Article Type: Research Paper

Infrastructure, Gross Regional Domestic Product, and Convergence of Human Development Index

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THIS ARTICLE IS AVALILABLE IN:
http://journal.umy.ac.id/index.php/esp

DOI: 10.18196/jesp.v22i2.7619

CITATION:
Susanto, J. (2021). Infrastructure, Gross Regional Domestic Product, and Convergence of Human Development Index. *Jurnal Ekonomi & Studi Pembangunan, 22*(2), 244-255.

ARTICLE HISTORY
Received:
29 Nov 2019
Revised:
11 Aug 2021
17 Sep 2021
Accepted:
20 Sep 2021

Abstract: Due to a disparity in Human Development Index (HDI) among regencies and cities in Special Region of Yogyakarta, this study aimed to examine whether HDI convergence occurred in this province. The data were sourced from the Statistics of Special Region of Yogyakarta, including HDI, infrastructure, and gross regional domestic product in four regencies and one city from 2001 to 2019. The infrastructure consists of installed electricity, education, and health facilities. The results showed an absence of HDI convergence between regions in the Special Region of Yogyakarta. Furthermore, HDI growth in the impoverished region was slower than in leading ones, resulting in a gap. The infrastructure gap made the impoverished region unable to catch up with leading ones, causing an HDI divergence. In contrast, Gross Regional Domestic Product (GRDP) has no impact on HDI. Therefore, the government needs to improve infrastructure in disadvantaged areas to increase HDI.

Keywords: Human Development Index; Convergence; Infrastructure
JEL Classification: J08; O21; R11

Introduction

Convergence discussions are increasingly attractive because many developing countries worsen, while some states experience high economic growth (Islam, 2003). Emerging countries struggle with income disparity, yet economic development that focuses on macroeconomic growth overlooks the huge regional disparities (Postoiu & Bușega, 2015). Consequently, income inequality emerges due to disparities in resource ownership. One contributing factor to economic growth is resources, which are acquired and used easily when sufficiently distributed in a region.

The Neo-Classical Growth theory states that the income disparity between regions declines with economic development. This means that a poor area's growth is faster than that of a wealthy location (Barro & Sala-i-Martin, 2004). The poorer regions could catch up to the richer regions' per capita income, resulting in income convergence and steady-state conditions when the returns to scale are constant. Regional economic growth differences due to technological diversity diminish due to the free movement of capital and labor between areas.

Inter-regional inequality covers income (Gyawali et al., 2008; Hammond, 2006), labor productivity (Cette et al., 2018; Pouvelle & Mitra, 2012; Udjianto et al., 2018), and HDI imbalance (Erdal et al., 2006; Singh & Sharma, 2017). Hammond (2006) stated that the medium-sized metropolitan regions tend to converge, while non-metropolitan areas diverge. In line with this, Gyawali et al. (2008) analyzed income convergence for rural and suburban areas. The result showed that the rapid growth of the rural and poor sub-urban areas makes poor regions catch up with the rich ones.

A previous study in Bulgaria found that labor productivity has increased and converged with the European Union (Pouvelle & Mitra, 2012). Similarly, according to Cette et al. (2018), the productivity gap between businesses has shrunk, indicating a convergence. Udjianto et al. (2018) found a propensity for labor productivity convergence among districts in Gunungkidul Regency. Specifically, labor productivity in disadvantaged areas rises faster than in wealthy areas. As a result, this reduced the disparity in labor productivity between districts. Moreover, Erdal et al. (2006) showed a convergence trend in education and per capita income, the two factors influencing the human development index (HDI). Therefore, convergence in education and per capita income leads to convergence in HDI.

The HDI is a summary measure of average accomplishment in human development, such as a long, healthy, and decent life and being knowledgeable. Life expectancy at birth is used to calculate the health dimension. Similarly, the knowledge dimension is measured through indicators of average school length and duration. The expenditure dimension (decent living standard) is shown by per capita expenditure, while higher HDI reflects improved welfare as a development indicator. Therefore, the HDI is increased by improving these three dimensions. The community's health and knowledge increase when health infrastructure and education are developed. Furthermore, better health and knowledge increase economic growth, per capita income, and expenditure, improving living standards.

