Avalaible online at http://journals.ums.ac.id, Permalink/DOI: 10.23917/jep.v23i2.18287

Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi dan Pembangunan, 23 (2), 2022, 269-282

How Capital, Labor, and Technology Influence Java's Economic Growth

Sotya Fevriera[1], Sefira Archintia[2], Virgiana Nugransih Siwi[3]
[1,2,3]Faculty of Economics and Business, Universitas Kristen Satya Wacana
Corresponding Author: virgiana.siwi@uksw.edu

Received: 13 May 2022 | Revised: 17 August 2022 | Accepted: 9 December 2022

Abstract

Indonesia is a developing country with a relatively stable economy, as can be seen in Indonesia's real GDP per capita, which tends to increase before the Covid-19 pandemic. However, there is a disparity in economic growth between Java and outside Java. During the 2010-2020 period, Java's economic growth reached 61.9%, while outside Java was only 48.5%. According to the Solow Model theory, three factors can influence economic growth: capital, labor, and technology. Therefore, this study aims to determine the effect of capital, labor, and technology on economic growth in Java. This research was conducted using two approaches, namely generalized least square (GLS) and mixed-effect regression model (MEM). Both methods show the same result that capital and labor have a significant positive effect on the real GRDP of the provinces in Java. In contrast, technology has an insignificant effect on the real GRDP of the provinces in Java. This study also found significant random effects among provinces in Java for the number of workers and capital, but not on technology.

Keywords: Economic Growth, real GDP, Capital, Labor, Technology
JEL classification: O11, O13, O15, O16

How to Cite: Archintia S., Fevriera S., Siwi V. N. (2022). How Capital, Labor, and Technology Influence Java's Economic Growth, 23(2), 269-282. doi:https://doi.org/10.23917/jep.v23i2.18278

DOI: https://doi.org/10.23917/jep.v23i2.18278

1. Introduction

The development of a region can be measured through the economic conditions of that region. When an economy experiences a relatively stable increase, that region can be claimed success in improving the welfare of its population. Indonesia is one of the developing countries with a relatively stable economy. Based on the increase in Indonesia's real Gross Domestic Product (GDP) per capita from 2000 to 2019 after its recovery from the economic crisis in 1998 and before it is being hit by the economic crisis due to the Covid-19 pandemic in the world (World Bank, 2021a).

Economic growth is one of the essential indicators to assess the economic development of a country or a region (Octavianingrum, 2015). At a lower level, such as provinces or districts/ cities, the economic progress is determined through the Gross Regional Domestic Product (GRDP).

Table 1 presents the comparison of the real GDP of Java and outside Java from 2010 to 2020. The real GDP of Java is always higher than that of outside Java even though Java only consists of 6 provinces while outside Java consists of 28 provinces. During this period, the real GDP of Java also grew faster than outside Java. It indicates that there is an inequality growth between Java and outside Java. This study is interested in analyzing factors that affect economic growth in Java.

Table 1. Real GRDP of Java, Outside Java and Indonesia in 2010-2020 (trillion Rp)

Region	Java	Outside Java	Indonesia
2010	3.93	2.93	6.86
2011	4.18	3.10	7.29
2012	4.45	3.29	7.74
2013	4.72	3.46	8.18
2014	4.98	3.63	8.61
2015	4.88	4.10	8.98
2016	5.16	4.28	9.43
2017	5.86	4.06	9.91
2018	6.19	4.23	10.43
2019	6.53	4.42	10.95
2020	6.37	4.36	10.72
Growth	61.9%	48.5%	56.2%

Note: The growth is during 2010-2020

Source: BPS (2021b), data processed

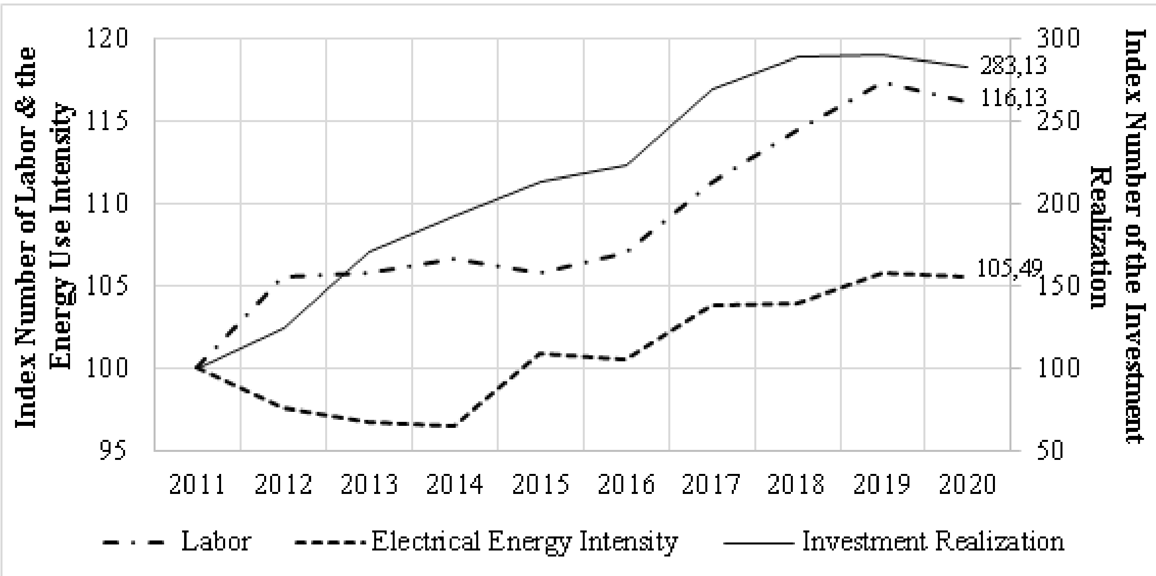

Figure 1. The Index Number of Capital, Labor, and Technology in Java, 2011-2020

Note: (1) capital = investment realization with the Foreign investment (PMA) converted into rupiah using the exchange rate from the World Development Indicator (World Bank, 2021b), (2) technology = the intensity of real GRDP to electricity sold by PLN.

