathematical tractability and direct elasticity interpretation.

The empirical model for the education sector frontier is formulated as $\ln (\text{IP})_{it} = \beta_0 + \beta_1 \ln (\text{EducExp})_{it} + \beta_2 \ln (\text{Pop}){it} + v_{it} - u_{it}$. In this education framework, the Education Index serves as the output variable, while the realized education expenditure from the regional budget (APBD) represents the primary input variable, with total population integrated as an environmental control variable to account for demographic scale and potential economies of scale in urban service delivery.

Concurrently, the empirical model for the health sector frontier is formulated as $\ln (\text{AHH})_{it} = \gamma_0 + \gamma_1 \ln (\text{HealthExp})_{it} + \gamma_2 \ln (\text{GRDPpc})_{it} + \gamma_3 \ln (\text{MedStaff})_{it} + \gamma_4 \ln (\text{HealthFac})_{it} + v_{it} - u_{it}$. Within this health framework, Life Expectancy (*Angka Harapan Hidup* / AHH) is deployed as the public service outcome output. The inputs for the health equation consist of the realized health expenditure as the primary fiscal input, regional economic capacity represented by GRDP per capita constant prices, alongside institutional supply factors including the total number of medical personnel and public health facilities.

In both sector equations, $\ln$ denotes the natural logarithm, while i and t subscript individual cities and observation years, respectively. The composite error term is split into two components where v_{it} represents the idiosyncratic, symmetric random error term assumed to be normally distributed ($v_{it} \sim N(0, \sigma_v^2)$) to capture statistical noise, measurement errors, and external shocks like the COVID-19 pandemic, while u_{it} represents the non-negative, one-sided error term ($u_{it} \ge 0$) capturing pure technical inefficiency.

The parameters of the Cobb-Douglas production frontiers and the variance parameters are estimated simultaneously using the Maximum Likelihood Estimation (MLE) method, where individual technical efficiency (TE_{it}) scores for each city across time are calculated using the conditional expectation model $TE_{it} = \exp(-u_{it})$ ranging between 0 and 1. A score of 1 indicates that a city lies directly on the production frontier, signifying 100% technical efficiency, whereas a lower score reveals the magnitude of technical inefficiency in converting fiscal resources into regional human resource development outcomes.

5. RESULTS

5.1 Descriptive Statistics

The empirical analysis is based on a balanced panel dataset covering eight cities in East Java Province (Surabaya, Malang, Batu, Kediri, Blitar, Madiun, Mojokerto, and Pasuruan) over the 2014–2023 period, yielding 80 city-year observations for each sector model. Tables 1 and 2 report the descriptive statistics prior to estimation.

Table 1. Descriptive Statistics — Education Model (N = 80)

Variable	Obs	Mean	Std. Dev.	Min	Max
Education Index (IP)	80	38.31	22.15	1	76
Education Expenditure (BPEND)	80	40.50	23.24	1	80
GRDP per Capita (PDRB)	80	40.50	23.24	1	80
Total Population (POP)	80	38.73	22.25	1	77

Source: STATA 17.0 output (2026).

All variables in the education model have 80 complete observations, confirming that no missing values occurred during the observation period and that the full panel is usable for estimation. The Education Index (IP) has a mean of 38.31 and a standard deviation of 22.15, with values ranging from 1 to 76 — a spread indicating meaningful disparity in education attainment across the eight cities over the ten-year window. Education Expenditure (BPEND) and GRDP per capita both average 40.50 with an identical standard deviation of 23.24, while Total Population (POP) averages 38.73 (SD = 22.25). Because the standard deviations are close in magnitude to the means, the data exhibit sufficient cross-sectional and temporal variation, which is a necessary condition for reliable frontier estimation and for distinguishing genuine efficiency differences from mere data noise.

Table 2. Descriptive Statistics — Health Model (N = 80)

Variable	Obs	Mean	Std. Dev.	Min	Max
Medical Personnel (MED)	80	2,706.14	4,567.67	412	16,542
Health Facilities (FASKES)	80	84.99	163.10	11	562
Life Expectancy (AHH)	80	33.74	19.20	1	66
Health Expenditure (BKES)	80	40.50	23.24	1	80
GRDP per Capita (PDRB)	80	40.50	23.24	1	80

Source: STATA 17.0 output (2026).

