THE ROLE OF INFRASTRUCTURE ON ECONOMIC GROWTH IN INDONESIA

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Abstract

The disparity on infrastructure is evident between Java and outside Java in Indonesia; both in quantity and quality. This paper confirm this evidence using σ-convergence statistic. Furthermore, this paper identify the determinant of per capita income by adopting the Solow growth model and β-convergence model. The result show the existence of β-convergence in Indonesia with 1.75% speed of convergence; or equivalent with half-life of 41.14 years. The result emphasize the availability of basic infrastructure including electricity, road and sea transport is a necessary condition to gain high and sustainable growth. Furthermore, the openness will increase the region’s productivity due to higher technology spillover.

Keywords: σ-convergence, β-convergence, Solow growth model, income distribution, Gini coefficient, disparity.

JEL Classification: O11, O18, O47, R11

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I. INTRODUCTION

Physical capital and human capital play a great role in the growth of economy. The availability of physical capital is closely related to the availability of investment fund. In the case of Indonesian economy, although the performance growth hasn’t reached the average Asian precrisis, but the strong economic fundamental followed by the improvement of the economic micro and macro risks, have lead many international institutions to attribute their positive assessment on the prospect of Indonesia’s economy, and put Indonesia as investment grade country.

A simple plot shows Indonesia’s economic growth share the same pattern with the growth of investment or the capital stock accumulation (Graphic 1). This graph conform the important role of the investment or the physical capital accumulation to drive the growth.

The conducive investment climate positively affected the increase of investment realization of 8.82% in 2011, which is tied to some positive reviews on Indonesia. UNCTAD’s survey as reported on World Investment Prospects Survey 2011-2014, has put Indonesia as the fourth rank of the most prospective country for investment purpose after China, USA, and India (Graphic 2). This is due to the position of Indonesia as investment grade zone based on the Japan Credit Agenct, the Fitch, and the Moody’s (Graphic 3).

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2 Increase by two grades from the previous rank.
Within this positive improvement, the major challenges for Indonesia’s economy in the mid term is the underdeveloped of the complementary production factor (the non-labor input), which may reduce the economic growth. In its latest report, the World Economic Forum (WEF) argued the competitiveness of Indonesia falls behind (Table 1), particularly in the infrastructure, the technological readiness, and the innovative pillar. The most binding constraints involving these three pillars is evident during the last eight years. More specifically on infrastructural pillar, the problem arise upon the low quality of the roads, the harbours, the airports, the train stations, and the power supply (Table 2). Meanwhile, the constraint on technological readiness and innovation pillar involve the low grade of technonological skill and innovation efforts.

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3 Global Competitiveness Report 2011-2012, Indonesia ranked 46 from 142 countries.
The survey carried out by the International Institute for Management Development (IMD) also confirmed the problem on infrastructure and put Indonesia at the rank of 37 over 59 countries. The weakest point is in infrastructure including the basic infrastructure, the technical infrastructure, the health and environment, and the education (Table 3).
In addition to the weak support on production factor, Indonesia’s human development quality is also low. Based on UNDP’s data, the gap between the Indonesia’s human development both with its peer-group and with East-Asian and Pasific countries has increased post the 1998 crisis (Graphic 4). The lower human quality measured by education, health, and income in Indonesia relative to the other countries, eventually lower Indonesia’s competitiveness.

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Sumber: IMD, 2011
The common problem to revive the infrastructure is financing and legal aspects. During the last eight years, the government averagely allocated only 1.6% of the GDP for infrastructure (Graphic 1.5). This is much lower compared to China and India with their significant allocation of 5.3% and 7.3% of their GDP.
Improving the infrastructure is important to reduce the income gap and is a major determinant for the long run GDP per capita. Referring to the World Development Report’s (World Bank, 1994), infrastructure plays important role in increasing the economic growth where the higher growth is evident in areas with sufficient infrastructure. In some countries, the program for infrastructure development focused on increasing the basic needs and the human connectivity, including water, electricity, energy, and transportation (highways, train stations, harbours, and airports). Weil (2009) stated that the disparity of physical capital availability and human capital plays a role in explaining the difference of economic growth between countries.

Some researches used cross country data while some others utilized the regional data within a country. In China, Wu (1998) argued the disparity across region differs between the coastal area, the central, and the western area. Using data from 24 provinces in China, Demurger (2001) concluded that the reformation, the degree of openness, and the infrastructure condition significantly influence the regional growth disparity. Furthermore, Caldreon (2011) concluded the economic growth is positively and significantly related to the stock and the quality of infrastructure.

In Indonesia, many empirical researches on the role of infrastructure on economy are available, albeit with varied result. Sibrani (2002) found that infrastructure (electricity and education) positively affected the income per capita in Indonesia, while the road and the telephone line contributed marginally. The policy of Indonesian government to concentrate the infrastructure development in Java and Western Indonesia enlarged the disparity between the Western and the Eastern area.

Yanuar (2006) used panel data of 26 province and found the physical capital, road, telephone line, health, and education infrastructure positively affected the economic output. Prasetyo (2008) concluded that except for the clean water, the electricity, the road length, the stock capital, and the regional authority positively influenced the economic growth in Western Indonesian. Furthermore, Prasetyo and Firdaus (2009) concluded that the economic growth in Indonesia depends on infrastructure including the electricity, the paved roads, and the clean water.

Considering the importance of infrastructure in boosting economic growth, this paper analyze the influence of physical infrastructure including transportation (road length and unloading port), electricity, and human capital (education) towards 33 provinces in Indonesia. This analysis also include the regional government policies, the economic structure, and the society structure.