Source: BPS (2021f, 2021g, 2021h, 2021i, 2021j, 2021k); PLN (2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020), data processed.

Various factors can affect the economy of an area. One theory that explains economic growth is the Solow model, which Robert M. Solow introduced. The theory explains that the determinants of economic growth are capital, labor, and technology (Mankiw, 2015). The development of capital (investment realization), labor quantity, and technology (the electrical energy intensity) in Java measured by index numbers have been summarized in Figure 1.

Based on Table 1, during 2011-2020, Java's GRDP increased. However, the trend of the economic growth in Java from 2011-2020 is decreased. During that period, the level of economic growth in Java decreased by 139% because, in 2020, Indonesia was struck by the Covid-19 pandemic, which caused economic growth in 2020 to decline by 2.51% from that of in 2019 (BPS, 2021a).

According to Figure 1, during 2011-2020, capital measured by the realization of foreign investment (PMA) and domestic investmenSt (PMDN) increased by 183.13%. The labor quantity increased by 16.13%. Furthermore, technology that could make economic activities more efficient or effective is measured by the ratio between the electricity use and the real GDP as an indicator to measure the energy use intensity. This method is copied from the data energy intensity available in the World Development Indicator (World Bank, 2021), that is the energy use (kg of oil equivalent) per $1.000 GDP (constant 2017 PPP) or GDP per unit of energy use (constant 2017 PPP $ per kg of equivalent). Assuming that the more advanced technology in an area, the more efficient the energy used in that area, then the amount of the electricity needed to produce 1 IDR of GDP will be less and vice versa, for every 1 GWh of electricity sold by PLN, the energy use is more efficient if the real GDP value in that area is higher (the more output can be produced) in the region. The intensity of the energy use has been used as an indicator of the technological advancement or stated to have a relationship with technology progress in many studies (Aboagye, 2017; Cheng et al., 2021; Deichmann et al., 2018; Díaz et al., 2019; Fiorito, 2013; Huang & Chen, 2020; Lin & Tian, 2017; Lin & Wang, 2021; Mahmood & Ahmad, 2018; Paul et al., 2019; Saudi et al., 2019; Tan & Lin, 2018; Tvaronavičienė & Prakapienė, 2018; Voigt et al., 2014). During 2011-2020, the intensity of electricity usage increased by 5.49%. It indicates that technology in Java becomes more efficient because the increase indicates that the more real GDP is produced for every 1 GWh of electrical energy.

There have been many researches on the determinants of economic growth in Java (Buana et al., 2018; Anwar, 2017; Baroroh, 2012) and for specific provinces in Java, i.e. DKI Jakarta (Yurianto, 2020), West Java (Ayu & Septiani, 2020), Central Java (Soekapdjo et al., 2020; Priambodo, 2015), DI Yogyakarta (Feriyanto, 2019; Octavianingrum, 2015), East Java (Yasin, 2020; Muqorrobin & Soejoto, 2017; Rofii & Ardyan, 2017) and Banten (Nugroho, 2017; Suci & Asmara, 2014) or for several provinces in Java (Novitasari et al., 2020). However, no studies have specifically analyzed economic growth with the Solow theory. Nonetheless, some researchers study several variables mentioned in Solow theory, especially capital (Anwar, 2017; Nugroho, 2017; Octavianingrum, 2015; Soekapdjo et al., 2020; Yasin, 2020; Yurianto, 2020) and labor (Buana et al., 2018; Nugroho, 2017; Octavianingrum, 2015; Priambodo, 2015; Rofii & Ardyan, 2017). To the best of our knowledge, only one study examined the influence of technology on economic growth in Indonesia, particularly in Aceh Province (Wahyuni et al., 2013), none have done it in Java. This study, nevertheless, is different from that of Wahyuni et al. (2013), which used the capital force ratio with the workforce as an indicator for technology, whilst this study used the electrical energy intensity to the GDP as the indicator for technology.

Based on the background described earlier, this study intends to learn whether Solow's growth theory can explain economic growth in Java. The issue that wants to be examined in this paper is whether capital, the number of workers, and technology affect the economic growth of Java. This study aims to determine the influence of capital, labor, and technology on the economic growth of Java. The results of this research are expected to be a useful reading and reference for further study in the same field and to give insights to whoever works as a policymaker or planning development in Indonesia.

2. Research Method

2.1 Research Data

The data used in this study are panel data by provinces in Java and the year 2011-2020 obtained from the Statistics Indonesia (BPS), which consist of GRDP at the constant prices in 2010, the domestic investment, the foreign investment, and the labor quantity (*Lab*) (BPS, 2021f, 2021h, 2021i, 2021j, 2021g, 2021k, 2021l, 2021m), the total electricity sold from the PLN publication series in 2011-2020 (PLN, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020) and the IDR exchange rate against the US dollar from the World Development Indicator which is used to convert the PMA value in the US dollar into the IDR value (World Bank, 2021b). Investment (*Inv*) is the sum of the domestic and foreign investment realization. Energy intensity is calculated from the comparison between electricity sold by PLN and GRDP at a constant price in 2010 following the energy intensity data in the World Development Indicator (World Bank, 2021). The less electrical energy needed to generate GRDP worth Rp. 1, the more efficient energy use. Therefore, it can represent the improvement in technology and is used as an indicator for technology enhancement (*Tec*). Other energy data such as energy for transportation and cooking is not considered in this study because the data at the provincial level is not available. Further, the regional group of PLN operational units is not the same as provinces in Java. Tangerang's electricity sales data, part of Banten Province, is the same group as DKI Jakarta province. Thus, to ensure that the data grouping of PLN is the same as that of BPS, data from Banten Province is combined with the data from DKI Jakarta.