In the health model, Medical Personnel (MED) averages 2,706 staff per city-year, with a wide range of 412 to 16,542. The large gap between the minimum and maximum values indicates that the distribution of medical personnel across cities is uneven, with larger cities commanding a substantially bigger health workforce than smaller ones. Health Facilities (FASKES) average 85 units with a standard deviation of 163.10, a standard deviation that exceeds the mean itself pointing to a highly unequal distribution of health infrastructure that mirrors each city's fiscal capacity and service-delivery scale. Life Expectancy (AHH) averages 33.74 (SD = 19.20), while Health Expenditure (BKES) and GRDP per capita both average 40.50 (SD = 23.24). Overall, the descriptive statistics for both models reveal considerable heterogeneity in inputs and outputs across the eight cities, providing an adequate empirical basis for identifying differences in local governments' ability to convert public spending into education and health outcomes through the SFA framework.

5.2 Stochastic Frontier Estimation

Two Cobb-Douglas SFA models were estimated separately via Maximum Likelihood Estimation (MLE), given that the education and health sectors employ distinct output and input variable R Square (R^2)

a. Education Sector

Table 3. Path Coefficients

Variable	Coefficient	Std. Error	z-statistic
ln Education Expenditure (BPEND)	0.006537	0.000017	387.54**
ln GRDP per Capita (PDRB)	−0.133142	0.000026	−5,100.13**
ln Total Population (POP)	0.380540	0.000014	27,800.00**
Constant	3.346334	0.000086	39,000.00**
Frontier Parameter		Value	
Wald $chi^2(3)$		1.80×10^9 (Prob > chi^2 = 0.000)	
Log likelihood		−71.8533	
Sigma-u (σu)		1.1881	
Sigma-v (σv)		4.12×10^{-8}	
Lambda (λ = σu/σv)		2.88×10^7	
LR test (H0: σu = 0)		56.90 (Prob > $chibar^2$ = 0.000)	

Notes: **p < 0.05. Source: STATA 17.0 output (2026).

The estimated education frontier equation is:
$\ln(IPit) = 3.346334 + 0.006537 \ln(BPENDit) - 0.133142 \ln(PDRBit) + 0.380540 \ln(POPit) + vit - uit$

All three input variables are statistically significant ($p < 0.05$), and the Wald chi^2 statistic of 1.80×10^9 ($p = 0.000$) confirms that the inputs are jointly significant predictors of the Education Index, indicating a well-fitting model. Education expenditure has a positive and significant coefficient of 0.006537, meaning that a 1% increase in education spending is associated with a 0.0065% increase in the Education Index, ceteris paribus. Although the elasticity is small, the positive sign confirms that public investment in education used for school infrastructure, teacher-quality programs, operational assistance, and learning-media development continues to contribute to improved education outcomes, even if spending alone is not sufficient to generate large gains. GRDP per capita carries a negative and significant coefficient of −0.133142, indicating that regional economic growth is not automatically accompanied by higher education attainment; the benefits of economic growth are only converted into education gains when local governments deliberately direct fiscal capacity toward education policy. Total population has the largest coefficient (0.380540, positive and significant), showing that more populous cities tend to record higher Education Index values, consistent with economies of scale in education service delivery — larger cities generally operate more complete school facilities, employ more teachers, and

provide broader access, and tend to receive correspondingly larger education budgets.

