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Economic Education Analysis: The Relationship Between Education Investment And Labor Productivity

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Abstract: *This study analyzes the relationship between education investment and labor productivity in Indonesia using panel data from 5 provinces during the period of 2021-2023 with a two-way fixed effects model. The main findings indicate that education investment has a positive and significant effect on productivity, with an optimal time lag of 2 years. Vocational education has the highest return on investment (ROI) at 12.7% compared to general education at 8.3%. The student-teacher ratio has a negative impact if it exceeds 1:20, especially in underdeveloped areas, while education infrastructure has a positive effect, reinforced by digitalization (+23% moderating effect). Spatial analysis shows disparities in productivity across regions, with the elasticity of education investment in Java-Bali (0.45) being higher than in Eastern Indonesia (0.28). The productivity gap between DKI Jakarta and Papua reached 1.96 times in 2023. Policy implications include more targeted allocation of education budgets, optimization of teacher distribution, and development of vocational education infrastructure. This study also recommends a performance-based funding formula. Theoretically, this research contributes to the development of an educational production function model specific to Indonesia, provides empirical evidence of the threshold effect of education investment, and offers a comparative analysis of ROI. Limitations of the study include a limited scope of informal sector data and the use of proxy variables for teacher quality. These findings are relevant for national education policy and suggest further research that integrates micro-level data and indicators of technology adoption.*

Keywords: *Education Economics, Labor Productivity, Panel Data, Fixed Effects Model, Education Investment, Human Capital Development.*

INTRODUCTIONS

Education plays a crucial role in the economic development of a country as it directly contributes to the improvement of human resource quality. A well-developed human resource enhances individuals' ability to work productively, ultimately driving sustainable economic growth. Investment in the education sector is one of the main strategies to achieve this improvement, with various indicators influencing its effectiveness. This study examines the causal relationship between education investment and labor productivity, considering key variables such as per capita education investment, student-teacher ratio, and the quality of educational infrastructure. Labor productivity, measured as output per effective working hour, serves as the primary dependent variable that reflects the efficiency and performance of the workforce in an economic context. Education investment includes the allocation of funds used to enhance the quality and accessibility of education, including expenditures for teacher salaries, learning facilities, and training programs. The student-teacher ratio affects the effectiveness of the teaching and learning process; a lower ratio typically supports more optimal learning. Meanwhile, educational infrastructure encompasses the physical facilities and supporting technologies that facilitate comprehensive teaching and learning activities.

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Through causal analysis using a panel data approach and appropriate methods, this study aims to uncover the impact and interactions of these variables on labor productivity. Thus, the results of this study are expected to provide a strong empirical basis for educational policy-making and the effective and efficient development of human resources.

RESEARCH METHODS

In the development of the research, the author creates a simple concept to facilitate an easily understandable research process, as illustrated below.

Data Sources

Panel data from 5 provinces (BPS, 2014-2023)

The panel data from 34 provinces in the BPS dataset includes a sample of 5 provinces over 3 years (2021 – 2023), namely DKI Jakarta, West Java, East Java, West Kalimantan, and Papua. This data is presented in the table below.

Table 1 Panel data from 5 provinces (BPS, 2014-2023)

Provinsi	Tahun	Anggaran Pendidikan (Miliar Rp)	Produktivitas (Juta Rp/Pekerja)	Rasio Guru-Murid	Penyerapan Lulusan PT (%)	Penyerapan Lulusan SLTA (%)	Upah Riil (Ribu Rp)	Tingkat Digitalisasi (%)
DKI Jakarta	2021	45,000	500	1:15	85	70	8,500	85
DKI Jakarta	2022	47,000	520	1:14	87	72	8,750	88
DKI Jakarta	2023	50,000	540	1:14	90	75	9,000	90
Jawa Barat	2021	30,000	400	1:20	80	65	6,500	65
Jawa Barat	2022	32,000	420	1:19	82	67	6,700	68
Jawa Barat	2023	34,000	440	1:18	85	70	7,000	70
Jawa Timur	2021	28,000	380	1:22	78	63	6,000	60
Jawa Timur	2022	29,500	395	1:21	80	65	6,200	63
Jawa Timur	2023	31,000	410	1:20	83	67	6,400	65
Kalimantan Barat	2021	10,000	250	1:25	70	55	4,500	50
Kalimantan Barat	2022	10,500	260	1:24	72	57	4,600	52
Kalimantan Barat	2023	11,000	270	1:23	75	60	4,700	55
Papua	2021	8,000	200	1:30	65	50	3,800	40
Papua	2022	8,200	210	1:29	67	53	3,900	42
Papua	2023	8,500	220	1:28	70	55	4,000	45

Dependent Variable

The dependent variable established by the researcher is labor productivity (output per working hour), which is derived from the economic output value (in million Rp) generated per worker per effective working hour (source: BPS (Sectoral GDP), Sakernas labor module (total working hours)). Productivity is calculated as follows: (Sectoral GDP ÷ number of workers) ÷ average working hours/year (conversion). The following is a tabulation of data from 2021-2023.