2.2 Analysis Technique

First, using the Levin, Lin, and Chu stationary test, we ensure that all data are stationer (see Table 2). Second, we identify the best model by conducting the Chow Test, the Hausman test, and the Breusch and Pagan LM test. The probability value of the chow test, 0.0000, is smaller than α (the significance test) = 0.01 (see Table 3). Therefore, the FEM (Fixed Effect Model) is more appropriate than the Pooled Regression model.

The probability value of the Hausman test, 0.9200, is greater than α = 0.10 (see Table 4). Thus, the REM (Random Effect Model) is a better model than the FEM. The probability value of the Breausch and Pagan LM, 0.0000, is smaller than α = 1% (see Table 5). Hence, the REM should be chosen over the Pooled Regression model. It can be concluded that REM is the best model.

Table 2. Levin, Lin, and Chu Stationary Test Results

Variable	*Adjusted t**	*Prob*	
LnGDRP	-2.7762	0.0027	***
Lab	-3.3250	0.0004	***
Inv	-4.2097	0.0000	***
Tec	-3.1084	0.0009	***

Note: (1) *Ln = natural logarithm*, (2) *** the test is significance at α = 1%

Table 3. Chow Test

Fixed-effects (within) regression		Number of obs	= 50
Group variable: Province		Number of groups	= 5
R^2		Obs per group:	
within	= 0.7321	min	10
between	= 0.7204	avg	10.0
overall	= 0.7172	max	10
		F(3,42)	= 38.27
corr(u_i, Xb)	= 0.4796	Prob > F	= 0.0000

	Coefficient	St. Error	t	p-value	
Lab	8.03E-08	1.90E-08	4.24	0.000	***
Inv	3.06E-06	6.91E-07	4.43	0.000	***
Tec	−0.0042	0.0087	−0.48	0.631	
Constant	12.3793	0.3943	31.39	0.000	***
σ_v	0.7514				
σ_ε	0.0818				
ρ	0.9883 (fraction of variance due to u_i)				
F test that all $u_i = 0$:		F(4,42)	= 276.56		
		Prob > F	= 0.0000		

Note: (1) Dependent variable = *LnGDRP* with Ln = natural logarithm, (2) e = the overall error model. u = the error within-group (3) *** means the test is significance at α = 1%.

Table 4. Hausman Test

	Coefficient (b) FEM	(B) REM	(b-B) Difference	S.E.
Lab	8.03E-08	9.30E-08	−1.27E-08	1.70E-08
Inv	3.06E-06	3.12E-06	−5.56E-08	4.20E-07
Tec	−0.0042	−0.0032	−0.0010	0.0041

b = *consistent under Ho and Ha*

B = *inconsistent under Ha*

Test: *Ho*: *difference in coefficients not systematic*

$chi^2(2) = (b - B)'[(V_b-V_B)^{-1}](b - B)$

$= 0.17$

$Prob > chi^2 = 0.9200$

The probability value of the Hausman test, 0.9200, is greater than α = 0.10 (see Table 4). Thus, the REM (Random Effect Model) is a better model than the FEM. The probability value of the Breausch and Pagan LM, 0.0000, is smaller than α = 1% (see Table 5). Hence, the REM should be chosen over the Pooled Regression model. It can be concluded that REM is the best model.

Table 5. Breusch and Pagan LM Test

	Var	*sd =*
LnPDRB	1.2754	1.1293
e	0.0067	0.0818
u	0.0721	0.2686

Test: *Var*(*u*) = 0

$chibar^2(01) = 21.63$

$Prob > chibar^2 = 0.0000^{***}$

Note: (1) sd = standard deviation dan Var = variance, (2) Dependent variable = *LnGDRP* with Ln = natural logarithm, (3) e = the overall error. u = the error within group (4) *** means the test is significance at α = 1%.

The formula of the REM is stated in equation (1).

$$LnGDRP_{ij} = (b_0 + u_{0i}) + (b_1 + u_{1i}).Inv_{ij} + (b_2 + u_{2i}).Lab_{ij} + (b_3 + u_{3i}).Tec_{ij} + \varepsilon_{ij} \quad (1)$$

where: i = index for province in Java, j = index for years = {2011, ..., 2020}, *GDRP* = GDRP at constant price (in billion IDR), *Inv* = PMDN + PMA (in billion IDR), *Lab* = labor quantity = number of labor force that works (in people), *Tec* = electrical energy intensity = the real GRDP per total electricity consumption (billion IDR/GWh) = indicator of technological advances, b_0 = constant of the model, u_{0i} = variations of constants of province i, b_k = fixed regression coefficient of variables k, u_K = variation of regression coefficients of variables k with k = {1,2,3}, and ε = error model.

The model (1) is then estimated using two approaches, i.e. the Generalized Least Square (GLS) and the Mixed Effect Regression Model (MEM), estimated by the Maximum Likelihood (ML) method. Later, we can estimate the random effect of provinces in the study using the MEM. Moreover, the model with the GLS approach is estimated using the Driscoll-Kraays standard error to overcome the problem of cross-sectional dependence. The MEM is estimated using the robust standard error to ensure the fulfillment of the homoscedasticity assumption.

Before the estimation results are interpreted, we ensure that both models fulfill the rest of the assumptions. The overall error (e) of both models is normally distributed because the probability value of the normality test is greater than α = 1% (see Table 6).

The models also do not have a multicollinearity problem (strong relationship between two independent variables) because the correlation coefficient among the independent variables is smaller than 0.9 (Gujarati, 2015) (see Table 7).