From the frontier-decomposition perspective, sigma-u ($\sigma u = 1.1881$) is far greater than sigma-v ($\sigma v = 4.12 \times 10^{-8}$), and the resulting lambda ($\lambda = 2.88 \times 10^{7}$) confirms that residual variation in the model is overwhelmingly driven by technical inefficiency rather than random statistical noise. The Likelihood Ratio test for the presence of inefficiency (56.90, $p = 0.000$) is statistically significant, confirming that an SFA specification rather than an ordinary regression is the appropriate method for this sector, since it allows the technical efficiency of each city government to be separately identified and measured.Effect Size (F^2)

b Health Sector

Table 4. SFA Estimation Results — Health Model

Variable	Coefficient	Std. Error	z-statistic
ln Health Expenditure (BKES)	4.0261	2.0935	1.92*
ln GRDP per Capita (PDRB)	5.4760	2.0425	2.68**
ln Medical Personnel (MED)	0.0285	0.0068	4.23**
ln Health Facilities (FASKES)	−0.7608	0.1890	−4.02**
Constant	−8.7381	60.8673	−0.14 (n.s.)
Frontier Parameter		Value	
Wald chi²(4)		36.00 (Prob > chi² = 0.000)	
Log likelihood		−334.3403	
Sigma-u (σu)		3.2624	
Sigma-v (σv)		15.6821	
Lambda (λ = σu/σv)		0.2080	
LR test (H0: σu = 0)		0.00039 (Prob > chibar² = 0.492)	

Notes: **p < 0.05, *p < 0.10, n.s. = not significant. Source: STATA 17.0 output (2026).

The estimated health frontier equation is:

$\ln(AHHit) = -8.7381 + 4.0261 \ln(BKESit) + 5.4760 \ln(PDRBit) + 0.0285 MEDit - 0.7608 FASKESit + vit - uitt$

The Wald chi² statistic of 36.00 ($p = 0.000$) confirms that the four inputs are jointly significant in explaining variation in Life Expectancy. Health expenditure has a positive coefficient of 4.0261, significant only at the 10% level ($p = 0.054$); its effect on AHH is directionally positive but statistically weaker than the other variables, which is consistent with the fact that the benefits of health spending such as facility upgrades, medical-supply procurement, and workforce training typically materialize over the medium to long term rather than within the same fiscal year. GRDP per capita is positive and significant (coefficient = 5.4760, $p = 0.007$), indicating that cities with higher economic capacity tend to achieve better health outcomes, plausibly because greater fiscal capacity allows for higher-quality health services, broader access to facilities, and greater health-sector investment. Medical personnel is positive and significant (coefficient = 0.0285, $p = 0.000$), confirming that a larger health workforce enables faster and higher-quality service delivery, which in turn supports higher life expectancy. Health facilities, by contrast, carry a negative and significant coefficient (−0.7608, $p < 0.05$); this should not be interpreted as more facilities harming health outcomes, but rather as evidence that facility expansion alone without complementary investment in service quality, staffing distribution, equipment completeness, and access does not proportionally translate into higher AHH. The constant is not statistically significant ($p = 0.886$), but this does not affect the interpretation of the input variables, since the focus of the analysis is on the effects of the input factors themselves.

The frontier decomposition for the health model differs markedly from the education model: sigma-v ($\sigma v = 15.6821$) dominates sigma-u ($\sigma u = 3.2624$), yielding a lambda of only 0.2080, and the LR test for inefficiency is not statistically significant (0.00039, $p = 0.492$). This indicates that cross-city variation in Life Expectancy is driven predominantly by random, exogenous factors such as community health behavior, environmental conditions, demographic structure, and shocks such as the COVID-19 pandemic rather than by systematic technical inefficiency in local government management. Consequently, the technical efficiency scores for the health sector should be interpreted more cautiously than those for education, since a larger share of the residual variation lies outside local governments' direct control.

5.3 Technical Efficiency Levels

Technical efficiency (TE) scores range from 0 to 1, where values closer to 1 indicate that a city government more fully converts its inputs into education or health outputs. Following Coelli et al. (2005), TE scores are classified into five categories: Very Efficient (≥ 0.90), Efficient (0.80–<0.90), Reasonably Efficient (0.70–<0.80), Less Efficient (0.60–<0.70), and Inefficient (< 0.60).