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4 See Calderon and Serven (2004); and Canning and Pedroni (1999).
To test the condition of economic disparity across region in Indonesian, we adopt the convergence theory and apply the static and the dynamic panel data methods. Explicitly, the purpose of this paper is to examine the economic disparity within Indonesian regions by identifying the convergence, and to identify the impact of infrastructure on economic growth; both in national and regional level.

The next section of this paper discuss the theory and related empirical studies. The third section discuss methodology and the data, while the estimation result and its analysis is presented in section four. The fifth section outline the conclusion and will close the presentation of this paper.

II. THEORY

2.1. Growth Theory

The commonly referred growth model is the exogenous growth model or the Solow growth model. The Solow model assumed that economic growth depends only on the changes of the physical capital (saving and investment) and the labor (population growth), while the technology, which shows the efficacy level is exogenous to this model and is residually derived.

The Solow model is an improvement of Harrod-Domar growth model with the inclusion of labors and technology to the growth equation. Individually, the labor and the capital follow the law of diminishing returns, and constant returns to scale when both are analyzed together (Todaro and Smith, 2006). Solow growth model uses the following aggregate production function:

\[ Y = AK^\alpha L^{1-\alpha} \]  

Where \( Y \) is the gross domestic product; \( K \) is stock physical and human capital; \( L \) is labor; \( A \) is the technological progress; and \( \alpha \) is the output elasticity toward capital.

Per effective labor, we can write Equation (1) as:

\[ \frac{Y}{L} = A \left( \frac{K}{L} \right)^\alpha \left( \frac{L}{L} \right)^{1-\alpha} = A \left( \frac{K}{L} \right)^\alpha \]

\[ y = Ak^\alpha \]  

where \( y \) is the income per effective labor, and \( k \) is the capital accumulation per effective labor.

The Solow growth model emphasize the importance of investment in capital accumulation process. The rate of economic growth will be measured by the capital accumulation per effective labor. Based on this model, any region with higher capital accumulation will also grow higher.
The capital stock is the function of investment ($I$) and depreciation ($D$): 

$$\Delta K = I - D.$$ 

In term of per effective labor: 

$$\Delta k = i - d$$ 

(3)

where $i$ and $d$ each represents the investment quantity over labor and depreciation from capital. Investment is assumed as a fixed ratio ($\gamma$) from output, and investment per labor is noted as: 

$$i = \gamma y$$ 

(4)

Capital is assumed to depreciate with a fixed rate ($\delta$): 

$$d = \delta k$$ 

(5)

Recall equation (3) and re-arranging, the capital accumulation per effective labor can be written as a function of output and depreciation: 

$$\Delta k = \gamma y - \delta k$$ 

$$\Delta k = \gamma f(k) - \delta k$$ 

$$\Delta k = \gamma Ak^\alpha - \delta k$$ 

(6)

The steady state in Solow model occur when there is no more capital accumulation per labor, or $\Delta k = 0$. In steady state: 

$$\gamma A k_{ss}^\alpha = \delta$$ 

$$\gamma A = \delta k_{ss}^{1-\alpha}$$ 

$$k_{ss} = (\gamma A / \delta)^{1/(1-\alpha)}$$ 

(7)

So during steady state, the output per labor: 

$$y_{ss} = Ak_{ss}^\alpha$$ 

$$y_{ss} = A^{1/(1-\alpha)} (\gamma / \delta)^{\alpha/(\alpha-1)}$$ 

(8)

In steady state, the output per effective labor will increase as the investment ratio increase. A region with similar initial capital but with a higher investment ratio will have a higher steady state income per capita (Graphic 6.a).
It is sensible to assume that initially the factor production is immobile, therefore the capital and the skilled labors tended to concentrate in a more advanced regions; this leads to regional disparity. With a better infrastructure and communication facility connecting these regions, the capital and the labors can move more easily; for this reason, the disparity across region will decrease. This is the second feature of this growth model, and is widely recognize as the Neoclassic Hypothesis.

2.2. Convergence

Generally, the indicator for an inclusive economic growth is the presence of convergency (either the \( \sigma \)-convergence and the \( \beta \)-convergence). Initially the \( \beta \)-convergence is more popular within the economic growth subject\(^5\), however, the \( \sigma \)-convergence attract more attention since it can directly assess the income distribution across regions. Within this framework, the presence of \( \beta \)-convergence is not sufficient condition for the \( \sigma \)-convergence.

2.2.1. \( \sigma \)-Convergence

\( \sigma \)-convergence occur when the disparity of the real income per capita decreases gradually. In this paper, we distinguish four measurements for the \( \sigma \)-convergence: (i) Unweighted Coefficient of Variation, (ii) Weighted Coefficient of Variation, (iii) Theil Index, and (iv) Gini Coefficient.

The Coefficient of Variation (CV) is calculated using the standard deviation of real income per capita across provinces, divided by its average:

$$Unweighted \ CV = \frac{\sum(Y_i - \bar{Y})^2}{n} / \bar{Y}$$

The picture below shows two distributions with equal mean, but the distribution with 0.1 shows smaller disparity than that with 0.5 CV.

The weight used in CV calculation resulted the second type of $\sigma$-convergence, or the weighted CV. The variable used for weighting is the proportion of population of a province to national.

$$Weighted \ CV = \sqrt{\sum p_i (Y_i - \mu)^2 / \mu}$$

A low weighted CV value indicates a better economic growth equalization.