Table 6. Normality Test

REM – GLS						
Tests for skewness and kurtosis				Number of obs = 50		
				Replications = 50		
(Replications based on 5 clusters in Province)						
	Observed Coef.	*Bootstrap* Std. Err.	z	P > |z|	Normal-based [*95% Conf. Interval*]	
$Skewness_e$	−9.48E−05	4.60E-05	−2.06	0.039	−0.0001849	−4.64E−06
$Kurtosis_e$	1.48E-05	2.69E-05	0.55	0.582	−3.80E−05	6.76E-05
$Skewness_u$	0.1253	1.38E-01	0.91	0.365	−1.46E−01	3.96E-01
$Kurtosis_u$	−0.0869	3.41E-01	−0.25	0.799	−7.55E−01	5.81E-01
Joint test for Normality on e:			$chi^2(2)$	4.55	*Prob* > chi^2	0.1028
Joint test for Normality on u:			$chi^2(2)$	0.89	*Prob* > chi^2	0.6419
MEM – ML						
Tests for skewness and kurtosis				Number of obs = 50		
				Replications = 50		
(Replications based on 5 clusters in Province)						
	Observed Coef.	*Bootstrap* Std. Err.	z	**P** > |z|	Normal-based [*95% Conf. Interval*]	
$Skewness_e$	−4.22E−06	5.72E-06	−0.74	0.461	−0.0000154	6.99E-06
$Kurtosis_e$	2.62E-08	8.79E-07	0.03	0.976	−1.70E−06	1.75E-06
$Skewness_u$	5.86E-08	2.43E-09	24.09	0.000	5,38E-08	6.34E-08
$Kurtosis_u$	1.12E-07	1.66E-09	67.55	0.000	1.09E-07	1.15E-07
Joint test for Normality on e:			$chi^2(2)$	0.54	Prob > chi^2	0.7615
Joint test for Normality on u:			$chi^2(2)$	5142.9	Prob > chi^2	0.0000

Note: e = the overall error and u = the error within group

Table 7. Multicollinearity Test

Correlation Matrix of Coefficients of REM-GLS				
e(V)	***Inv***	***Lab***	***Tec***	**Constant**
Inv	1.0000			
Lab	−0.8826	1.0000		
Tec	0.6308	−0.8941	1.0000	
Constant	−0.0437	0.4396	−0.7756	1.0000
Correlation Matrix of Coefficients of MEM-ML				
e(V)	***Inv***	***Lab***	***Tec***	**Constant**
Inv	1,0000			
Lab	−0,1682	1,0000		
Tec	0,1025	−0,6131	1,0000	
Constant	−0,1611	−0,5665	−0,2198	1,0000

3. Results And Discussion

3.1 Results

Table 8 displays the estimation of the model (1) using the REM-GLS method with Driscoll-Kraays standard error and using the MEM-ML method with the robust standard error. Based on Table 8, capital (investment), labor quantity, and technology significantly affect GRDP. It can be proved from the probability of the Wald Chi^2 test, 0.0000, which is smaller than α = 0.01 (both for REM-GLS and MEM-ML). The R^2 value of the REM-GLS is 0.7052, while the R^2 value of MEM-ML indicated by R^2 Bryk/Raudenbush is 0.7318 (level 1). Thus, capital (investment), labor quantity, and technology can explain the real GRDP of around 71−73%, and other variables outside the research model explain the rest. According to level 2 of R^2 Bryk/Raudenbush or within the provincial group, capital (investment), labor quantity, and technology can only explain the real GRDP of about 64%.

Table 8. The Regression Model Estimation

REM-GLS				
Regression with Driscoll-Kraay standard errors		Number of obs		= 50
Method: Random-effects GLS regression		Number of groups		= 5
Group variable (i): Province		Wald $chi^2(3)$		= 1872.40
maximum lag: 2		Prob > chi2		= 0.0000***
corr(u_i, Xb) = 0 (assumed)		overall R^2		0.7052
Independent Variables	**Coefficient**	**Driscoll-Kraays St. Error**	**t**	***Prob***(2)
Inv	3.12E-06	4.33E-07	7.20	0.000 ***
Lab	9.30E-08	2.41E-08	3.86	0.002 ***
Tec	−0.0032	0.0178	−0.18	0.430
Constant	12.1680	0.2673	45.52	0.000 ***
σ_u 0.2686				
σ_e 0.0818				
ρ 0.9151	(fraction of variance due to u_i)			

MEM-ML

Mixed-effects regression	Number of obs = 50
Group variable: Province	Number of groups = 5
	Obs per group:
	min = 10
	avg = 10.0
	max = 10
	Wald chi2(3) = 30.41
Log pseudolikelihood = 49.752398	Prob > chi^2 = 0.0000
	(Std. Err. adjusted for 5 clusters in Prov)

Independent Variables	Coefficient	St. Error	z	*Prob*$^{(2)}$	
Inv	2.80E-06	5.85E-07	4.78	0.000	***
Lab	2.71E-07	1.74E-07	1.55	0.060	*
Tec	0.0014	0.0131	0.11	0.456	
Constant	11.5642	0.6014	19.23	0.000	***

Random Effect	Coefficient	St. Error	Confidence Interval 95%	
var (*Inv*)	2,.77E-13	6.63E-13	2.54E-15	3.01E-11
var(*Lab*)	1.11E-13	9.96E-14	1.91E-14	6.44E-13
var (*Tec*)	4.667E-04	1.903E-04	0.0002	0.0010
var (Constant)	1.1626	0.3610	0.6327	2.1366
var (Residual)	0.0016	5.058E-04	9.043E-04	0.0030

Note: (1) Dependent variable = *LnGDRP,* (2) probability value is for one-sided test, (3) * and *** consecutively means the tests are significance at α = 10% and 1%.