Average education efficiency across the eight cities is 0.5574 (55.74%), placing the sector overall in the Inefficient category, while average health efficiency is 0.5621 (56.21%), also Inefficient. Surabaya records the highest education efficiency (0.8823, Efficient), consistent with its position as the city with the largest fiscal capacity and a steadily rising education-expenditure trend; Kediri records the lowest (0.2724, Inefficient). Mojokerto and Madiun both reach the frontier (TE = 1.0000) in 2023, despite considerably smaller fiscal capacity than Surabaya, indicating that budget-management quality not budget size is the binding constraint. At the annual level, average education efficiency rises steadily from 26.88% in 2014 to 82.61% in 2023.

Table 5. Technical Efficiency (TE) by City, 2014–2023 Average

City	Education TE	Category	Health TE	Category
Batu	0.3162	Inefficient	0.8477	Efficient
Blitar	0.4873	Inefficient	0.1518	Inefficient
Kediri	0.2724	Inefficient	0.2526	Inefficient
Madiun	0.7373	Reasonably Efficient	0.3156	Inefficient
Malang	0.7286	Reasonably Efficient	0.8124	Efficient
Mojokerto	0.7349	Reasonably Efficient	0.9803	Very Efficient
Pasuruan	0.2998	Inefficient	0.5016	Inefficient
Surabaya	0.8823	Efficient	0.6349	Less Efficient
Average (8 cities)	0.5574	Inefficient	0.5621	Inefficient

Source: STATA 17.0 output (2026).

For health, Mojokerto records the highest efficiency (0.9803, Very Efficient), while Blitar records the lowest (0.1518, Inefficient). Notably, Surabaya the top performer in education falls to only 0.6349 (Less Efficient) in health, illustrating an asymmetry in sectoral performance within the same city, plausibly reflecting the greater complexity of health-service delivery in a large metropolitan population. At the annual level, average health efficiency rises from 58.23% (2014) to 66.74% (2019), falls sharply to 43.82% during 2020 –2021 amid the COVID-19 pandemic as health budgets were reallocated toward emergency response and only partially recovers to 52.93% by 2023.

6. DISSCUSIONS

6.1 Education Sector

a. Effect of Education Expenditure on the Education Index

Education expenditure has a positive and significant effect on the Education Index (coefficient = 0.006537), indicating that a 1% increase in education spending raises the Education Index by 0.0065%, ceteris paribus. This confirms that budget allocation for education used to finance school infrastructure, teacher and staff competency development, operational assistance, learning-media development, and other quality-improvement programs continues to contribute to improved education outcomes, primarily by raising expected years of schooling and mean years of schooling, the two components underlying the Education Index. However, the small magnitude of the elasticity indicates that spending increases alone do not automatically translate into large gains; the efficiency results in Table 5 reinforce this point, since Surabaya (0.8823) and Kediri (0.2724) sit at opposite ends of the efficiency spectrum despite both operating within the same fiscal and regulatory environment. This is consistent with Human Capital Theory (Schultz, 1961; Becker, 1964), which treats education as an investment that raises individual productivity and long-run economic growth, and with the Value for Money principle (Mardiasmo, 2018), which holds that the success of public financial management should be measured not by how much is spent but by how economically, efficiently, and effectively it generates outputs and outcomes. The fact that Mojokerto and Madiun reach the efficiency frontier despite markedly smaller budgets than Surabaya's further indicates that spending effectiveness driven by planning quality, program targeting, and implementation matters more than spending volume.

b. Effect of GRDP per Capita on the Education Index

GRDP per capita has a negative and significant effect on the Education Index (coefficient = −0.133142), indicating that an increase in regional economic capacity is not always followed by an improvement in education outcomes across the eight East Java cities during 2014–2023. Economically, this suggests that regional economic growth does not automatically raise education quality unless the resulting fiscal gains are deliberately directed toward education policy; GRDP per capita reflects the level of economic activity and average household income, while the Education Index reflects education-service equity, quality, and effectiveness two dimensions that are related only indirectly. This is consistent with Wagner's Law, which holds that economic growth expands government capacity to provide public services, but does not by itself guarantee that expanded capacity is converted into higher-quality services. It is also consistent with the New Public Management (NPM) perspective, which emphasizes that public-sector success is determined not by the volume of resources available but by the ability to generate public value through efficient, effective, and accountable resource management. Empirically, Surabaya the city with the largest economy does record high education efficiency (0.8823), yet Mojokerto and Madiun reach the frontier (TE = 1.0000 in 2023) despite far smaller economies, confirming that economic capacity is not the sole determinant of education outcomes. These findings align with Afonso et al. (2005) and Herrera and Pang (2005), who show that fiscal capacity and expenditure size do not automatically produce better public-service performance; institutional quality, bureaucratic effectiveness, governance, and performance-based budgeting are the more decisive factors.