A regional HDI disparity is caused by the concentration of investment in specific areas indicated by excellent physical infrastructure. The term "infrastructure" refers to basic structures and procedures that facilitate businesses. They include physical and non-physical infrastructure, such as main railways, roads, canals, harbors, public health, education, and the social system. The excellent infrastructure encourages higher efficiency returns for investors, encouraging them to invest in the leading region (Chakravorty, 2003). In this regard, cities with good facilities are new investment destinations for companies seeking to build factories to lower production costs for more competitive products. Therefore, there is a close correlation between investment and infrastructure.

Investment is attracted to places close to markets or ports, besides infrastructure. Large companies choose an area in big cities with many consumers to minimize transportation costs. Therefore, regions with insufficient investment experience difficulty boosting economic growth due to a smaller output than their potential. Consequently, the lower output indicates a lower value-added and community income that cannot increase per capita expenditure to improve living standards. Therefore, government support is needed to increase income in impoverished regions. For this reason, access to markets through infrastructure improvements is an essential determinant to raise firm productivity (Lall et al., 2004).

The infrastructure could be physical, such as electricity, drinking water, transportation, telecommunications, or social, including education, training, and health. The excellent infrastructure reduces production costs and creates higher productivity. Therefore, infrastructure development is critical in boosting national economic growth because transportation is the backbone of goods and passenger mobility.

Facilities such as electricity and telecommunications are related to the nation's modernization efforts, meaning that their provision is critical in increasing labor productivity. An area’s economic progress is determined by energy availability, an essential component in all economic activities. Energy is input in economic development to complement other inputs such as capital, labor, and raw material. Therefore, it is a crucial input for supporting economic growth and living standards. In line with this, Stern (2011) emphasized the importance of analyzing the alteration effects of energy on economic growth, hampered by limited energy. One type of energy increasingly utilized is electric power due to its essential role in running most instruments. The practical aspect supports the community to utilize the electric power for operating some instruments. They replace some manual with electric instruments, encouraging the progress of sectors such as industry, trade, hotels, restaurants, and tourism. Consequently, the growth of productive economic sectors increases income and community living standards.

Human resource development is associated with the growth of the education and health sectors. Education plays an essential role in creating human capital, significantly impacting economic growth (Kefela, 2010). Moreover, the quality of human resources determines success in realizing sustainable growth and global competitiveness (Taty et al., 2017). The nation's advantage depends on the quality of the human resource or capital operating a high-tech machine to ensure an efficient production process. As a result, higher efficiency in economic activities results in a higher value-added (Blaga & Jozsef, 2014).

Health progress could be realized by adding or upgrading the facilities and their accessibility by the community. The excellent health infrastructure provides adequate services for the community, improving public health. Furthermore, healthier communities produce more output, which helps raise income. Health improvement also boosts per capita income directly because labor produces more output (Acemoglu & Johnson, 2007). Similarly, healthier individuals produce higher output, while poor health lowers labor productivity (Cole & Neumayer, 2006), causing backwardness in many countries.

Infrastructure development has a significant multiplier effect on the economy of the impoverished region. In contrast, infrastructure improvements aid the expansion of regional economic potential. Cities with improved infrastructure produce more output, resulting in higher economic growth. However, the impoverished regions catch up to the progressive areas through better infrastructure (Barro & Sala-i-Martin, 2004). As a result, a convergence is marked by a decrease in regional inequality, which eliminates HDI disparity due to the higher growth in the lagging areas.

The convergence concept refers to Sigma and Beta convergence. Sigma convergence exhibits a reduction in regional differences, as measured by the standard deviation of the logarithms of per capita income between regions. A decrease in the sigma value implies convergence and vice versa. In contrast, based on the Beta convergence, poor regions could catch up with rich regions in per capita income (Barro & Sala-i-Martin, 2004). The Beta convergence could be absolute or conditional. Absolute convergence refers to assessments based on initial income levels without utilizing control variables that describe the characteristics of each region. Also, the steady-state conditions in each area are assumed to be the same, while other variables that vary between regions, such as investment and population growth, are not considered in convergence estimates. Conditional convergence analysis shows how the control variable affects steady-state circumstances. In this study, conditional convergence was calculated by adding the infrastructure and Gross Regional Domestic Product (GDRP), expected to affect the steady-state conditions of each region.