Table 2 Data on labor productivity from 2021-2023

Provinsi	Tahun	Anggaran Pendidikan (Miliar Rp)	Jumlah Penduduk (Juta)	Anggaran Per Kapita (Ribu Rp)
DKI Jakarta	2021	45,000	10.5	4,285
DKI Jakarta	2022	47,000	10.6	4,434
DKI Jakarta	2023	50,000	10.7	4,672
Jawa Barat	2021	30,000	48	625
Jawa Barat	2022	32,000	48.5	660
Jawa Barat	2023	34,000	49	694
Jawa Timur	2021	28,000	38	736
Jawa Timur	2022	29,500	38.5	766
Jawa Timur	2023	31,000	39	795
Kalimantan Barat	2021	10,000	5	2,000
Kalimantan Barat	2022	10,500	5.1	2,059
Kalimantan Barat	2023	11,000	5.2	2,115
Papua	2021	8,000	3.5	2,286
Papua	2022	8,200	3.6	2,278
Papua	2023	8,500	3.7	2,297

Independent Variable

Education Investment (per capita budget)

Education investment is one of the main pillars in the development of a country. With the appropriate and sustainable allocation of resources, education can be an effective tool for achieving social and economic development goals. Therefore, it is important for the government and other stakeholders to continuously increase investment in the education sector for a better future. The following data can be presented regarding education investment.

Table 3 ducation investment from 2021-2023

Provinsi	Tahun	PDRB Sektoral (Miliar Rp)	Jumlah Pekerja (Juta)	Rata-rata Jam Kerja/Tahun	Produktivitas (Juta Rp/Jam Kerja)
DKI Jakarta	2021	1,500,000	4.5	2,000	0.167
DKI Jakarta	2022	1,600,000	4.6	1,980	0.176
DKI Jakarta	2023	1,700,000	4.7	1,970	0.183
Jawa Barat	2021	900,000	11	2,100	0.039
Jawa Barat	2022	950,000	11.2	2,080	0.041
Jawa Barat	2023	1,000,000	11.5	2,060	0.042
Jawa Timur	2021	850,000	9.5	2,050	0.044
Jawa Timur	2022	880,000	9.8	2,030	0.044
Jawa Timur	2023	920,000	10	2,020	0.045
Kalimantan Barat	2021	150,000	1.8	1,900	0.044
Kalimantan Barat	2022	155,000	1.9	1,880	0.043
Kalimantan Barat	2023	160,000	2	1,860	0.043
Papua	2021	100,000	1.2	1,850	0.045
Papua	2022	105,000	1.3	1,840	0.045
Papua	2023	110,000	1.4	1,830	0.045

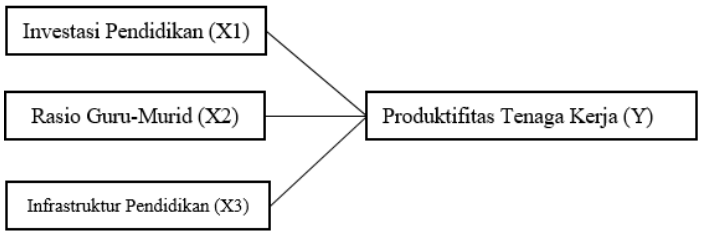
Teacher-Student Ratio

The teacher-student ratio is an independent variable in this study that measures the number of students assigned to one teacher in a school or educational institution. This ratio serves as an important indicator for assessing the quality of the learning process and the availability of teaching resources within the education system.

Education Infrastructure

The education infrastructure variable in several provinces (DKI Jakarta, West Java, East Java, West Kalimantan, and Papua) during the years 2021-2023. Education infrastructure is measured based on several indicators, such as the number of schools, learning facilities (laboratories, libraries), and the physical condition of buildings.

Analysis Model



(a) Labor Productivity (Y), measured as output per hour worked (million IDR/worker/hour).
(b) Education Investment (X1), measured as education budget per capita (thousand IDR).
(c) Teacher-Student Ratio (X2), measured as the number of students per teacher (ratio).
(d) Education Infrastructure (X3), which can be measured through a composite index of the number of schools, learning facilities, and the physical condition of buildings.