c. Effect of Population on the Education Index

Total population has a positive and significant effect on the Education Index (coefficient = 0.380540) the largest elasticity among the three input variables indicating that a 1% increase in population raises the Education Index by 0.3805%, ceteris paribus. This shows that a large population is not necessarily a development burden but

can instead become an asset for education outcomes when accompanied by adequate service provision: larger cities generally require, and tend to receive, more schools, more teachers, and more classrooms, translating into higher school participation, mean years of schooling, and expected years of schooling. Surabaya, the most populous city in the sample, also records the highest education efficiency (0.8823), while Madiun and Mojokerto with smaller populations still achieve very high (frontier) efficiency by the end of the period, indicating that population size interacts with, rather than substitutes for, governance quality. This finding is consistent with Human Capital Theory (Schultz, 1961; Becker, 1964), which regards population as a developmental asset when adequately invested in through education, and with Todaro and Smith's (2020) view that population growth becomes a development asset rather than a burden when matched with investment in education and health. It also supports the Public Goods Provision perspective, which holds that public-service provision must be scaled to community needs including the distribution of teachers, facilities, and access in order for population growth to translate into improved education outcomes rather than service strain.

d. Inter-City Differences in Education Efficiency

The results in Table 5 reveal substantial variation in education efficiency across the eight cities. Surabaya leads with 0.8823 (Efficient), reflecting its large fiscal capacity combined with a rising education-expenditure trend and continued Human Development Index gains even after 2023 budget adjustment evidence that budget-management quality, rather than budget size alone, underlies its performance. A reasonably efficient tier Madiun (0.7373), Mojokerto (0.7349), and Malang (0.7286) shows a consistent year-on-year improvement, with Mojokerto and Madiun both reaching the frontier (TE = 1.0000) by 2023 despite considerably smaller fiscal capacity than Surabaya's, demonstrating that high-quality budget management can achieve optimal outcomes even without large budgets. At the other end, Kediri (0.2724), Pasuruan (0.2998), Batu (0.3162), and Blitar (0.4873) remain Inefficient, indicating substantial unrealized potential in education-program quality, service equity, and monitoring-and-evaluation systems. Annually, average efficiency across all eight cities rises steadily from 26.88% (2014) to 82.61% (2023), tracking the sector's overall improvement in Education Index outcomes over the same period but the fact that Surabaya's larger budget does not guarantee the top efficiency rank, and that smaller-budget cities like Mojokerto and Madiun approach or reach the frontier, confirms that program targeting, implementation quality, and governance capacity are the more decisive determinants of education efficiency than fiscal capacity itself.

6.2 Health Sector

a. Effect of Health Expenditure on Life Expectancy

Health expenditure has a positive coefficient (4.0261) but is significant only at the 10% level ($p = 0.054$), indicating a directionally positive but statistically weaker relationship with Life Expectancy than the other input variables. Economically, health expenditure remains an important instrument for financing health-facility provision, medicine and equipment procurement, medical-workforce competency development, and promotive, preventive, curative, and rehabilitative programs all of which support higher life expectancy over time. This is consistent with Human Capital Theory (Grossman, 1972), which treats health as a form of human capital (health capital) that raises productivity and welfare. The weaker statistical significance is consistent with the nature of health investment, whose benefits typically materialize over the medium to long term rather than within a single fiscal year, and is also consistent with Kruse et al. (2012) and Rajkumar and Swaroop (2008), who emphasize that governance quality, allocation effectiveness, and institutional capacity not spending size alone determine whether health expenditure translates into better health-sector performance. This is reflected in the efficiency results: several cities with smaller health budgets, such as Mojokerto and Batu, achieve high efficiency, while Surabaya, despite a large health budget, records only moderate efficiency (0.6349), underscoring that effective allocation matters more than the level of spending itself.