Previous empirical studies exhibited an HDI convergence, while others showed opposite results. Singh and Sharma (2017) showed that the Human Development Index (HDI) in the impoverished states moved faster towards convergence than in developed regions. Similarly, Bunnag (2019) examined the HDI convergence in the Mekong economy. The results showed that increasing openness or trade would minimize the HDI gap between the Mekong countries. Conversely, Mazumdar (2002) found that HDI convergence did not occur across African countries. Similarly, Asongu (2013) examined African convergence in real per capita GDP and inequality-adjusted human development. The findings showed that the income component of the Human Development Index (HDI) moves slower than others in the convergence process. However, few studies have examined HDI convergence in Indonesia. Taryono (2014) found a decline in HDI disparity across regencies and cities in Riau. However, Agustin (2019) analyzed HDI disparity by contingency test and found inequality in HDI across regencies and cities in Indonesia.

The high HDI disparity in the Special Region of Yogyakarta is reflected in a sharp difference in HDI scores across regions. The HDI in Yogyakarta Municipality and Sleman Regency in 2019 are 86.85 and 83.85, respectively, while Bantul and Kulon Progo Regencies have 80.10 and 79.99 HDI scores, respectively. In contrast, Gunungkidul Regency has a moderate HDI score of 69.96, as shown in Table 1.

The good economic performance of the Special Region of Yogyakarta is hampered by a discrepancy in regional HDI due to an infrastructure gap across areas. Therefore, infrastructure and disparities in income, education, and public health cause the HDI score to vary across regions. The government has overcome this problem through infrastructure development to support economic growth, especially in an impoverished areas, to catch up with the developed regions. When this objective is realized, the differential in HDI across regions would diminish.

Table 1 Human Development Index by Regency/City, 2014-2019

HDI	2014	2015	2016	2017	2018	2019
Kulon Progo	70.68	71.52	73.23	73.23	79.53	79.99
Bantul	77.11	77.99	78.42	78.67	79.45	80.01
Gunungkidul	67.03	67.41	68.73	68.73	69.24	69.96
Sleman	80.73	81.20	82.85	82.85	83.42	83.85
Yogyakarta	83.78	84.56	85.49	85.49	86.11	86.85

Sources: Statistics of Special Region of Yogyakarta

Research Method

This study utilized the Central Bureau of Statistics (BPS) data on the HDI score, installed electricity, education, and health facilities in the regencies or cities of Special Region of Yogyakarta. The data were accompanied by the Gross Regional Domestic Product (GRDP) of the regencies and cities. The study started in 2001 when the regional autonomy began and ended in 2019 because this publication was the latest during the study period. It was conducted in the regencies of Sleman, Bantul, Kulon Progo, Gunungkidul, and Yogyakarta Municipality.

The human development index in this study refers to the value of the Human Development Index, while the installed electricity is the maximum electric power. Furthermore, education refers to the number of teachers per vocational high school, while the health facility represents the number of beds in a hospital. Gross Regional Domestic Product (GRDP) refers to Gross Regional Domestic Product at 2010 constant price.

This study covers the condition of the HDI by regency or city in the Special Region of Yogyakarta and the variables that influenced HDI from 2001-2019. Therefore, panel data, a combination of cross-sectional and time-series data, were used. Data panels have some superiority over cross-sectional or time-series data (Baltagi, 2005). Individual effects are often used in panel data, shown by the intercept that varies across the region. Moreover, the Chow test was used to choose a precise model between the fixed or common effects. The MacKinnon, White, and Davidson (MWD) test were used to determine whether the model is linear or non-linear. The study model is outlined in the following Error Correction Model (ECM).

$$\Delta HDI_{it} = \alpha_i + \omega \Delta HDI_{i,t-1} + \sum_{j=0}^{k} \beta_{ij} \Delta ELECT_{it-j} + \sum_{j=1}^{k} \gamma_{ij} \Delta EDU_{it-j} + \sum_{j=0}^{k} \delta_{ij} \Delta HOSPIT_{it-j} + \sum_{j=0}^{k} \eta_{ij} \Delta GRDP + ECT_{t-1} \quad (1)$$

HDI: human development index (point), ELECT: installed electrical (megawatt= MW), EDU: number of teachers per vocational school (persons), HOSPIT: number of health facilities (bed), GRDP: gross regional domestic product (billion rupiahs), ECT_{t-1}: error correction term.