Both models produce similar estimation results. Variables that have significance and insignificant effects are the same in both variables. The signs of the regression coefficient are also the same for capital (investment) and labor quantity. Although the regression coefficient sign of technology is different for both models, the effect of technology is insignificant in both models.

3.2 Discussion

Both models show that capital (foreign and domestic investment) (*Inv*) has a significant positive effect on the real GRDP of provinces in Java. It can be proven by the probability value of the t-test of investment in both models, i.e., 0.000, which is smaller than α = 0.01. This result is in line with research by Yurianto (2020), Anwar (2017), and Octavianingrum (2015), who found that capital has a significant positive effect on economic growth, despite that they used different indicators.

The regression coefficient of investment in both models is around 3.0E-06. When the number of capital increases by 1 billion IDR, the real GRDP of the provinces in Java will increase by 0.0003%. It can also be said that when capital increases by 10 trillion IDR, then the real GRDP of provinces in Java will increase by 3%. This indicates that investment is an important aspect of economic activity in Java. More than 50% of Indonesia's GRDP is currently dominated by the Java region (BPS, 2021b). The high economic growth is an important factor in attracting domestic and foreign investors. Table 1 clearly describes that the economic growth of Java is higher than that outside of Java. Therefore, around 80% of Indonesia's medium and large processing industries are located in Java (BPS, 2021d). Of course, it is accompanied by the government efforts such as the ease of the licensing system and the availability accessing of facilities and infrastructure that make it easier for foreign and domestic investors to reach areas in Java. Those things may enhance investment in Java which has a positive impact on the Java economy because when the capital inflows in Java keep increasing, then the economic activity in Java is getting stronger.

Both models also show that the labor quantity (*Lab*) has a significant positive effect on the real GRDP of provinces in Java. The evidence can be seen from the probability value of the t-test of labor quantity, viz. 0.002 (REM-GLS), which is smaller than α = 0.01 and 0.06 (MEM-ML) which is smaller than α = 0.1. This outcome is in line with the research result of Buana et al. (2018), Priambodo (2015), and Rofii & Ardyan (2017). They found that labor has a significant positive effect on the economic growth.

The regression coefficient of labor quantity in the REM-GLS method is 9.30E-08 (REM-GLS) and in the MEM-ML method is 2.71E-07. Hence, it can be interpreted that if the number of workers increases by one person, then the real GRDP of provinces in Java will increase by 0.000009%–0.000027% when the number of workers increases by 1 million people or the real GRDP of provinces in Java will increase by 9%–27%. Human resource is an essential factor in production activities because when labor productivity is high, the production output increases. It indicates the high level of labor productivity in Java. Labor absorption in Indonesia tends to be centered in Java. Of Indonesia's total working labor force, around 57.5% are in Java (BPS, 2021c). It is supported by the growth of the number of industries in Java which must have increased the number of available jobs (BPS, 2021d).

Furthermore, both models show that technological progress (*Tec*) has no significant effect on the real GRDP of provinces in Java. It can be proved by the probability value of technology about 0.4, greater than α = 0.1. This finding does not support the research conducted by Saudi et al. (2019), Wahyuni et al. (2013), Diaz et al. (2019), Aboagye (2017), Deichmann et al. (2018), Shahbaz et al. (2016), and Mahmood and Ahmad (2018).

This result indicates that technological developments in Java have not significantly affected the economy. Several things might be the reason why the impact of technology is insignificant. First, most industries in Indonesia are labor-intensive industries that tend to use human labor because the government hopes there will be more job opportunities so that human capabilities play a more critical role in increasing output than physical capital such as machines or robots. Of the 17 main employment fields in Indonesia, the working labor force in the manufacturing sector is in the third rank, which is around 16,694,463 or 14% of the total number of working labor force in 17 sectors (BPS, 2021e).

Second, the low capacity of human resources is related to technology understanding. The human resource's ability is closely related to their level of education. In 2019, UNDP (2020) noted that out of 189 countries in the world, Indonesia's average length of schooling (13.6 years) was 91st place. It may affect the decision of entrepreneurs to adopt technology because when the adopted technology is not used correctly, it could cause losses.

Third, the limited financial condition often experienced by entrepreneurs can become an obstacle to improving production technology. Adopting technology in the production process requires quite a lot of money. Hence, entrepreneurs with a limited budget tend not to increase their production technology by using more machines or robots and choosing to utilize humans relatively much cheaper. It is also supported by labor quantity, which has a significant positive effect on GRDP in this study.

In this study, the selected model is a random effect model, so it is necessary to identify the random effect of the regression coefficient among provinces. Table 9 presents the random effects of the constant and the regression coefficient of capital, labor, and technology for each province.

Table 9 The Random Effect of the Provinces in Java

Province	Constant	R	Labor	R	Investment	R	Technology
Special Capital Region of Jakarta and Banten	12,559	1	0,003	3	0,00000230	5	0,0014
West Java	12,557	2	0,010	2	0,00000283	4	0,0014
Central Java	11,908	3	−0,012	4	0,00000303	1	0,0014
Special Region of Yogya-karta	10,362	5	−0,027	5	0,00000284	3	0,0014
East Java Timur	10,435	4	0,027	1	0,00000294	2	0,0014

Note: R = rank

In Table 9, the provinces that have the highest constant values are DKI Jakarta and Banten, while the lowest is DI Yogyakarta. In this model, the constant represents the real GRDP value which is not influenced by capital, labor, and technology but by other factors outside of the model such as population, local government's original revenue (PAD), Human Development Index (HDI), culture, and so on. The local government's original revenue is an important factor in a region's economy because the local government can use it to implement its policies or programs to increase the region's GRDP. Priambodo (2015) explains that local government original revenue has a significant positive effect on the economic growth in Java. Based on Kemenkeu (2021) data, DKI Jakarta and Banten are provinces with the highest local government original revenue, around 48% of Java's total local government original revenue. The next rank is West Java (19%), East Java (18%), Central Java (13%), and DI Yogyakarta (2%). The local government's original revenue might be one factor that affects the difference among provinces in Java in the contribution of the constant to real GRDP.