b. Effect of GRDP per Capita on Life Expectancy

GRDP per capita has a positive and significant effect on Life Expectancy (coefficient = 5.4760, $p = 0.007$), indicating that regional economic capacity is associated with health outcomes. Economically, higher GRDP per capita reflects greater fiscal capacity, which can be directed toward health-facility provision, medical equipment, health workforce, and community health programs. However, this does not mean that greater economic capacity automatically produces higher health-spending efficiency: Wagner's Law suggests that economic growth expands government spending capacity to meet public-service needs, but higher spending does not guarantee more efficient service unless supported by strong institutions, budgeting systems, bureaucratic capacity, and oversight mechanisms a pattern also documented by Afonso et al. (2005), Afonso and Fernandes (2008) and Herrera and Pang (2005), who find that public-sector efficiency depends more on governance quality than on expenditure size or income level. Empirically, the city with the largest economy, Surabaya, is not the most efficient in health (0.6349, Less Efficient), whereas Mojokerto, with a comparatively smaller economy, achieves the highest efficiency (0.9803, Very Efficient) evidence that fiscal capacity alone does not determine health-spending success, and that planning quality and targeted program implementation play the larger role.

c. Effect of Medical Personnel on Life Expectancy

Medical personnel has a positive and significant effect on Life Expectancy (coefficient = 0.0285, p = 0.000), confirming that a larger health workforce strengthens diagnostic, treatment, preventive, and public-health-program capacity, thereby supporting faster and higher-quality service delivery. This is consistent with the WHO (2023) characterization of the health workforce as the backbone of health systems, given that the availability of doctors, nurses, midwives, and other health personnel contributes to reduced mortality and improved life expectancy and quality of life. The WHO (2023) also notes, however, that service effectiveness depends not only on personnel numbers but also on their distribution, professional competency, and management a pattern reflected in the results: cities with high health efficiency generally combine an adequate medical workforce with effective distribution across facilities, while lower-efficiency cities continue to face uneven personnel distribution, limited specialist availability, and underutilized primary-care staffing. This indicates that expanding the medical workforce should be paired with more equitable distribution policies and more effective human-resource management in order to translate workforce growth into system-wide efficiency gains.

d. Effect of Health Facilities on Life Expectancy

Health facilities have a negative and significant effect on Life Expectancy (coefficient = −0.7608, $p < 0.05$). This finding does not imply that adding health facilities worsens health outcomes; rather, it indicates that facility expansion alone does not automatically raise health-spending efficiency. The effectiveness of health facilities depends heavily on utilization rates, distribution equity, availability of accompanying medical personnel, completeness of equipment, referral-system functioning, and overall facility-management quality. This is consistent with the WHO's (2023) Health System Strengthening framework, which holds that health-system success depends on the integration of service delivery, workforce, financing, health information, technology, and governance, and with OECD (2023) guidance that health-infrastructure investment yields optimal benefits only when accompanied by improved service quality, strengthened primary care, digitalization, and effective facility management. Empirically, cities with higher health efficiency are able to utilize their health facilities more optimally than lower-efficiency cities, and metropolitan areas such as Surabaya face more complex service-delivery burdens than smaller cities, requiring different management approaches. These findings, together with the negative coefficient, reinforce that facility quantity is not the sole determinant of health-service success and must be paired with equitable access, adequate staffing, complete equipment, and stronger management-and-evaluation systems.