The third $\sigma$-convergence indicator is Theil Index, calculated as each provincial contribution to the inequality. The wealthiest province will contribute large and positive Theil Index, while the poorest province will contribute the largest negative Theil Index.

$$Theil \ Index = \sum Y_i \log \left(\frac{Y_i}{\bar{Y}}\right) / n\bar{Y}$$
The fourth σ-convergence is the Gini coefficient. The Gini Coefficient is calculated based on the Lorenz Curve which shows the plot of cumulative population and cumulative real income cumulative. The Gini Coefficient (area C) is the difference between the rectangle area of equal income (area A) and the Lorenz Curve (area B).

\[ \text{Gini Coefficient} = \sum \sum \sqrt{Y_i - Y_j} / 2n^2 \bar{Y} \]

Where \( p_i \) is the share of population of region \( i \) to national; \( Y_i \) is the income per capita for province \( i \); \( Y_j \) is income per capita for province \( j \); \( \bar{Y} \) is average of income per capita; \( \mu \) is the population-weighted income, \( \mu = \sum p_i Y_i \); and \( n \) is the number of provinces.

2.2.2. β-Convergence

The estimation of the β-convergence was introduced by Islam (1995), which measure how fast a poor region will catch up with the wealthier region. The use of panel estimation to estimate is provide two benefits: (i) we can control the problem of omitted variables, especially related to the inequality of initial technology across regions; and (ii) we can reduce the endogeneity problem and reduce the measurement error (Islam, 2003; Bond et al., 2001). In this paper, we estimate the β-convergence based on the Solow growth model. We slightly modify the estimation by distinguishing the capital into: (i) production factor (physical and human capital) and (ii) infrastructure.
We include the set of control variables to increase the robustness of the model. The general form of the model to estimate is:

\[ \ln y_{it} - \ln y_{it-1} = \alpha_i + \eta_t + \beta \ln y_{it-1} + \gamma X_{it} + \phi Z_{it} + \psi W_{it} + \epsilon_{it}; \]

for \( \beta = e^{-\tau t} - 1 \),

or equivalent with:

\[ \ln y_{it} = \alpha_i + \eta_t + \rho \ln y_{it-1} + \gamma X_{it} + \phi Z_{it} + \psi W_{it} + \epsilon_{it}; \]

for \( \rho = e^{-\tau t} \) (9)

The parameter \( \tau \) represent the national convergence rate; \( \alpha_i \) is the individual effect; \( \eta_t \) is time effect; \( y_{it} \) is real income per capita rate; \( X_{it} \) is production factor (physical and human capital accumulation); \( Z_{it} \) is infrastructure; \( W_{it} \) represent the economic structure as our control variable; and \( \epsilon_{it} \) is the error term.

The presence of lag of dependent variable on the right hand side creates an endogeneity problem. On this case, the use of dynamic data panel method becomes more relevant as we explain in the next section.

III. METHODOLOGY

3.1. Data, variables, and Empirical Models

We distinguish the capital in two groups: (i) production factor which consists of physical and human capital, and (ii) infrastructure. We use the real investment to proxy the physical capital and use the average of schooling years to proxy the human capital. For infrastructure we use transportation indicator (road length and loading/unloading harbor) and the amount of electricity subscriber. All these variables are in per capita.

The empirical model to estimate is:

\[
PDRB_{it} = \alpha_{it} + \beta_1 PDRB_{it-1} + \beta_2 PMTB_{it} + \beta_3 AYS_{it} + \beta_4 ELEC_{it} + \beta_5 ROAD_{it} + \beta_6 LOAD_{it} + \beta_7 URBAN_{it} + \beta_8 OPEN_{it} + \beta_9 CSGRL_{it} + \beta_10 YAGR_{it} + \epsilon_{it} \tag{10}
\]

where

- \( PDRB \) : regional real GDP per capita;
- \( PMTB \) : gross fixed capital formation (per capita)
- \( AYS \) : average schooling years
- \( ELEC \) : electricity subscribers per capita
- \( ROAD \) : road length per capita
LOAD: harbor loading/unloading per capita
URBAN: percentage of people living in cities
OPEN: the trade openness for each region
CSGRL: the share of real government consumption on total GDP
YAGR: the share of agriculture on total GDP

All variables are estimated in a natural logarithm. The detail of measurement used is as such:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Measurement</th>
<th>Expected Sign</th>
<th>Sample</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDRB</td>
<td>Regional Real Gross Domestic Product</td>
<td>Rp billion</td>
<td></td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
<tr>
<td>POPNL</td>
<td>Population</td>
<td>Thousand people</td>
<td></td>
<td>2000-2010</td>
<td>BPS: Statistic of Indonesia</td>
</tr>
<tr>
<td>PMTB</td>
<td>Real Investment</td>
<td>Rp billion</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
<tr>
<td>AYS</td>
<td>Average schooling years</td>
<td>year</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS: Statistic of Indonesia</td>
</tr>
<tr>
<td>ELEC</td>
<td>Number of electricity subscribers</td>
<td>people</td>
<td>+</td>
<td>2000-2010</td>
<td>PLN: Statistic of PLN</td>
</tr>
<tr>
<td>ROAD</td>
<td>Road length</td>
<td>Km</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS: Statistik of Transportation</td>
</tr>
<tr>
<td>LOAD</td>
<td>Loading/Unloading Harbor</td>
<td>Ton</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS: Statistic of Transportation</td>
</tr>
<tr>
<td>URBAN</td>
<td>Urban population</td>
<td>% Populasi</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
<tr>
<td>OPEN</td>
<td>Openness rate</td>
<td>%</td>
<td>+</td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
<tr>
<td>CSGRL</td>
<td>Government consumption</td>
<td>Rp miliar</td>
<td>-</td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
<tr>
<td>YAGR</td>
<td>Share of agriculture in RGDP</td>
<td>Rp billion</td>
<td>+/-</td>
<td>2000-2010</td>
<td>BPS</td>
</tr>
</tbody>
</table>