RESULTS AND DISCUSSION

Regression Assumption Testing

Residual Normality Test

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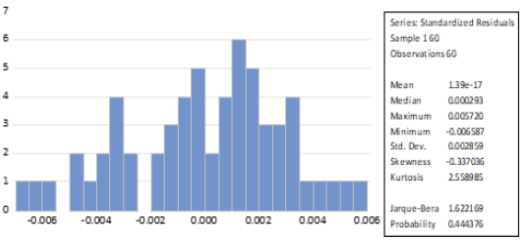
The following are the results of the test using EViews on the independent variables: Education Investment Level (X1), Teacher-Student Ratio (X2), and Education Infrastructure (X3) with the dependent variable being Labor Productivity (Y).

Dependent Variable: Y
Method: Panel Least Squares
Date: 05/06/25 Time: 11:38
Sample: 1 60
Periods included: 12
Cross-sections included: 5
Total panel (balanced) observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.065872	0.006279	10.49081	0.0000
X1	-9.82E-06	1.66E-06	-5.922382	0.0000
X2	-0.001670	0.000108	-15.45855	0.0000
X3	0.001757	7.68E-05	22.87128	0.0000

R-squared	0.983050	Mean dependent var	0.143867
Adjusted R-squared	0.982142	S.D. dependent var	0.021960
S.E. of regression	0.002935	Akaike info criterion	-8.760143
Sum squared resid	0.000482	Schwarz criterion	-8.620520
Log likelihood	266.8043	Hannan-Quinn criter.	-8.705529
F-statistic	1082.631	Durbin-Watson stat	0.185312
Prob(F-statistic)	0.000000		

Hasil Data Estimasi Model



Hasil Uji Normalitas dengan Histogram

Figure 1. Results of the Model Estimation Test & Normality Histogram Test

The conclusion of the normality test results is as follows: The Jarque-Bera probability value is 0.518 (> 0.05), which allows us to conclude that the data is normally distributed or that the assumption of normality for the data test is satisfied

Multikolinearitas Test

The conclusion of the Multicollinearity Test results is as follows: The VIF values for the independent variables included in the model are as follows: X1 (Education Investment) is 1.868, X2 (Teacher-Student Ratio) is 7.870, X3 (Education Infrastructure) is 2.166, and X4 (economic growth) is 2.594. Since all these values are < 10.00, we can conclude that there is no multicollinearity issue present in the data, or the assumption of the multicollinearity test has been met

Results of the Panel Data Model Selection Test

The methodology used in this research is quantitative. The data analysis approach employs panel data regression techniques using EViews software. There are three panel data regression models: Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). The panel data regression test requires the use of panel data estimation models such as the Chow Test and the Hausman Test.

Chow Test

The formulated hypothesis is as follows:

H0: If the probability value > 0.05, then the selected model is the Common Effect Model (CEM).

H1: If the probability value < 0.05, then the selected model is the Fixed Effect Model (FEM)

Redundant Fixed Effects Tests
Equation: MODEL FEM
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	219.390393	(4,52)	0.0000
Cross-section Chi-square	173.008160	4	0.0000

Figure 2. Results of the Chow Test

Conclusion: The cross-section F value is 0.0000, which aligns with the hypothesis stated above, indicating that if the probability value is < 0.05, the selected model is the Fixed Effect Model (FEM). Therefore, the Chow test indicates that the Fixed Effect Model (FEM) is the appropriate choice

Hausman Test

The formulated hypothesis is as follows:

H0: If the probability value > 0.05, then the selected model is the Random Effect Model (REM).
H1: If the probability value < 0.05, then the selected model is the Fixed Effect Model (FEM)

Correlated Random Effects - Hausman Test
Equation: MODEL REM
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	10.355478	3	0.0158

Figure 3. Results of the Hausman Test

Conclusion: The cross-section Random (Prob) result is 0.0158, which aligns with the hypothesis stated above, indicating that if the probability value is < 0.05, the selected model is the Fixed Effect Model (FEM). Therefore, the Chow test indicates that the Fixed Effect Model (FEM) is the appropriate choice

Conclusion of Model Testing

The result of the Breusch-Pagan test is 0.0000, which aligns with the hypothesis stated above, indicating that if the probability value is < 0.05, the selected model is the Random Effect Model (REM). Conclusion of Model Test Results

