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Infrastructure and human development: the case of Java, Indonesia

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This study examines the relationship between infrastructure and human development in Java, Indonesia, using regency-level 2002–2005 panel data. We find that improving infrastructure significantly enhances human development. In particular, electricity infrastructure has a greater influence on human development than other types of infrastructure, such as clean water, roads or the number of classrooms per student. We find that for every 1% increase in the proportion of households with electricity, the human development index (HDI) increases by 0.2%. Improvements in other types of infrastructure lead over the long run to lesser increases in the HDI, ranging from 0.01% to 0.03%.

Keywords: infrastructure; human development index; Java; panel data

JEL classifications: O15, O18, R11

1. Introduction

Indonesia consists of five main islands: Kalimantan, Sumatra, Irian Jaya, Sulawesi and Java. Java is located midway across the lower Indonesian archipelago and covers an area of approximately 132,246 square km. Despite being only the third-largest Indonesian landmass, Java is the most populous island and its 128 million inhabitants comprised around 59% of the republic's population in 2005 (BPS-Statistics Indonesia 2005). Java consists of six provinces: DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java and Banten. Java also includes the island of Madura.

Java enjoys the highest level of economic development of any region in Indonesia, and its contribution to the Indonesian economy is significant, comprising 59% of the gross domestic product (GDP). In 2005, the gross regional domestic product (GRDP) at current prices amounted to 1571 trillion rupiahs. The province of DKI Jakarta has the highest GRDP compared with other provinces in Java or in Indonesia generally (Table 1).

The quality of human resources in Indonesia, measured by the human development index (HDI) of the United Nations Development Programme (UNDP), falls into the medium range by international standards. In 2005, the HDI of Indonesia (72.8) ranked 107th in the world (UNDP 2007). Moreover, although Java's HDI is commensurate with its status as the most highly developed area in Indonesia, it is far below the international standard (the global average is above 80). The HDI for DKI Jakarta province, which is the highest HDI in Indonesia, is only 76.1 (Table 1).

The level of human development in Java varies widely between urban and rural areas. Most regencies that are located far from the capital province fall into the lower-middle HDI

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Table 1. GRDP by province and HDI, 2005.

Provinces	GRDP*	HDI
Nanggroe Aceh Darussalam	34,942	69.0
North Sumatra	87,898	72.0
West Sumatra	29,159	71.2
Riau	79,284	73.6
Jambi	12,620	71.0
South Sumatra	49,635	70.2
Bengkulu	6239	71.1
Lampung	29,326	68.8
Bangka Belitung Islands	8226	70.7
Riau Islands	30,382	72.2
Sumatra	**367,710**	–
DKI Jakarta	295,270	76.1
West Java	245,798	69.9
Central Java	143,051	69.8
Dista Yogyakarta	16,940	73.5
East Java	256,375	68.4
Banten	58,107	68.8
Java	**1,015,541**	–
Bali	21,072	69.8
Java and Bali	**1,036,613**	
West Kalimantan	23,450	66.2
Central Kalimantan	13,960	67.4
South Kalimantan	21,555	67.4
East Kalimantan	93,589	63.6
Kalimantan	**152,555**	–
North Sulawesi	12,745	74.2
Central Sulawesi	11,729	68.5
South Sulawesi	36,424	68.1
South-East Sulawesi	8027	67.5
Gorontalo	2025	67.5
West Sulawesi	3121	65.7
Sulawesi	**74,070**	
West Nusa Tenggara	15,225	62.4
East Nusa Tenggara	9739	63.6
Maluku	3259	69.2
North Maluku	2237	67.0
West Irian Jaya	5302	64.8
Papua	22,237	62.1
Others	**58,000**	
Total all provinces	**1,688,948**	**69.6**

Note: *Billion rupiahs at 2000 constant price. Source: BPS Statistics Indonesia.

category, while regencies or municipalities that are near the capital province are more likely to fall into the upper-middle category (Figure 1). This difference in human development across the regencies results primarily from differences in educational achievement, such as mean years of schooling, and in living standards, as reflected in per capita consumption. Based on this fact, human development in Java remains in need of attention.