The control variable consists of (i) urbanization proxied with the share of people living in cities; (ii) the openness; (iii) the share of government consumption towards regional GDP; and (iv) the share of agriculture in regional GDP. Urbanization is useful to capture the structure of urban area which usually work in manufacturing and service sector, instead of agriculture. For this reason, the urbanization contribute more on value added. We also use the share of agriculture on regional GDP to capture the growth of regional productivity. We expect a lower relative productivity as the share of agriculture is higher, hence produce lower growth of regional income per capita. The openness captures the regional intensity on international trade, while the share of government consumption is useful to see the consequence when the government gives more attention on non investment/capital purchase.
We expect the $\beta$-convergence to be positive, showing the convergence process occur in Indonesian. The physical capital (investments and infrastructures including electricity, road, and loading/unloading harbours) and human capital (schooling years) are expected to positively affect the growth of per capita income.

We expect the effect of urbanization is positive, since the more urban people, the more manufacturing and service-related activities; hence the higher income per capita. On the contrary, we expect the sign of coefficient for the agricultural share to be negative since agriculture provide lower productivity relative to manufacturing and services sector.

A larger openness reflect a more productive manufacturing sector and a larger expose to the international trade, which potentially provide positive spillover for the region. For this reason we expect the sign of the coefficient for openness to be positive. Lastly, the government consumption is expected to negatively affect the growth due to fewer purchase on capital and investment.

### 3.2. Estimation Technique

This paper uses panel data estimation. The advantages of using this method is it can accommodate the unobserved individual heterogeneity into the model, reduce the collinearity across variables, and minimize the bias from individual aggregation (Baltagi, 2005).

There are two types of panel data estimation; the static and the dynamic model. What differentiates the two is that the dynamic data panel include the lag of dependent variable as explanatory. The static data panel consists of three methods, the pooled least square (PLS), the fixed effect model (FEM), and the random effect model (REM).

PLS assumed there is no common effect across time, nor a unique behavior of individuals within the measurement set. The regression equation can be written as:

$$ y_{it} = \alpha + \beta X_{it} + \epsilon_{it}, \text{ untuk } i = 1, \ldots, N \text{ and } t = 1, \ldots, T $$

where $N$ is the number of cross section or individuals and $T$ is the length of series. Within this structure, we can have $T$ number of equations, each of them with $N$ observations. Otherwise, we can have as much as $N$ equations with $T$ observation each. To get a constant and efficient parameter of $\alpha$ and $\beta$, we can regress one equation with $N \times T$ observations. This method is simple but slightly weak since it assume there are no unique attributes of individuals within the measurement set, and no universal effects across time.

**Fixed Effect Model (FEM)** assumes there are differences across individual reflected in the intercept. The unique attributes of individuals are not the results of random variation and that do not vary across time. This approach is used when individual effect correlates with the regresor. The FEM is also known as Least Squares Dummy Variable Model (LSDVM), specified as:
$y_{it} = \alpha_{i} + \lambda_{i} + \beta X_{it} + \varepsilon_{it}$, untuk $i = 1, \ldots, N$ and $t = 1, \ldots, T$

There are two components of $\varepsilon_{it}$: one-way and two-way error components. One-way error component is when $\varepsilon_{it}$ contains individual effect and random error, while the two-way is when the error, $\varepsilon_{it}$, contains both individual effect and time effect, and random error. The FEM estimator can be estimated using within group method or least square dummy variable (LSDV) method.

The third variant of static panel model is REM. This approach assumes there are unique, time constant attributes of individuals that are the results of random variation, which do not correlate with the individual regressor. The model with random effect can be stated with this equation.

$y_{it} = \beta X_{it} + (\alpha_{i} + u_{i}) + \varepsilon_{it}$, for $i = 1, \ldots, N$ and $t = 1, \ldots, T$

Estimator in REM can be estimated using two techniques, (i) the between estimator approach, and (ii) Generalized Least Square (GLS).

To choose between the fixed and the random effect, we use Hausman test to see the presence of corelation between regressor and individual effect with $H_0$: random effect and $H_1$: fixed effect.

Besides the static data panel, there is also dynamic data panel that consist of two methods, which are GMM first difference and GMM system. As stated previously, this research will indentify the convergence process indication in inter-region economy through $\beta$-convergence method. The model that estimated in having lag from dependent variable as the clarifying variable. This fact classifies dynamic model but also causes endogeneity problem that has to be solved. GMM-system method was introduced by Blundell and Bond (1998) as an improvement from GMM-first difference from Arellano and Bond (1991). Gmm-system Estimator basically use first-difference lag varianle as instrument for rate level equation.