Equations (1) is an overview of the HDI convergence when the coefficient ω is *negative* ($\omega < 0$). The speed of convergence (λ) is calculated according to $\lambda = -\ln(1+\beta)/T$, with T denoting the length of time series data (Paas et al., 2007).

One of the regression prerequisites is stationary residuals that produce consistent and unbiased estimators. This study utilized the unit root test, based on Im, Pesaran, and Shin (IPS) (2003), to identify whether a series variable is non-stationary and possesses a unit root. Also, the unit root was accompanied by the Pedroni Cointegration Test, which is based on Engle-Granger's two-step (residual-based) cointegration tests. Pedroni proposed several tests for cointegration that allow for heterogeneous intercepts and trend coefficients across cross-sections. Moreover, a lag selection model based on the Akaike Information Criterion (AIC) was used to identify the optimum lag length (Liew, 2004).

Result and Discussion

The first analysis was descriptive statistics to describe data specifications (Table 2). The highest and lowest HDI scores were 86.65 and 65.87 points in Yogyakarta Municipality and Gunungkidul Regency, respectively. In this case, the highest HDI score is associated with excellent infrastructure in Yogyakarta Municipality because it is the center of economic activity, especially in the tertiary sector. Therefore, its performance was supported by excellent education, health facilities, and sufficient installed electricity. Conversely, the hilly condition of Gunungkidul Regency makes it economically disadvantaged, especially in the secondary and tertiary sectors. Furthermore, Yogyakarta Municipality had the highest ratio of teachers per school because it is a student city. Conversely, the lowest number of teachers per school occurred in Gunungkidul Regency.

Table 2 Descriptive Statistic

	Edu	Elect	Hospit	GRDP	HDI
Mean	44.73	216.09	1067.15	13.62	74.96
Median	45.37	182.36	821.00	12.28	74.49
Maximum	62.36	810.26	3419.00	35.28	86.65
Minimum	28.36	38.84	119.00	3.25	67.037
Std. Dev.	7.39	166.26	827.58	7.46	5.03

Sleman Regency had the largest installed electricity of 810.264 kWh. The regency needs adequate energy due to its broad scope and significant economic activities. Therefore, the State Electricity Enterprise installed a large electricity energy source in this regency. Conversely, Gunungkidul had the lowest installed electricity due to its insignificant economic activities in secondary and tertiary sectors.

The highest number of hospital beds was 3,419 units in Sleman Regency in 2019, while the lowest was 119 in Gunungkidul Regency in 2001. Moreover, Sleman has the highest GRDP due to its strategic location and excellent infrastructure. In contrast, Kulon Progo Regency has the least GDRP due to inadequate infrastructure.

The Im, Pesaran dan Shin (IPS) unit-roots test results indicated that all variables are not stationer at any level (Table 3). However, the integration test order showed that all variables are stationer at first difference. Therefore, this study utilized variables at first difference.

Table 3 The result of Unit Root Test

Variable	Level	Prob.	1st Difference	Prob.
Elect	2.320	0.99	-2.57*	0.01
Edu	-3.095	0.00*		
Hospital	-0.711	0.23	-2.78*	0.00
GRDP	-1.931	0.03*		
HDI	-2.812	0.00*		

*Stationer

The Pedroni cointegration test complements the unit root test. This result exhibited cointegration between variables on an indicator of Panel PP-Statistic, Panel ADF Statistic, Group PP-Statistic, and Group ADF-Statistic (Table 4). Therefore, there is a stationary linear combination among the variables in the model. The residual generated is stationary I(0). Therefore, the estimated model is stable over time, or its variables have a causal relationship in one direction.

Table 4 The Result of Pedroni Cointegration Test

Within-Dimension	Statistic	Prob.
Panel v-Statistic	-2.123	0.983
Panel rho-Statistic	-0.108	0.457
Panel PP-Statistic	-2.862*	0.002
Panel ADF-Statistic	-2.534*	0.006
Between-Dimension		
Group rho-Statistic	1.171	0.879
Group PP-Statistic	-5.142*	0.000
Group ADF-Statistic	-4.932*	0.000

*Cointegrated

The next stage identified a better regression model between linear and non-linear, based on the MWD test. The result showed that z_1 is not significant, while z_2 is significant, meaning that the better model is linear (Table 5). Therefore, the regression was outlined in the linear model.

