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Education, Skilled Labour, And Per Capita Income In Indonesia

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Abstract:
Indonesia's economic development heavily relies on human capital quality, particularly through education and skilled labour development. Understanding the relationship between education, skilled labour, and economic outcomes is crucial for policy formulation. This study examines the impact of education and skilled labour on per capita income in Indonesia over the period 2000-2024, employing advanced time series econometric analysis. The research utilises an ARIMAX (Autoregressive Integrated Moving Average with Exogenous variables) model with skilled labour as the exogenous variable. This approach was selected for its robustness in handling time series data characteristics and addressing potential autocorrelation issues. Data were sourced from Indonesia's Central Statistics Agency (BPS) and Trading Economics, with analysis conducted using Stata 17 statistical software. Comprehensive residual diagnostic tests were performed to validate model assumptions. The ARIMAX regression analysis reveals that changes in the skilled labour force have a statistically significant positive effect on per capita income growth in Indonesia. The model demonstrates strong predictive capability and meets all necessary econometric assumptions, confirming the reliability of the findings. The study provides empirical evidence that skilled labour serves as a primary driver of economic well-being in Indonesia. These findings underscore the critical importance of investing in education and skills development programs to enhance national economic performance and individual prosperity.

Keywords: *Per Capita Income; Education; Skilled Labor; ARIMAX*

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I. Introduction

Education and skilled labour are pivotal to influencing per capita income in Indonesia, underscoring human capital's critical role in national economic development. As a developing nation, Indonesia faces significant challenges, including regional disparities in education access and escalating demand for digital skills driven by Industry 4.0. The COVID-19 pandemic further exacerbated these issues, disrupting learning quality and impacting youth workforce readiness for the global labour market (Wuri et al., 2022). Initial analysis suggests direct measurement of this complex relationship is challenging due to diverse economic and social factors, necessitating sophisticated econometric approaches. Vocational education is recognized as a strategic solution for aligning workforce skills with market needs, thereby enhancing productivity and per capita income (Wibawanto et al., 2021). This study aims to deeply examine the causal relationship among education, skilled labour, and per capita income, providing a robust empirical basis for inclusive economic policies in Indonesia.

This research addresses a key methodological gap in Indonesian empirical economic studies. Many prior studies on education or skills and economic growth/per capita income relied on simple regression models, overlooking long-term structural dynamics and lagged inter-variable effects. For example, Sutarman et al. (2024) noted the positive impact of competence and training on manufacturing labour productivity but lacked a macro-econometric time series approach. Our study offers a more comprehensive methodology: using annual time series data, including the post-COVID-19 period, integrating education and skilled labour in a multiple linear regression, and crucially, employing the ARIMAX model to enhance estimation validity and resolve autocorrelation and multicollinearity. This approach expands empirical understanding of the education-skills-economic well-being nexus. The specific objectives are to analyze the influence of education levels and skilled labour on per capita income, and identify the simultaneous relationship between education and skilled labour in affecting Indonesia's economic prosperity.

II. Material And Methods

This study employs a quantitative approach with an econometric analysis based on annual time series data from 2000 to 2024. This approach was chosen to identify the causal relationship between education levels,

the number of skilled labourers, and per capita income in Indonesia. A multiple linear regression model was applied as the primary method for hypothesis testing, with consideration for potential issues of multicollinearity and non-stationarity in time series data. If classical regression assumptions are not met, alternative models such as ARIMAX (Autoregressive Integrated Moving Average with Exogenous Variables) will be used to ensure the validity. This research utilizes secondary data from the Central Statistics Agency (BPS) and Trading Economics, analyzed with Stata 17 statistical software to produce accurate and reliable estimations.

The sample comprised 25 annual observations from 2000 to 2024, based on the availability of consistent macroeconomic time-series data for per capita income, education level, and skilled labour. For time-series econometric analysis, particularly ARIMAX (0,1,0) modelling with one exogenous variable (skilled labour), 20–30 observations are typically recommended to ensure sufficient degrees of freedom for parameter estimation, capture temporal trends, and address non-stationarity through first-order differencing. The 25 observations are adequate for robust estimation, accommodating structural economic shifts, such as those induced by the COVID-19 pandemic, which enhance the model's ability to capture long-term dynamics. As the dataset forms a complete annual sequence, no attrition or dropout was applicable.

The variables constituting this study's dataset comprised national-level macroeconomic indicators: per capita income (Y) as the dependent variable, and education level (X_1) and skilled labour (X_2) as independent variables. These indicators were strategically selected based on their established theoretical relevance within the frameworks of human capital theory and labour market dynamics, along with practical considerations of data availability and completeness across the study period.