Based on the labor coefficient in Table 9, two provinces have negative coefficient values, i.e., Central Java and DI Yogyakarta, out of the five provinces in Java. In those provinces, labor has a negative effect on the real GRDP, which reflects a diminishing marginal product. According to the diminishing marginal product theory, an excessive increase in labor quantity can decrease productivity (Mankiw, 2021). Hence, an increase in labor quantity does not constantly improve the economy. Several things might cause this. One of them is the age factor. When labor is getting older, his productivity level will decrease so that the amount of output produced is not proportional to the expenditure for labor. According to Kurniawati and Sugiyanto (2021), the middle-aged workforce (50-60+ years) has a significant negative effect on economic growth. According to BPS, of those provinces in Java, three provinces have more than 30% of the middle-aged workforce, viz., Central Java, DI Yogyakarta, and East Java (BPS, 2021f, 2021g, 2021h, 2021i, 2021j, 2021k). This may explain the labor regression coefficient of Central Java and DI Yogyakarta, which has a negative effect.

In addition to the age factor, the living cost factor may also explain the variety of the labor regression coefficient. When the cost of living in an area is relatively high, it can encourage laborers to increase their productivity to meet their daily needs. According to BPS (2018), the three provinces in Java with the lowest living cost are Central Java, West Java, and DI Yogyakarta. The living cost of Semarang, IDR 3,287,159, can be a representative of that of Central Java; the living cost of Bandung, IDR 2.845.620, can be a representative of that of West Java; and the living cost of Yogyakarta, IDR 2,727,964, can be a representative for that of DI Yogyakarta. Among those three provinces, the number of productive age workers in West Java is relatively high. Thus, although the cost of living in West Java is relatively low, its high productivity level may cause its labor regression coefficient to affect the real GDP positively.

Table 9 also shows that the province whose investment has the most significant effect on real GDP is Central Java, i.e., 3,03E-06. The province whose investment has the lowest impact on real GDP is DKI Jakarta and Banten, i.e., 2,36E-06. During 2011-2020, DKI Jakarta and Banten are the provinces with the highest total investment of IDR 121.671,85 billion, or about 39% of the total investment in Java, while the investment of Central Java is only IDR 334,011.91 billion or around 10.7% of total investment in Java (BPS, 2021l, 2021m). Thus, the province with a bigger investment realization tends to have a smaller investment effect on the real GDP. On the other hand, the province with a lower investment realization tends to have a greater investment effect on the real GDP. In economic theory, this condition may describe a steady-state economy. A steady-state economy is a theory that says that an economy will eventually achieve a stable economic growth if there is no change in technological progress so that when there is additional capital in a high economic area, the impact on economic growth is smaller than in a lower economic area (Dornbusch et al., 2011). According to BPS (2021b), the total real GRDP value for DKI Jakarta and Banten during 2011-2020, IDR 18,813,761.5, is the highest compared to the other provinces. Meanwhile, the total real GRDP of Central Java during 2011-2020, is relatively low, that is IDR 8,287,473.61. Hence, due to the economics of DKI Jakarta and Banten being already high, then although the investment realization in DKI Jakarta and Banten is the highest, the effect is the lowest compared to the other provinces. On the other hand, because the economics of Central Java is relatively low, then the low investment realization, its impact on the economy is very high.

Last, in contrast to the labor and investment, technology has the same regression coefficient for each province, i.e., 0.0014, because it has no significant impact on the real GRDP.

4. Conclusions

This study aims to analyze the effect of variables in the Solow growth theory, viz. a viz. capital, labor, and technology, on the economic growth in Java. This study finds that capital has a significant positive effect on real GRDP. Hence, the higher the availability of capital, the greater the real GRDP. This study also finds that labor has a significant positive effect on real GRDP. Thus, when the labor quantity increases, then the real GRDP increases. Another finding of this study is that technology has no significant effect on the real GRDP.

Further, this study also finds that the random effects of the constants and the regression coefficients of investment and labor are significant, but the random effect of technology is insignificant. Several things that might cause technology not to have a significant effect are the characteristic of a labor-intensive industry, the low capacity of human resources, and the limited budget to develop production technology in terms of physical capital such as machines and robots.

Moreover, the difference in the constant among provinces might be because of differences in the province's original revenue, while the variation in the labor regression coefficient among provinces maybe because of the labor age and the living cost. Last, diversity in the investment regression coefficient among provinces could be because of the steady-state economy theory.

The limitation of this research is that the energy data used to measure the technology is only the electrical energy. Therefore, if it is available, indicators from other energy can be added for further research.

5. References

Aboagye, S. (2017). The Policy Implications of The Relationship Between Energy Consumption, Energy Intensity and Economic Growth in Ghana. *OPEC Energy Review*, *41*(4), 344–363. https://doi.org/10.1111/opec.12114

Anwar, A. (2017). Peran Modal Manusia Terhadap Pertumbuhan Ekonomi Regional Di Jawa. *Economia*, *13*(1).

Ayu, P. P., & Septiani, T. (2020). Determination of the Economic Growth of the City and Districts of West Java Province. *Advances in Economics, Business and Management Research*, *123*(Icamer 2019), 123–125.

Baroroh, U. (2012). Analisis Sektor Keuangan Terhadap Pertumbuhan Ekonomi Regional Di Wilayah Jawa: Pendekatan Model Levine. *Etikonomi*, *11*(2), 180–195. https://doi.org/10.15408/etk.v11i2.1892

BPS. (2018). *Survey Biaya Hidup*. Badan Pusat Statistik.