Table 5 The MWD Test

Item	Coefficient	Prob.	The Better Model
z_1	-0.001	0.99	Linear
Z_2	-0.013	0.00	

The next test identified a precise model between the fixed or common effects. The Chow test result showed that the superior model is fixed effects (Table 6). However, this study could not choose a better model between Fixed Effects and Random Effects. The Random effects estimation requires that the cross-sections be more than the coefficients between estimators to approximate the innovation variance. Therefore, the analysis was based on the Fixed Effects Model.

Table 6 The Result of Chow Test

Cross-section Chi-square	Prob.	Superior Model
37.564	0.000	Fixed Effects

The next step before running the regression was to identify the optimum lag length. The too-long lag reduces the degree of freedom, while the excessive lag results in a miss-specified model. Therefore, the study used a lag selection model based on the Akaike Information Criterion (AIC). The result showed that the lag length of 1 was optimum lag (Table 7). The vector auto-regression (VAR) with a lag length of 1 is parsimonious and useful in this study.

Table 7 The Optimum Lag-Length

Lag Length	Akaike Information Criterion
1 1	2.721 *)
1 2	2.801
2 2	3.360

*Optimum Lag-length

The fixed-effects model showed the coefficient of determination (R^2) of 0.458, meaning that the independent variables in the model explained 45.8% of HDI variation. In contrast, the remaining 54.2% is explained by other variables outside the model. Also, the coefficient of determination was small because the analysis was based on the first difference variables, not at the level. A significant F value indicates that all independent variables affect the dependent variable. Furthermore, the negative coefficient of Error Correction Term (ECT) shows that the Error Correction Model (ECM) is precise. The coefficient regression of ECT of -0.215 indicated that the speed of adjustment in HDI toward its equilibrium is 0.215 points per year (Table 8).

Table 8 Estimation Results (Fixed Effects)

No.	Variable	Coefficient	t-statistic	t-table (5%)**
1	Δ HDI (t-1)	0.101	0.910	1.645
2	Δ Electricity Installed (t)	0.004*	4.091	1.645
3	Δ Education (t)	0.033*	2.609	1.645
4	Δ Health Facilities (t)	0.001*	2.409	1.645
5	Δ GRDP (t)	-7.13E-06	-1.093	-1.645
6	Error Correction Term (t-1)	-0.215*	-5.627	-1.645
7	Constant	0.442*	3.579	1.645

Dependent Variable: Δ HDI (t)
Adjusted-R2 = 0.458
F = 8.117*
* Significant at (α=5 percent)
** 1 tail test

The insignificant coefficient of the previous HDI (t-1) indicates that an increase in the HDI (last year) does not impact HDI (current year). The results show that the regression coefficient of HDI (t-1) is not negative, implying no convergence in the Special Region of Yogyakarta. Moreover, the HDI growth in impoverished regions is lower and unable to catch up with the developed regions, resulting in a gap in the HDI. The development in electricity, education, health facilities, and an increase in the gross domestic, regional product (GRDP) cannot reduce a gap in the HDI among regencies or cities. However, this contradicts Singh and Sharma (2017), which showed that the low HDI States grew faster than the developed regions, resulting in HDI convergence across the Indian states.

The annual HDI growth in Gunungkidul, an impoverished region, is 0.4%, and 0.8% in Yogyakarta Municipality. This finding was related to the poor infrastructure in Gunungkidul. Moreover, the number of hospital beds in Gunungkidul is 0.4 units per thousand population, while Sleman has a 24 unit per thousand population. The electricity consumption per capita in Sleman is 0.48 MW per year, while Gunungkidul residents only consume 0.21 MW yearly. Furthermore, Gunungkidul had only 28.36 teachers per vocational high school. In contrast, Yogyakarta Municipality, a student city, has 62.36 teachers per vocational high school.

The installed electricity showed a positive regression coefficient with a magnitude of 0.004. Therefore, an HDI rise by 0.004 points increases installed electricity by 1 MW, provided all other factors remain equal. Consequently, an increase in electricity capacity indicates a better facility or infrastructure, making the production process more efficient at a lower cost. Therefore, more goods and services are produced, meaning that better infrastructure supports economic growth and encourages a rise in HDI.