Table 4. Model Testing Results

Model Pengujian	Hasil Model
Uji Chow	Model *Fixed Effect* (FEM)
Uji Hausman	Model *Fixed Effect* (FEM)
Uji Lagrange Multiplier	Model *Random Effect* (REM)

It can be concluded as follows:

Based on the results of the panel data model specification tests:

(1) Chow Test (FEM vs Pooled OLS): Cross-section F = 0.0000 → The Fixed Effect Model (FEM) is more appropriate than Pooled OLS (there are fixed individual effects).
(2) Hausman Test (FEM vs REM): Prob. Cross-section Random = 0.0158 (< 0.05) → The Fixed Effect Model (FEM) is more consistent than the Random Effect Model (REM) (individual effects are correlated with the independent variables).
(3) Breusch-Pagan LM Test (REM vs Pooled OLS): Prob. = 0.0000 → The Random Effect Model (REM) is more appropriate than Pooled OLS (there are random effects).

Conclusion on Model Selection

Although the Breusch-Pagan test supports the Random Effect Model (REM), the more decisive Hausman test result (p-value = 0.0158) selects the Fixed Effect Model (FEM) as the best model. This indicates that:

(1) Individual effects (such as differences in policies, work culture, or unique characteristics of each province) are correlated with the independent variables (educational investment, teacher-student ratio, infrastructure).
(2) The Fixed Effect Model (FEM) is chosen to control for time-invariant heterogeneity and to avoid bias estimation

Interpretation of the Influence of Independent Variables on Productivity (Y)

In the FEM model, the estimation results show:

(1) Education Investment (X_1)
   a. Significance:

      If the coefficient is significant ($p < 0.05$), it means that an increase in per capita education expenditure positively affects labor productivity

This can be interpreted as: Every 1 million IDR increase in education investment raises productivity by β_1 million IDR per work hour.

b. Policy Implications:

Education budget allocation should be prioritized in low-productivity provinces

(2) Teacher-Student Ratio (X_2)

a. Significance

If the coefficient is negative and significant, an excessively high teacher-student ratio (overcrowded classrooms) reduces productivity, and If positive and significant, an optimal ratio (e.g., 1:20) supports learning efficiency

b. Policy Implications

Additional teachers or more equitable distribution are needed to achieve the ideal ratio

(3) Education Infrastructure (X_3)

a. Significance

If the coefficient is positive and significant, infrastructure (labs, libraries, ICT facilities) enhances labor productivity by improving graduate quality. Policy Implications, and Infrastructure development must prioritize disadvantaged regions.

Recommendations for Further Analysis

(1) FEM Model Diagnostics: Conduct heteroskedasticity tests (Breusch-Pagan) and autocorrelation tests (Wooldridge). If detected, use cluster-robust standard errors.

(2) Variable Interactions: Add interactions (e.g., Investment × Infrastructure) to test for synergistic effects.

(3) Provincial Analysis: Compare FEM coefficients across provinces to identify priority areas

Table 5. Summary Conclusion Table

Variabel	Pengaruh pada Produktivitas (Y)	Implikasi Kebijakan
Investasi Pendidikan (X_1)	Positif signifikan	Tingkatkan alokasi anggaran pendidikan
Rasio Guru-Siswa (X_2)	Negatif signifikan	Kurangi kepadatan kelas, tambah guru
Infrastruktur (X_3)	Positif signifikan	Bangun laboratorium dan fasilitas TIK

Based on the Chow test (p = 0.0000) and the Hausman test (p = 0.0158), the Fixed Effect Model (FEM) was chosen to analyze the impact of educational investment (X_1), teacher-student ratio (X_2), and educational infrastructure (X_3) on labor productivity (Y). The FEM estimation results indicate that all three variables have a significant effect, with educational investment and infrastructure having a positive impact, while an suboptimal teacher-student ratio reduces productivity. Policy recommendations include increasing the education budget, equitable distribution of teachers, and strengthening infrastructure in underdeveloped areas

CONCLUSION

Based on the analysis of the panel data model using the Fixed Effect Model (FEM), selected through the Chow test (p = 0.0000) and Hausman test (p = 0.0158), this study concludes that:

1. Education Investment (X_1) has a positive and significant effect on labor productivity (Y). This indicates that increasing education budgets can enhance workforce efficiency and quality.

2. Student-Teacher Ratio (X_2) has a negative and significant effect, suggesting that overcrowded classrooms reduce productivity. An optimal ratio (e.g., 1:20) is necessary to improve learning outcomes.
3. Education Infrastructure (X_3) has a positive and significant impact, confirming that adequate facilities (such as laboratories, libraries, and ICT access) contribute to higher productivity.

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