BPS. (2021a). *[Seri 2010] Laju Pertumbuhan PDRB Atas Dasar Harga Konstan (Persen)*. Badan Pusat Statistik.

BPS. (2021b). *[Seri 2010] PDRB Atas Dasar Harga Konstan (Miliyar Rupiah)*.

BPS. (2021c). *Jumlah Angkatan Kerja Yang Bekerja (Juta Jiwa)*. Badan Pusat Statistik.

BPS. (2021d). *Jumlah Industri Pengolahan Besar dan Sedang, Jawa dan Luar Jawa*. Badan Pusat Statistik.

BPS. (2021e). *Jumlah Tenaga Kerja Menurut Lapangan Pekerjaan Utama*. Badan Pusat Statistik.

BPS. (2021f). *Jumlah Tenaga Kerja Menurut Usia Provinsi Banten*. Badan Pusat Statistik.

BPS. (2021g). *Jumlah Tenaga Kerja Menurut Usia Provinsi DI Yogyakarta*. Badan Pusat Statistik.

BPS. (2021h). *Jumlah Tenaga Kerja Menurut Usia Provinsi DKI Jakarta*. Badan Pusat Statistik.

BPS. (2021i). *Jumlah Tenaga Kerja Menurut Usia Provinsi Jawa Barat*. Badan Pusat Statistik.

BPS. (2021j). *Jumlah Tenaga Kerja Menurut Usia Provinsi Jawa Tengah*. Badan Pusat Statistik.

BPS. (2021k). *Jumlah Tenaga Kerja Menurut Usia Provinsi Jawa Timur*. Badan Pusat Statistik.

BPS. (2021l). *Realisasi Investasi Penanaman Modal Dalam Negeri (Milyar Rp)*. Badan Pusat Statistik.

BPS. (2021m). *Realisasi Investasi Penanaman Modal Luar Negeri (Juta US$)*. Badan Pusat Statistik.

Buana, A. L., Saragih, H. J. R., & Aritonang, S. (2018). Pengaruh Pengeluaran Pemerintah, Investasi Pemerintah, Investasi Swasta Dan Tenaga Kerja Terhadap Pertumbuhan Ekonomi Di Pulau Jawa Tahun 2011-2015. *Jurnal Ekonomi Pertahanan*, *4*(2), 1–20.

Cheng, M., Yang, S., & Wen, Z. (2021). The Effect of Technological Factors on Industrial Energy Intensity in China: New Evidence from The Technological Diversification. *Sustainable Production and Consumption*, *28*(October), 775–785. https://doi.org/10.1016/j.spc.2021.06.032

Deichmann, U., Reuter, A., Vollmer, S., & Zhang, F. (2018). *Relationship between Energy Intensity and Economic Growth, New Evidence from a Multi Country Multi Sector Data Set* (No. 8322; Policy Research Working Paper). https://openknowledge.worldbank.org/bitstream/handle/10986/29288/WPS8322.pdf;sequence=5

Díaz, A., Marrero, G. A., Puch, L. A., & Rodríguez, J. (2019). Economic Growth, Energy Intensity and The Energy Mix. *Energy Economics*, *81*, 1056–1077. https://doi.org/10.1016/j.eneco.2019.05.022

Dornbusch, R., Fischer, S., & Startz, R. (2011). *Macroeconomics* (Eleventh E). McGraw-Hill.

Feriyanto, N. (2019). The Effect of The Quality of Human Development Factors on The Rate of Economic Growth in Yogyakarta Special Province. *International Journal for Quality Research*, *13*(1), 157–176. https://doi.org/10.24874/IJQR13.01-10

Fiorito, G. (2013). Can We Use the Energy Intensity Indicator to Study "Decoupling" in Modern Economies? *Journal of Cleaner Production*, *47*(May), 465–473. https://doi.org/10.1016/j.jclepro.2012.12.031

Gujarati, D. (2015). *Econometrics by Example* (Second). PALGRAVE.

Huang, J., & Chen, X. (2020). Domestic R&D Activities, Technology Absorption

Ability, and Energy Intensity in China. *Energy Policy*, *138*(March). https://doi.org/10.1016/j.enpol.2019.111184

Kemenkeu. (2021). *Realisasi PAD di 34 Provinsi di Indonesia*. Direktorat Jenderal Perimbangan Keuangan. https://djpk.kemenkeu.go.id/?p=20813

Kurniawati, E., & Sugiyanto, C. (2021). Pengaruh Struktur Umur Penduduk terhadap Pertumbuhan Ekonomi di Indonesia. *Jurnal Ekonomi Dan Pembangunan Indonesia*, *21*(1), 41–58.

Lin, B., & Tian, P. (2017). Energy Conservation in China's Light Industry Sector: Evidence from Inter-Factor and Inter-Fuel Substitution. *Journal of Cleaner Production*, *152*(May), 125–133. https://doi.org/10.1016/j.jclepro.2017.03.099

Lin, B., & Wang, M. (2021). What Drives Energy Intensity Fall in China? Evidence from a Meta-Frontier Approach. *Applied Energy*, *281*(January). https://doi.org/10.1016/j.apenergy.2020.116034

Mahmood, T., & Ahmad, E. (2018). The Relationship of Energy Intensity with Economic Growth : Evidence for European Economies. *Energy Strategy Reviews*, *20*, 90–98. https://doi.org/10.1016/j.esr.2018.02.002

Mankiw, N. G. (2015). *Macroeconomics* (Ninth Edit). Worth Publishers.

Mankiw, N. G. (2021). *Principles of Economics* (Issue February).

Muqorrobin, M., & Soejoto, A. (2017). Pengaruh Indeks Pembangunan Manusia (IPM) Terhadap Pertumbuhan Ekonomi Provinsi Jawa Timur. *Jurnal Pendidikan Ekonomi (JUPE)*, *5*(3).