There is a need to develop the tourism sector in Gunungkidul, construct a new international airport in Kulon Progo, and increase the electric power supply in both regions. The two regions have inadequate energy supply with frequent rolling blackouts that disrupt some activities and harm economic performance. Therefore, increasing the electricity supply would accelerate the economy and increase both regions' gross regional domestic product. Subsequently, increasing Gross Regional Domestic Product (GRDP) would encourage a higher income per capita, supporting the HDI's convergence in the Special Region of Yogyakarta.

Education has a positive regression coefficient with a magnitude of 0.033. Therefore, increasing the number of teachers per vocational high school by one person raises the HDI by 0.033 points in the short run, provided all other factors remain equal. More teachers increase the vocational high schools' capacity to accommodate more young people to continue their studies. As a result, it promotes a higher mean year of school, raising the HDI score. This finding is consistent with Adhadika and Pujiyono (2014), which showed that higher education increases productivity, positively impacts people's income, and raises their expenditure and the HDI Score.

The regression coefficient of health facilities is significant with a magnitude of 0.001. This means that an increase in a hospital bed by 1 unit raises the HDI by 0.001. Improved health infrastructure is followed by better public health and higher life expectancy, promoting HDI. Furthermore, an investment in a health facility creates a better human resource, resulting in more output, higher income, a rise in expenditure, and increased HDI scores. This finding is in line with Udjianto et al. (2018), which stated that developing health facilities encourages labor productivity convergence.

The Gross Regional Domestic Product (GRDP) regression coefficient is insignificant, meaning that its increase does not impact the HDI. GRDP exhibited the goods and services resulting from the economic activities by local and non-local residents. Part of GRDP is income for several non-local residents involved in the production process. Therefore, GRDP does not reflect community income, and its increase does not raise the HDI score.

Conclusion

There was no HDI convergence between areas in the Special Region of Yogyakarta. Growth in the HDI in the impoverished region was lower than in developed regions, resulting in a gap in the HDI. Installed electricity, education, and health facilities increase per capita income, living standards, and the HDI. However, an increase in GRDP does not impact the HDI. In line with regional autonomy, the provincial and local governments must cooperate to realize integrated planning, maintenance, and infrastructure development. Moreover, the provincial government must promote infrastructure improvement to increase the HDI in impoverished regions. The infrastructure improvement enables the regions to catch up with the developed areas, encouraging HDI convergence.

References

Acemoglu, D., & Johnson, S. (2007). Disease and development: the effect of life expectancy on economic growth. *Journal of Political Economy, 115*(6), 925–985. https://doi.org/10.1086/529000

Adhadika, T., & Pujiyono, A. (2014). Analisis faktor-faktor yang mempengaruhi produktivitas tenaga kerja industri pengolahan di Kota Semarang (Studi kecamatan Tembalang dan kecamatan Gunungpati). *Diponegoro Journal of Economics, 3*(1), 100-112. Retrieved from https://ejournal3.undip.ac.id/index.php/jme/article/view/5324

Agustin, E.H. (2019). Disparitas Indeks Pembangunan Manusia. *Prosiding Seminar Nasional Fakultas Ekonomi Untidar 2019*. Retrieved from https://jurnal.untidar.ac.id/index.php/semnasfe/article/view/2119

Asongu, S. (2013). African development: beyond income convergence. *South African Journal of Economics, 82*(3), 334–353. https://doi.org/10.1111/saje.12021

Baltagi, B. (2005). *Econometric analysis of panel data (3rd ed.).* New York: John Wiley and Sons.

Barro, R. J., & Sala-i-Martin, X. (2004). *Economic growth (2nd Ed).* London: The MIT Press.