e. Inter-City Differences in Health Efficiency

Health efficiency also varies substantially across the eight cities. Mojokerto leads with 0.9803 (Very Efficient), demonstrating a strong ability to convert health inputs into Life Expectancy gains despite a comparatively smaller fiscal capacity than Surabaya's evidence that health-development success is driven more by planning effectiveness, program targeting, and service-management quality than by budget size. Batu (0.8477) and Malang (0.8124) also fall in the Efficient category, showing that mid-capacity cities can achieve high efficiency when supported by sound budget governance, adequate health-workforce distribution, and effective service provision. Surabaya, despite the largest health budget, records only 0.6349 (Less Efficient), plausibly reflecting the greater complexity of health-service delivery in a large metropolitan population with high mobility and a more complex service burden. Pasuruan (0.5016), Madiun (0.3156), Kediri (0.2526), and Blitar (0.1518) remain in the Inefficient category, indicating that health-input utilization in these cities has not yet translated into optimal Life Expectancy gains and pointing to a need for improved service quality, more equitable medical-workforce distribution, expanded community access to health facilities, and strengthened promotive-and-preventive programs. Annually, average health efficiency rises from 58.23% (2014) to 66.74% (2019), then falls sharply to 43.82% during 2020–2021 amid the COVID-19 pandemic when health budgets were reallocated toward emergency response, testing, and vaccination rather than routine service delivery before partially recovering to 52.93% by 2023. This pattern is consistent with the frontier decomposition in Section 5.2(b), in which random/exogenous error dominates the technical-inefficiency component, confirming that Life Expectancy outcomes are shaped not only by local governments' budget-management capacity but also by external factors such as community health behavior, environmental conditions, demographic structure, and pandemic shocks factors that lie outside the scope of the estimated model.

7. CONCLUSIONS

This study measured and compared the technical efficiency of public expenditure in the education and health sectors across eight cities in East Java Province during 2014–2023 using a panel Stochastic Frontier Analysis. Two main conclusions emerge. First, average technical efficiency remains suboptimal in both sectors 55.74% for education and 56.21% for health indicating that local governments have converted only part of their available inputs into education and health outputs, and that increases in budget allocation have not been fully matched by proportional gains in outcomes; substantial room remains to improve efficiency through more effective planning, implementation, and evaluation of public programs. In the education sector, efficiency is shaped by education expenditure, regional economic

capacity, and population size; in the health sector, it is shaped by health expenditure, regional economic capacity, medical-personnel availability, and health-facility provision. Second, technical efficiency varies significantly across cities and is only weakly related to fiscal capacity: Surabaya leads in education efficiency (0.8823) but ranks only fifth in health (0.6349), while Mojokerto is the only city that performs strongly in both sectors ranking in the reasonably-efficient tier for education and the very-efficient tier for health (0.9803) despite a comparatively smaller budget than Surabaya's. This asymmetry underscores that governance quality, institutional capacity, and effective policy implementation not spending volume alone are the primary determinants of efficient public service delivery. The contrasting frontier decomposition between the two sectors adds a further layer to this conclusion: in the education model, technical inefficiency dominates the residual variation ($\lambda \approx 2.88 \times 10^7$; LR test significant at $p = 0.000$), indicating that differences in education outcomes across cities are primarily attributable to differences in local governments' resource-management capacity. In the health model, by contrast, random and exogenous error dominates ($\lambda = 0.2080$; LR test not significant at $p = 0.492$), indicating that health outcomes are shaped substantially by factors beyond local governments' direct control including the COVID-19 pandemic, community health behavior and demographic conditions and that health-efficiency scores should therefore be interpreted with greater caution than education-efficiency scores. These findings support a policy shift from input-oriented budgeting (quantity of spending) toward performance-based, outcome-oriented budget management, with underperforming cities Kediri, Pasuruan, Batu, and Blitar in education, and Blitar, Kediri, Madiun, and Pasuruan in health encouraged to adopt the governance practices of benchmark cities such as Surabaya (education) and Mojokerto (health).

This study is subject to several limitations that offer directions for future research. First, the analysis covers only eight cities in East Java Province, so the findings cannot be generalized to all districts and cities in Indonesia. Second, the study estimates two separate SFA models limited to the education and health sectors, without extending to other public-service sectors such as social protection, infrastructure, or employment. Third, the input variables used remain limited to macro-level indicators and do not directly capture institutional quality, governance capacity, or public-service-quality dimensions; incorporating such institutional variables in future research would help to better explain the observed efficiency gaps between cities and sectors.

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