Novitasari, F., Drestalita, N. C., & Maryati, S. (2020). The Impacts of Infrastructure Development on Economic Growth (Case Study: DKI Jakarta, Banten Province and West Java Province). *IOP Conference Series: Earth and Environmental Science*, *592*(1). https://doi.org/10.1088/1755-1315/592/1/012017

Nugroho, R. E. (2017). Analisis Faktor-Faktor yang Mempengaruhi Pertumbuhan Ekonomi di Propinsi Banten. *JIEMS (Journal of Industrial Engineering and Management Systems)*, *10*(1), 46–56.

Octavianingrum, D. (2015). Analisis Pengaruh Investasi, Tenaga Kerja, Dan Tingkat Pendidikan Terhadap Pertumbuhan Ekonomi. In *Skripsi Fakultas Ekonomi Universitas Negeri Yogyakarta*.

Paul, R., Kenway, S., & Mukheibir, P. (2019). How Scale and Technology Influence the Energy Intensity of Water Recycling Systems- An Analytical Review. *Journal of Cleaner Production*, *215*(April), 1457–1480. https://doi.org/10.1016/j.jclepro.2018.12.148

PLN. (2011). *PLN Statistics 2011*. PT PLN (PERSERO).

PLN. (2012). *PLN Statistics 2012*. PT PLN (PERSERO).

PLN. (2013). *PLN Statistics 2013*. PT PLN (PERSERO).

PLN. (2014). *Statistik PLN 2014*. PT PLN (PERSERO).

PLN. (2015). *PLN Statistics 2015*. PT PLN (PERSERO).

PLN. (2016). *Statistik PLN 2016*. PT PLN (PERSERO).

PLN. (2017). *Satistik PLN 2017*. PT PLN (PERSERO).

PLN. (2018). *Statistik PLN 2018* (Vol. 53, Issue 9). PT PLN (PERSERO).

PLN. (2019). *PLN Statistics 2019* (Vol. 1). PT PLN (PERSERO).

PLN. (2020). *Statistik PLN 2020*. PT PLN (PERSERO).

Priambodo, A. (2015). Analisis Pengaruh Pendapatan Asli Daerah, Belanja Modal, Tenaga Kerja Terhadap Pertumbuhan Ekonomi. *Economics Development Analysis Journal*, *4*(1), 1–9. https://doi.org/10.15294/edaj.v4i1.14795

Rofii, A. M., & Ardyan, P. S. (2017). Analisis Pengaruh Inflasi, Penanaman Modal Asing (PMA) Dan Tenaga Kerja Terhadap Pertumbuhan Ekonomi Di Jawa Timur. *Jurnal Ekonomi & Bisnis*, *2*(1), 303–316.

Saudi, M. H. M., Sinaga, O., Roespinoedji, D., & Ghani, E. K. (2019). The Impact of Technological Innovation on Energy Intensity: Evidence from Indonesia. *International Journal of Energy Economics and Policy*, *9*(3), 11–17. https://doi.org/10.32479/ijeep.7731

Shahbaz, M., Jam, F. A., Bibi, S., & Loganathan, N. (2016). Multivariate Granger Causality between CO2 Emissions, Energy Intensity and Economic Growth in Portugal: Evidence from Cointegration and Causality Analysis. *Technological and Economic Development of Economy*, *22*(1), 47–74. https://doi.org/10.3846/20294913.2014.989932

Soekapdjo, S., Tribudhi, D. A., Hariyanti, D., & Nugroho, L. (2020). Factors Affecting Economic Growth in Central Java. *International Journal of Commerce and Finance*, *6*(1), 155–165.

Suci, S. C., & Asmara, A. (2014). Pengaruh Kemandirian Keuangan Daerah Terhadap Pertumbuhan Ekonomi Kabupaten/Kota Provinsi Banten. *Jurnal Ekonomi Dan Kebijakan Pembangunan*, *3*(1), 8–22.

Tan, R., & Lin, B. (2018). What Factors Lead to the Decline of Energy Intensity in China's Energy Intensive Industries? *Energy Economics*, *71*(March), 213–221. https://doi.org/10.1016/j.eneco.2018.02.019

Tvaronavičienė, M., & Prakapienė, D. (2018). Energy Efficiency in The Long Run in The Selected European Countries. *Interdiciplinary Approach to Economics and Sociology*, *11*(1), 245–254. https://doi.org/10.14254/2071- 789X.2018/11-1/16

UNDP. (2020). *Latest Human Development Index Ranking*. United Nations Development Programme. http://hdr.undp.org/en/content/latest-human-development-index-ranking

Voigt, S., De Cian, E., Schymura, M., & Verdolini, E. (2014). Energy Intensity Developments in 40 Major Economies: Structural Change or Technology Improvement? *Energy Economics*, *41*, 47–62.

Wahyuni, S., Hamzah, A., & Syahnur, S. (2013). Analisis Pengaruh Teknologi terhadap Pertumbuhan Ekonomi Provinsi Aceh (Ak Model). *Jurnal Ilmu Ekonomi*, *1*(3), 71–79. https://jurnal.unsyiah.ac.id/MIE/article/view/4536

World Bank. (2021a). *GDP per Capita Indonesia (Constant LCU).* World Development Indicator.

World Bank. (2021b). *Official Exchange Rate (LCU per US$).* World Development Indicator.

Yasin, M. (2020). Analisis Pendapatan Asli Daerah dan Belanja Pembangunan terhadap Pertumbuhan Ekonomi Di Kabupaten/Kota Jawa Timur. *Journal of Economic, Business and Accounting*, *53*(9), 1689–1699.

Yurianto. (2020). Pengaruh Belanja Daerah Investasi dan Kurs Terhadap Pertumbuhan Ekonomi DKI Jakarta Periode 1987-2017. *Sosio E-Kons*, *12*(1), 31–43.