The selection process adhered to rigorous criteria for data quality and consistency, utilizing only validated annual time series data. Education data, specifically the Net Enrollment Rate of Senior High School/Vocational High School (X_1), were sourced from Statistics Indonesia (BPS) Education Indicators. Data for skilled labour (X_2), representing the total number of skilled labourers, were obtained from BPS Labour Statistics. Per capita income (Y) data were acquired from Trading Economics' GDP per capita series. This systematic approach ensured that the selected variables provide reliable and comprehensive measures essential for a robust macroeconomic analysis over the specified time frame.

III. Procedure Methodology

This study employed a multi-stage econometric procedure to analyze the dynamic relationship between education, skilled labour, and per capita income in Indonesia using annual time-series data from 2000 to 2024. The analytical workflow proceeded as follows:

1. **Preliminary Estimation (OLS)**: A multiple linear regression model using Ordinary Least Squares (OLS) was initially estimated. This step aimed to examine the basic linear relationship between the dependent variable (Y: per capita income) and the two independent variables (X_1: education level, X_2: skilled labour) and to identify potential violations of classical assumptions.
2. **Diagnostic Testing**: Following the preliminary OLS estimation, comprehensive classical assumption tests were performed on the OLS residuals to assess the model's validity:

- Normality: Assessed using the Jarque-Bera test.
- Homoskedasticity: Evaluated using the Breusch-Pagan test.
- Multicollinearity: Detected using the Variance Inflation Factor (VIF).
- Autocorrelation: Examined using the Durbin-Watson statistic.
- Stationarity: The Augmented Dickey-Fuller (ADF) test was applied to all variables (per capita income, education level, and skilled labour) at their levels and first differences to determine their order of integration.

3. **Model Adjustment (ARIMAX)**: Due to significant violations of classical assumptions identified in the OLS model, particularly multicollinearity, autocorrelation, and the presence of non-stationarity in the dependent variable, an ARIMAX (Autoregressive Integrated Moving Average with Exogenous Variables) model was employed. This model is robust in handling non-stationary time series and inherent autocorrelation issues. The final specification selected was ARIMAX (0,1,0), which implies that the dependent variable (per capita income) was transformed by first-order differencing (ΔY_t) to achieve stationarity. The model incorporated first-differenced skilled labour (ΔX_{2t}) as the sole exogenous regressor, consistent with the transformation applied to the dependent variable.
4. **Model Selection and Validation**: The optimal ARIMAX model specification was selected based on statistical information criteria, specifically the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), with preference for models exhibiting the lowest values. Model validity was further evaluated using residual diagnostics, including:

- Ljung-Box Q test: To confirm the absence of autocorrelation.
- Histogram and Q-Q plots: To assess residual normality.
- Residual scatter plots: To visually confirm randomness and homoscedasticity.

Statistical analysis

All statistical analyses were conducted using Stata version 17, a robust platform for time-series econometric modelling. The analytical process involved both preliminary and advanced methods to ensure the reliability of estimates and robustness of inference.

Descriptive statistics were first computed to summarise the central tendencies and dispersion of each variable. The OLS regression model served as an initial step to evaluate baseline relationships and detect violations of classical assumptions. Residuals were rigorously tested for normality (Jarque-Bera), homoskedasticity (Breusch-Pagan), multicollinearity (Variance Inflation Factor - VIF), autocorrelation (Durbin-Watson), and stationarity (Augmented Dickey-Fuller - ADF test) to assess model adequacy.

Due to significant diagnostic violations identified in the preliminary analysis, an ARIMAX (0,1,0) model was subsequently employed. Model selection was guided by established statistical information criteria, namely the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Post-estimation model diagnostics were performed on the ARIMAX residuals, including the Ljung-Box Q test for autocorrelation, histogram and Q-Q plots for normality, and residual scatter plots for randomness. A significance level of 0.05 was consistently used throughout the analysis. All hypothesis testing was conducted under two-tailed assumptions.

IV. Result

Descriptive Statistics

The dataset comprises annual observations from 2000 to 2024. Per capita income shows an average of 2.9596 thousand USD with a standard deviation of 0.7951. This figure indicates that most regions have per capita incomes that range around that average value. The data range from 1,830 to 4,290 thousand USD reveals an economic gap that needs attention. The lowest-income regions have a per capita income that is almost half that of the highest-income areas, reflecting substantial regional economic disparities.

Education levels show a more consistent pattern with an average of 51.6% and a standard deviation of 9.2%. The range from 37.1% to 64.1% shows that while there are variations, the differences are not too extreme. This can be interpreted as an indication that education programs have been quite successful in creating relatively equitable access. However, there is still room for improvement in areas with low levels of education.