Konsistensi estimator GMM bergantung pada validitas instrumen nilai lag autoregressive (kondisi momen) di persamaan regresi yang diuji. Estimasi yang dilakukan mensyaratkan ortogonalitas antara error term di first difference dan lag dari variabel dependen, artinya tidak ada hubungan antara error tersebut dengan lag variabel dependen. Ini diperlukan untuk menjamin estimator yang tidak bias and konsisten. Untuk menguji kondisi ortogonalitas tersebut, akan dilakukan pengujian serial correlation pada orde pertama dan kedua (Arellano and Bond (1991), and Roodman (2009a, b)) dengan tiga uji spesifikasi, yaitu AR(1), AR(2) and uji Hansen.

GMM estimator consistency depends on instrument validity autoregressive lag value (moment condition) and tested regression equation. The estimation that is done conditioned ortogonality between error term in the first difference and lag from dependent variable, which means no connection between that error and dependent lag variable.
A robust data panel model is marked by AR(1) statistic which reject the hypothesis of a serial correlation presence in orde one, and AR(2) statistic which accept the hypothesis of a no serial correlation in orde two. Meanwhile, to test the total validity to instrument, we use a Hansen over-identifying test under hypothesis of instrument set is exogenous. This means the larger the p-value of Hansen statistic, the better.

In addition, the Hansen test can also provide information regarding the validity of instrument addition; if the significance of the Hansen statistic increases drastically when adding instrument, then a moment condition is violated. By that, the use of GMM-system method will not valid, while the first difference GMM method will.

IV. RESULT AND ANALYSIS

4.1. \( \sigma \)-Convergence

This paper assesses the convergence of the real per capita income both on national level and regional corridor. Following the corridor distribution in MP3EI, we have the economic corridor of Sumatera, Java, Bali, Nusa Tenggara, Kalimantan, Sulawesi, and Papua and Maluku island.

At national level, every provinces experienced a rise in real income per capita, but the gap across provinces widen (Graphic 4.35). The persistence of real income per capita disparity across provinces in Indonesia is also reflected by constant disparity indicator during the last ten years. This includes the weighted Coefficient of Variation (CV), the Theil Index, and the Gini coefficient. Furthermore, the unweighted CV tends to decrease, however the magnitude is not significat (Graphic 4.36).
The calculation shows the Gini coefficient of the per capita real income across provinces in Indonesia reached 0.37 (year 2010), which is considered to be sufficiently high based on international standards. However, excluding the DKI Jakarta and East Kalimantan will lower the Gini coefficient significantly, for instance to 0.26 for 2010. This value belongs to the category of low disparity according to the international standards (Graphic 4.37). Simple illustration, the per capita real income for DKI Jakarta and East Kalimantan averagely during 2000-2010 is Rp 33,4 juta, while for NTT dan Gorontalo is Rp 2,3 juta.

The disparity measure using the unweighted and weighted CV shows similar trend. The plot of these two indicators show a persistent disparity in economic corridor of Sumatera, Java, Bali and Nusa Tenggara, and also in economic corridor Sulawesi. On the other hand, a lowering disparity in real income per capita occurred in economic corridor Kalimantan, Papua and Maluku Isles (Graphic 4.38).

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6 Gini coefficient BPS is 0.38 (2010)
When calculating the *Theil Index* and the *Gini coefficient* in national level, the provincial disparity in real income per capita decreased. By economic corridor, we found a persistence in disparity within the economic corridor of Sumatera, Java, Bali, and Nusa Tenggara, Sulawesi and Papua and also in Maluku Isles. On the opposite, a lower disparity is evident in the economic corridor of Kalimantan. Furthermore, the economic corridor of Sulawesi and Bali has a better economic equality compared to other EC’s (Graphic 4.39 and 4.40).
Economic Corridor of Sumatera

During the last ten years, there is no significant change in the real income gap across provinces in the economic corridor of Sumatera. The Gini coefficient initially decrease, then slightly increase, and now decrease again but with slower trend.\(^7\) This could have a relation with the split of province Riau onto Riau province and Riau Isles. The latter has higher real income per capita than the other provinces in Sumatera.

The real income per capita (average during 2000-2010) in economic corridor Sumatera is as Rp 8,56 million, Riau recorded Rp 16,95 million, while the province of Riau Isles was Rp 24,56 million. If Riau and Riau Isles are excluded, the average real income per capita in EC Sumatera is only Rp 6,4 million (Graphic 4.41). The presence of the new province with a higher real income per capita than the average has increased the income gap in this economic corridor.

Furthermore, besides a better economic performance, the province of Riau and Riau Isles have bigger investment ratios compared to other provinces in EC Sumatera (Graphic 4.42). This fact indicates that these investments bring a positive influence in economic development in EC Sumatera.

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7 Gini coefficient EC Sumatera 0,31 (2000) becomes 0,29 (2010)
Economic Corridor of Java

A disparity persistency in income in economic corridor of Java is evident for the last ten years. The high real income per capita of DKI Jakarta is far above the other provinces in this economic corridor. The average of real income per capita (200-2010) in EC Java is Rp 10,5 million, while the DKI Jakarta reached Rp33,86 million. Excluding the DKI Jakarta, the average of the real income in this economic corridor becomes only Rp 5,9 million (Graphic 4.43).

Compared to other provinces, the DKI Jakarta has a higher investment ratio. Particularly before 2005, the DKI’s investment ratio had reached 35% from its Regional Bruto Domestic Product, while the other provinces achieved less than 25%. On the other hand, the real income per capita of DIY Yogyakarta and Banten have increased along with a higher investment ratio in both provinces (Graphic 4.44). By that, a higher investment activities comes a higher real income per capita.