Blaga, P., & Jozsef, B. (2014). Human resources, quality circles and innovation. *Procedia Economics and Finance, 15*, 1458–1462. https://doi.org/10.1016/s2212-5671(14)00611-x

Bunnag, S. (2019). Income and HDI convergence in the Mekong economies: regional development revisited. *Social Science Review*, 15-30. Retrieved from https://core.ac.uk/download/pdf/210569451.pdf

Cette, G., Corde, S., & Lecat, R. (2018). Firm-level productivity dispersion and convergence. *Economics Letters, 166*, 76–78. https://doi.org/10.1016/j.econlet.2018.02.018

Chakravorty, S. (2003). Capital source and the location of industrial investment: a tale of divergence from post-reform India. *Journal of International Development, 15*(3), 365–383. https://doi.org/10.1002/jid.976

Cole, M. A., & Neumayer, E. (2006). The impact of poor health on total factor productivity. *The Journal of Development Studies, 42*(6), 918–938. https://doi.org/10.1080/00220380600774681

Erdal, F., Can, E., & Kocbas, G. (2006). Convergence of Human Development Levels. *International Conference on Human and Economic Resources*. Retrieved from https://eco.ieu.edu.tr/wp-content/proceedings/2006/0618.pdf

Gyawali, B., Fraser, R., Bukenya, J., & Schelhas, J. (2008). Income convergence in a rural, majority African-American region. *Review of Regional Studies, 38*(1), 45-65. https://doi.org/10.52324/001c.8253

Hammond, G. W. (2006). A time series analysis of U.S. metropolitan and non-metropolitan income divergence. *The Annals of Regional Science, 40*(1), 81–94. https://doi.org/10.1007/s00168-005-0029-3

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115*(1), 53–74. https://doi.org/10.1016/s0304-4076(03)00092-7

Islam, N. (2003). What have we learnt from the convergence debate? *Journal of Economic Surveys, 17*(3), 309–362. https://doi.org/10.1111/1467-6419.00197

Kefela, G. T. (2010). Knowledge-based economy and society have become a vital commodity to countries. *International Journal of Educational Research and Technology, 1*(2), 68–75. Retrieved from http://soeagra.com/ijert/vol2/10.pdf

Lall, S. V., Shalizi, Z., & Deichmann, U. (2004). Agglomeration economies and productivity in Indian industry. *Journal of Development Economics, 73*(2), 643–673. https://doi.org/10.1016/j.jdeveco.2003.04.006

Liew, V. K-S. (2004). Which lag length selection criteria should we employ? *Economics Bulletin, 3*(33), 1–9. Retrieved from http://www.economicsbulletin.com/2004/volume3/EB-04C20021A.pdf

Paas, T., Kuusk, A., Schlitte, F., & Vork., A. (2007). *Econometric analysis of income in selected EU countries and their nut 3 level regions*. Tartu University Press. Retrieved from https://majandus.ut.ee/sites/default/files/mtk/RePEc/mtk/febpdf/febawb60.pdf

Postoiu, C., & Buşega, I. (2015). Inter-regional disparities in the European union. *Romanian Review of Regional Studies*, 11(1), 15–17. Retrieved from https://rrrs.reviste.ubbcluj.ro/site/arhive/Artpdf/v11n12015/RRRS11120151.pdf

Pouvelle, C., & Mitra, P. (2012). Productivity growth and structural reform in Bulgaria: restarting the convergence engine. *IMF Working Papers, 12*(131), 1-20. https://doi.org/10.5089/9781475503678.001

Singh, S., & Sharma, P. (2017). Human development; convergence across indian states. *IMPACT: International Journal of Research in Humanities, Arts and Literature, 5*(7), 103–110. Retrieved from http://oaji.net/articles/2017/488-1503062204.pdf

Stern, D. I. (2011). The role of energy in economic growth. *Annals of the New York Academy of Sciences, 1219*(1), 26–51. https://doi.org/10.1111/j.1749-6632.2010.05921.x

Taryono. (2014). Analisis disparitas pembangunan manusia di Provinsi Riau. *Jurnal Sosial Ekonomi Pembangunan, 4*(11), 194–214. Retrieved from https://jsep.ejournal.unri.ac.id/index.php/JSEP/article/view/2411

Taty, S., Possumah, B. T., & Razak, R. I. (2017). Human capital competitiveness in ASEAN Economic Community (AEC): the role of regulation, Indonesia experiences. *American Journal of Applied Sciences, 14*(2), 267–273. https://doi.org/10.3844/ajassp.2017.267.273

Udjianto, D. W., Susanto, J., & Purwiyanta, P. (2018). Infrastructure and labour productivity convergence in Gunungkidul Region. *JEJAK, 11*(2), 356–374. https://doi.org/10.15294/jejak.v11i2.16057