The number of skilled labour shows an average of 41.9 million persons with a standard deviation of 11.5 million persons. The range from 26.8 million persons to 60.8 million persons reflects a fairly substantial difference in the capacity of skilled labour. This high variability can be caused by a variety of factors, including differences in population size, industrialization rates, and lower human resource development policies in each region. See Table 1 for details.

Table 1. Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Per Capita Income (thousand USD)	2.9596	0.7951	1.83	4.29
Education (%)	51.586	9.2341	37.13	64.06
Skilled Labour (million persons)	41.9	11.5	26.83	60.81

Source: Data processed

Regression Results

Initial estimation using Ordinary Least Squares (OLS) indicated that education (coefficient=36.26525, p=0.015) and skilled labour (coefficient=0.0000395, p=0.002) were statistically significant, with the overall model significant (Prob > F=0.0000). However, diagnostic tests revealed violations of classical assumptions: severe multicollinearity due to a high correlation between education and skilled labour (r=0.9691, VIF=16.45), positive autocorrelation (Durbin-Watson=0.3675), and non-stationarity (ADF p=0.9892). Normality (Jarque-Bera Chi2=1.66, p=0.4368) and homoscedasticity (Breusch-Pagan Chi2=0.36, p=0.5461) were satisfied. See Table 2 for OLS results and diagnostics.

Table 2. OLS Regression and Diagnostic Tests

Aspect	Value	p-value
Education	36.26525	0.015
Skilled Labor	0.0000395	0.002
Model Significance	0.0000	-
Jarque-Bera (Normality)	1.66	0.4368

Breusch-Pagan (Homoscedasticity)	0.36	0.5461
VIF (Multicollinearity)	16.45	0.9691
Durbin-Watson (Autocorrelation)	0.3675	-
ADF (Stationarity)	0.9892	-

Source: Data processed

Due to multicollinearity and autocorrelation, an ARIMAX (0,1,0) model was estimated with the differenced skilled labor variable (Skilled_Labor) as the exogenous variable, excluding education to avoid multicollinearity. The model was selected based on the lowest AIC (-93.68055) and BIC (-90.14638). Results show that changes in skilled labor significantly affect per capita income (coefficient=0.0205148, p=0.000), implying a 20.5148 USD increase in per capita income per million skilled workers. The model passed diagnostic checks, with normal residuals (Jarque-Bera Chi2=0.61, p=0.7387) and no autocorrelation (Ljung-Box Prob > Q=0.7671). See Table 3 for the ARIMAX result.

ARIMAX

The ARIMAX (0,1,0) model diagnostics confirm robust results, with normal residuals (Jarque-Bera Chi2=0.61, p=0.7387) and no autocorrelation (Ljung-Box Prob > Q=0.7671). Visualizations, including ACF, PACF, actual vs. predicted values, and residual plots, support stationarity and model fit. See Figures 1–3 for details.

Table 3. ARIMAX Regression Results

Variable	Coefficient	Std. Error	p-value
Skilled_Labor	0.0205148	0.0018627	0.000
Constant	0.0774719	0.0068026	0.000
Wald chi2	121.30	-	0.0000
AIC	-93.68055	-	-
BIC	-90.14638	-	-

Source: Data processed

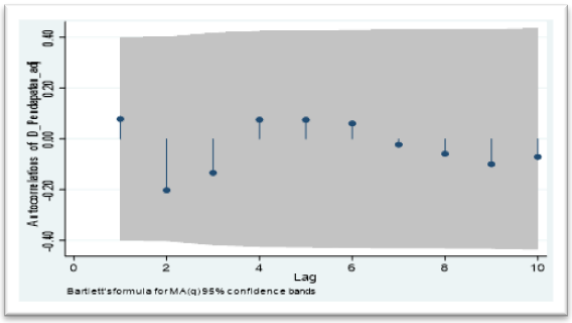

Figure 1. Autocorrelation Function (ACF) of Differenced Per Capita Income

This figure displays the Autocorrelation Function (ACF) of the differenced per capita income. The plot shows a significant spike only at lag 0, followed by a rapid decay within the confidence bounds, indicating that the series has become stationary and resembles a white noise process.

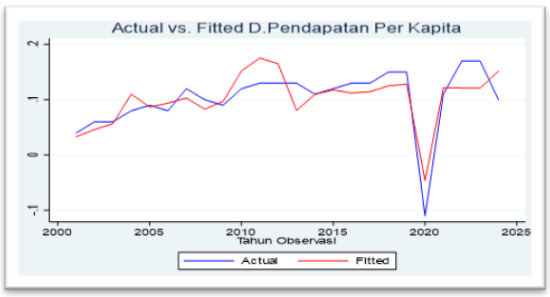

Figure 2. Actual vs. Predicted Per Capita Income

This graph compares the actual values with the predicted values of the differenced per capita income from the ARIMAX model. The predicted line generally follows the actual values, indicating a good model fit in explaining the variations in per capita income changes.