Economic Corridor of Bali and Nusa Tenggara’s

The income disparity in the economic corridor of Bali and Nusa Tenggara is lower than the others, and is the second most equal corridor after EC Sulawesi. During 2000-2010, the average real income per capita in economic corridor of Bali and Nusa Tenggara is Rp 4,1 million. The highest income per capita in this corridor is in Bali, Rp6.3 million, Nusa Tenggara Barat Rp3.7 million, and Nusa Tenggara Timur Rp2.3 million (Graphic 4.45).

8 Gini coefficient for KE Jawa 0,39 (2000) and 0,40 (2010)
Province of Nusa Tenggara Barat eventually recorded high investment ratio during the last ten years. However, the absolute value of this investment is low relative to Bali (Graphic 4.46).

**Economic Corridor of Kalimantan**

The disparity of real income per capita significantly declined over the last ten years in economic corridor of Kalimantan. The Gini coefficient declined from 0.43 (2000) to 0.34 (2010), although these measures does not fall into low disparity in international standards. The decline of the Gini coefficient was driven by the increase of the real income per capita.
in Kalimantan Barat, Kalimantan Tengah, and Kalimantan Selatan. At the same time the real income per capita in Kalimantan Timur decreased since its economic growth is lower than the population growth.

On average, the real income per capita in economic corridor of Kalimantan is Rp 13.3 million with Kalimantan Timur gained the highest of Rp 32.9 million while the other provinces are way below. Kalimantan Barat recorded Rp5.8 million, while Kalimantan Tengah and Kalimantan Selatan shared similar per capita income of Rp 7.2 million (Graphic 4.48).

Historically, the investment ratio of Kalimantan Barat and Central Kalimantan is higher than that of Kalimantan Timur (Graphic 4.49). But, the economic size of these two provinces are far below Kalimantan Timur; in 2010 the regional Gross Domestic Product of Kalimantan Timur was Rp110.58 trillion, while Kalimantan Barat was only Rp30.29 trillion and Kalimantan Tengah was Rp18.79 trillion. Even the investment ratio was higher, but the absolute value of investment in Kalimantan Barat and Kalimantan Tengah was low and could not stimulate their economy better than Kalimantan Timur. The high economic growth in Kalimantan Timur is mainly driven by mining sector with the share of 34.78% from their regional GDP in 2000, and 40.22% in 2010.

**Economic Corridor of Sulawesi**

Sulawesi’s economic corridor has the best economic equality compare to other economic corridors. The Gini coefficient is approximately 0.18 during the last ten years, which is considered to low income disparity according to international standards. On average, the real income per capita during 2000-2010 is Rp4.5 million; the highest was in Sulawesi Utara of Rp6.3
million and the lowest was Gorontalo of Rp2.2 million (Graphic 4.50). The investment ratio in Gorontalo is sufficiently high, but it could not bring Gorontalo’s economy to the national average (Graphic 4.51).

**Graphic 22. Real Income per Capita, EC Sulawesi**

**Graphic 23. Investment Ratio, EC Sulawesi**

*pendapatan per kapita riil, konstan price tahun 2000
Source: BPS, calculated

Source: BPS, calculated

**Economic Corridor of Papua and Kepulauan Maluku**

In the last eight years, the disparity of real income per capita in Papua and Kepulauan Maluku has a declining trend, but slightly increase during the last two years. The average of the real income per capita during 2000-2010 in this economic corridor is Rp5.5 million. The highest average income per capita is in province of Papua (Rp9.3 million), then West Papua (Rp9.1 million), Maluku and North Maluku (Rp2.6 million), see Graphic 4.52.

Province of Papua and West Papua historically have a higher investment than Maluku and North Maluku (Graphic 4.53). This investment activities became the engine for economic growth in Papua and West Papua.
The Role of Infrastructure on Economic Growth in Indonesia

Table 4.4 summarizes the calculation of sigma convergence for all economic corridors above. In general, the real income distribution for the last ten years is less satisfactorily; both using the average of real income per capita and the Gini coefficient.

Table 4.4: Sigma Convergence

<table>
<thead>
<tr>
<th>Region</th>
<th>Real Income per Capita</th>
<th>Gini Coefficient</th>
<th>Sigma Convergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatera</td>
<td>8.56</td>
<td>0.29</td>
<td>Tidak</td>
</tr>
<tr>
<td>Jawa</td>
<td>10.57</td>
<td>0.40</td>
<td>Tidak</td>
</tr>
<tr>
<td>Banten</td>
<td>4.1</td>
<td>0.21</td>
<td>Tidak</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>13.3</td>
<td>0.34</td>
<td>Ya</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>4.5</td>
<td>0.18</td>
<td>Tidak</td>
</tr>
<tr>
<td>Maluku-Papua</td>
<td>5.5</td>
<td>0.31</td>
<td>Tidak</td>
</tr>
</tbody>
</table>

Source: BPS, calculated

The economic corridor of Java and Kalimantan have a real income per capita above the national average, but the disparity on these economic corridors are still high. Kalimantan is the only economic corridor which indicates the existence of sigma convergence. However, the sigma convergence in Kalimantan was driven both by the economic increase of Kalimantan Barat, Kalimantan Tengah, and Kalimantan Selatan, but also the economic decline in Kalimantan Timur (Table 4.4). Ideally, the convergence is a catching up process of the under developed region, without a decline in the wealthier one.
4.2. The $\beta$-Convergence

We estimate the GMM-system to test the $\beta$-convergence; the result is presented on the following table. Using AR (1) and AR (2) test, the model is proved to be free from serial correlation in the first order. Furthermore, the Hansen-diff statistic support and validate the use of instrumental variable in the model.

<table>
<thead>
<tr>
<th>Variabel Independen</th>
<th>OLS</th>
<th>Fixed</th>
<th>Random</th>
<th>GMM-Sys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constanta</td>
<td>0.400</td>
<td>1.619</td>
<td>0.400</td>
<td>0.442</td>
</tr>
<tr>
<td></td>
<td>4.000 ***</td>
<td>5.070 ***</td>
<td>4.170 ***</td>
<td>3.180 ***</td>
</tr>
<tr>
<td>Income per capita lag</td>
<td>0.862</td>
<td>0.513</td>
<td>0.862</td>
<td>0.825</td>
</tr>
<tr>
<td></td>
<td>37.340 ***</td>
<td>10.100 ***</td>
<td>44.430 ***</td>
<td>17.620 ***</td>
</tr>
</tbody>
</table>

**Production Factor Accumulation**

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed</th>
<th>Random</th>
<th>GMM-Sys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>0.060</td>
<td>0.054</td>
<td>0.060</td>
<td>0.081</td>
</tr>
<tr>
<td></td>
<td>5.800 ***</td>
<td>1.750 *</td>
<td>5.860 ***</td>
<td>3.260 ***</td>
</tr>
<tr>
<td>School year average</td>
<td>0.076</td>
<td>0.249</td>
<td>0.076</td>
<td>0.133</td>
</tr>
<tr>
<td></td>
<td>1.530</td>
<td>3.560 ***</td>
<td>1.800 *</td>
<td>2.100 **</td>
</tr>
</tbody>
</table>

**Infrastructure and corridor**

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed</th>
<th>Random</th>
<th>GMM-Sys</th>
</tr>
</thead>
<tbody>
<tr>
<td>electricity</td>
<td>0.052</td>
<td>0.337</td>
<td>0.052</td>
<td>0.088</td>
</tr>
<tr>
<td></td>
<td>3.060 ***</td>
<td>5.620 ***</td>
<td>3.270 ***</td>
<td>2.740 **</td>
</tr>
<tr>
<td>Roads</td>
<td>0.012</td>
<td>0.012</td>
<td>0.012</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>1.140</td>
<td>0.780</td>
<td>1.160</td>
<td>1.950 *</td>
</tr>
<tr>
<td>Harbours</td>
<td>0.009</td>
<td>0.001</td>
<td>0.009</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>2.780 ***</td>
<td>0.120</td>
<td>2.350 **</td>
<td>2.110 **</td>
</tr>
</tbody>
</table>

**Reformation and economic structure**

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Fixed</th>
<th>Random</th>
<th>GMM-Sys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanization</td>
<td>0.009</td>
<td>-0.060</td>
<td>0.009</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>0.460</td>
<td>-0.610</td>
<td>0.420</td>
<td>-0.860</td>
</tr>
<tr>
<td>Openness</td>
<td>0.008</td>
<td>0.053</td>
<td>0.008</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>0.570</td>
<td>2.110 **</td>
<td>0.710</td>
<td>2.090 **</td>
</tr>
<tr>
<td>Government Consumption sector</td>
<td>-0.022</td>
<td>0.020</td>
<td>-0.022</td>
<td>-0.054</td>
</tr>
<tr>
<td></td>
<td>-1.690 *</td>
<td>0.510</td>
<td>-1.430</td>
<td>-3.130 ***</td>
</tr>
<tr>
<td>Agricultural sector</td>
<td>-0.008</td>
<td>-0.009</td>
<td>-0.008</td>
<td>-0.013</td>
</tr>
<tr>
<td></td>
<td>-1.260</td>
<td>-1.070</td>
<td>-1.590</td>
<td>-1.360</td>
</tr>
</tbody>
</table>

Observation 229
AR(1) -1.18
AR(1) p-value (0.239)
AR(2) 0.70
AR(2) p-value (0.482)
Hansen J 22.71
Hansen J p-value (1.000)
Hansen-Diff J (GMM) -0.80
Hansen-Diff J (GMM) p-value (1.000)
Hansen-Diff J (IV) 0.79
Hansen-Diff J (IV) p-value (1.000)

***, **, and * significant in 1%, 5%, and 10%. The numbers in the second row are standard errors. Variable is stated as natural logarithm.

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9 Detail of the program is available on the author.
The coefficient of $\beta$ on We estimate the GMM-system to test the $\beta$-convergence; the result is presented on the following table. Using AR (1) and AR (2) test, the model is proved to be free from serial corelation in the first order. Furthermore, the Hansen-diff statistic support and validate the use of instrumental variable in the model.

Tabel 4.2 above is positive and significant with a convergence speed of 1.75%10. This is equivalent with the half life of about 41.14 years.11 The result shows the $\beta$-convergence is evident in Indonesia; where provinces with lower real per capita income will grow faster than those provinces with higher real per capita income (Graphic 4.54). However, the proses to converge require long time since the current gap between the rich and the poor region is very wide.