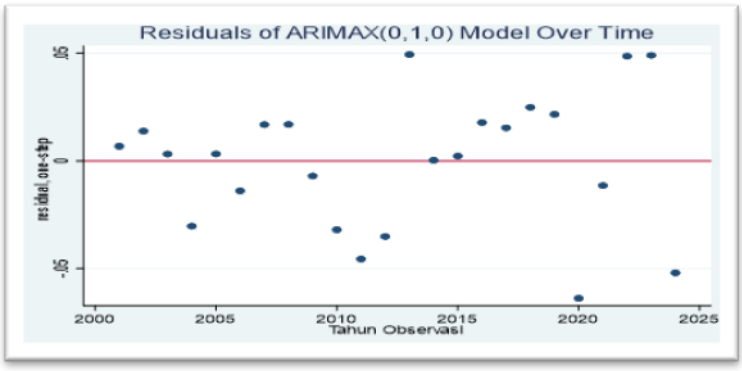

Figure 3. Residual Plot of ARIMAX (0,1,0) Model over Time

This figure displays the ARIMAX model's residuals scattered randomly around the zero line without any discernible pattern. This supports the assumption that the model's residuals are healthy and homoscedastic.

V. Discussion

This section interprets the econometric estimation results, linking them to the theoretical framework and comparing them with previous studies to generate new insights for Indonesian economic policy. Our analysis confirms the crucial role of skilled labour as a primary driver of economic well-being. It highlights the need for educational reform to better align with evolving labour market dynamics.

Initial OLS analysis indicated that education and skilled labour appeared significant, with the overall model also significant. However, these results were invalid due to significant violations of classical assumptions. To address these issues, a robust ARIMAX(0,1,0) model with skilled labour as the exogenous variable was adopted. This model was selected based on the lowest AIC and BIC, and it met all residual diagnostic assumptions, showing no autocorrelation and normally distributed residuals. The ARIMAX model revealed that changes in skilled labour significantly and positively affect changes in per capita income. This implies emphasising skills as a key driver of economic well-being.

This finding supports the Adaptive Human Capital Theory, which states that skills significantly impact economic growth when relevant to industry, technology, and the labour market. Ariansyah et al. (2024) found that Indonesian vocational graduates experience faster employment transitions and more stable incomes post-COVID-19, reinforcing the role of practical skills in digital transformation. Putranto et al. (2024) indicated that vocational education reduces labour market mismatch and increases youth income, yet regional educational quality gaps limit formal education's impact on national per capita income. This study's macroeconomic perspective, using time series data from 2000 to 2024 (including post-pandemic), and robust ARIMAX analysis, highlights the superior relevance of vocational skills over formal education access.

Given skilled labour's role as an income driver, the government should expand vocational training programs, focusing on digital and technical skills for modern industries. Education reform must prioritise competence-based curricula and industry collaboration to reduce labour market mismatch. Despite the initial multicollinearity complicating variable separation, the ARIMAX model addresses this. Limitations include data ending in 2024, which restricts insights into long-term post-pandemic trends, and the education proxy not capturing qualitative aspects. Future research should incorporate quality-based education indicators and extend the time frame, potentially using panel data for regional analysis. In conclusion, skilled labour is key to Indonesia's economic well-being, necessitating formal education reform to align with labour market demands and fostering adaptive skills.

VI. Conclusion

This study establishes that skilled labour significantly drives per capita income growth in Indonesia from 2000 to 2024. The ARIMAX (0,1,0) model shows that a one-million increase in skilled workers is associated with a USD20.51 rise in per capita income (coefficient = 0.0205148, p = 0.000), highlighting its critical role in promoting economic prosperity. By addressing econometric challenges such as diagnostic tests, the ARIMAX model delivers robust estimates, outperforming the invalidated OLS approach. These findings underscore the need for policy reforms to strengthen vocational training, such as Indonesia's Prakerja program, and align secondary education with industry demands, particularly in digital and technical skills vital for the post-COVID-

19 economy. Strategic investments in human capital are crucial to bridge skill gaps and sustain long-term economic growth. Future research should extend the time series beyond 2024 to capture evolving post-pandemic labour trends and incorporate quality-based education metrics, such as vocational competencies and digital literacy, to assess their economic contributions better. Additionally, panel data analysis across Indonesian provinces could provide insights into regional disparities in education and labour market integration, informing targeted and inclusive policy interventions.

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