Nationally the $\beta$-convergence exists, but there is no evident for the presence of $\sigma$-convergence. Indonesia experienced an increase in real income per capita during the last ten years (Graphic 4.33); nevertheless, the distribution of this is unequal across provinces. Some provinces recorded a very high real income per capita, way above the national average12, namely DKI Jakarta and East Kalimantan. On the other hand, there are also provinces with very

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10 Derived from Equation (9), $\rho = e^{-\tau}$ therefore $0,825 = e^{-\tau} \Rightarrow \tau = 0,0175 = 1,75\%$
11 Half-life is a periode required for the convergence process to reduce half of the income gap across provinces. Calculated based on: half life $= 72/\tau = 72/1.75 = 41.14$ years.
12 On average, the national real income per capita during 2000-2010 is Rp 8,05 million with the median of Rp 5,9 million. This means the national income distribution is right-skewed, indicating more provinces with real income per capita below the national average.
low real income per capita, way below the national average, such as Nusa Tenggara Timur and Gorontalo (Graphic 4.34). In 2010, there are 28 provinces or 84.8% from total provinces recorded real income per capita below the national average.13

Our estimation above imply that even when the poorer provinces have tried to grow faster, the equal distribution in real income per capita across provinces in Indonesia is difficult to achieve (Graphic 4.55). One good reason behind this is the low starting point of real income per capita in poor provinces, which is possibly related to the capital availability particularly on building infrastructure to support the economic growth. In the production factor block, the estimated coefficient of the physical capital proxied with the value of investments is positive and significant. This confirms the first hypothesis that investment is one of the main determinant of the economic growth.

On the other hand, the estimated coefficient for schooling year average as a proxy for the human capital is also significant with positive sign. By that, good quality of human resource plays important role in explaining the disparity of per capita income across provinces in Indonesia. The regions with high quality human resource tends to have higher income per capita.

On hard infrastructure, the roads, the electricity, and the port services positively affect the income per capita. This indicate that a sufficient infrastructure both in quality and quantity, particularly electricity and transportation is a perquisite for a balanced and high economic growth. It is important to note the contribution of infrastructure on economic growth is still

13 Indonesia’s real income per capita in 2010 was Rp 9,2 million
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low in Indonesia, (Global Competitiveness Report 2012-2013); and occurs in almost basic infrastructure’s segments including, the roads, the harbor, the airports, the trains, and the electricity supply (Table 2).

Related to road infrastructure, the economic corridor of Java has the advantage over the other EC’s, with the ratio of 0.81 km per km² (average during 2000-2010). This is a lot higher than the national average of 0.34 km per km². Meanwhile, the economic corridor of Papua Maluku have only 0,05 km length of road per km square of its area. In addition to the road ratio above, one can also use the ratio of the road length per capita. In economic corridor of Papua and Kepulauan Maluku, the ratio is the highest in 2010 of 6.0 km/person. In EC Java, the ratio is only 0,8 km/person.

In Java, the road availability in serving the needs of the society has reached its limit due to a highly concentrated population. This fact is confirmed by Susanto, Bambang and Danang Parikesit (2004) who argued that the population density, either directly or indirectly, will reduce the regional competitiveness of transportation.14

We use urbanization as control variable in the model. The estimation shows the urbanization does not significantly affect the income per capita. Previously we constructed hypothesis that the urbanization will positively affect the per capita income, which is fail. This means the plenty urban civilians working in manufacture and service sector fail to stimulate the

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income per capita. The unbalanced economic growth lead the population to concentrate in the cities, since they provide more job vacancy, better healthcare, and better education.

The largest citizen living in the cities is in economic corridor of Java amounting to 69% in 2010, while the lowest one is in economic corridor of Papua and Kepulauan Maluku of 27%. The ratio is increasing due to the growth of population and because of urbanization. For this reason, one has to control the high urbanization rate by distributing the economic activities.

The share of agriculture sector in total GDP does not affect the income per capita significantly. Although the sign of the estimated coefficient is similar, Demurger (2001) found the agricultural sector significantly give a negative impact on economic growth. The negative sign relates to the technology access, where a region depending more on agricultural sector will have lower opportunity to gain positive effect from the latest technology. This is contrary to the region with heavy industrial sector activities.

The openness positively and significantly affect the income per capita. When a region is more open, the opportunity to gain productivity improvement from technology spillover is larger, and this can help rising their wealth.

The last variable included on the model is the government expenditure, which negatively and significantly affect the real per capita income. This result encourage the local government to allocate their spending on a more productive post including capital spending and investment.
V. CONCLUSION

This empirical research provides some interesting conclusions; first, the resiliency of the Indonesia’s economic growth has managed to lift the average real income per capita. Second, although the national real income per capita has increased, there is no evident for equal distribution on the real income per capita across provinces. Third, the β-convergence exist with a convergence speed of 1.75% or equal to the half life of approximately 41.14 years. By that, the provinces with lower real income per capita will grow higher compared to provinces with higher real income per capita. Forth, σ-convergence has not yet occurred in Indonesia’s economy, which means there is still an imbalance in real income per capita across provinces in this country. Fifth, the infrastructural road condition and electricity significantly affect the growth of income per capita. Sixth, the investments is empirically proven to be a determinant for the economic growth in Indonesia.

It is necessary to note that this paper assumed no spatial dependence when testing the convergence, which is too restrictive. The spatial interaction is absolute, where naturally a region is open to other region for trades, technological diffusion, and production factor mobility, which will affect the convergence in respective regions. Future research needs to address the spatial analysis.

The empirical findings above has a few policy implications; first, the government policy needs to be directed to push the growth of the underdeveloped provinces. Second, the use of budget should focus more on capital accumulation both infrastructure and human capital. Third, building infrastructure must consider the geographical aspects and relative needs of the respective region.
REFERENCES


Badan Pusat Statistik, several years. Statistik Indonesia.


International Institute for Management Development, several years. World Competitiveness Year Book.


Perusahaan Listrik Negara, several years. Statistik PLN.