The Indonesian government engaged in an extensive programme of infrastructure development to foster economic growth prior to the economic crisis of 1997–1998. Infrastructure investment represented more than 5% of GDP before the crisis, but it has dropped to about 2% in recent years, largely because of the cancellation or postponement of many planned

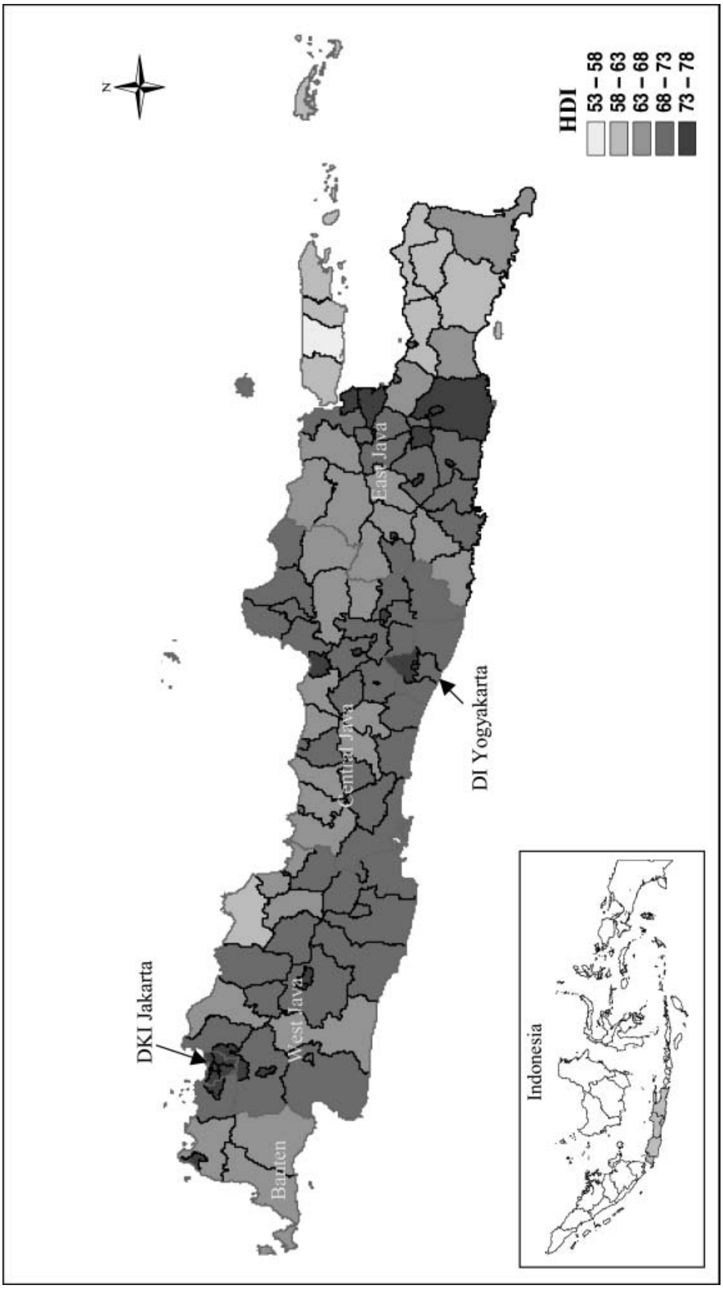

Figure 1. Map of HDI in Java. Source: BPS-Statistics Indonesia.

public and private infrastructure investment projects (ADB 2006). While Indonesia outperformed countries such as China, Thailand and Sri Lanka in 1996 in terms of overall infrastructure quality, these countries had surpassed it by 2004. In 2006, Indonesia ranked only 89th of 125 countries that were surveyed for the World Economic Forum's Global Competitiveness Report (Lopez-Claros *et al*. 2006). Currently, about 50 million Indonesians lack access to treated water, 90 million have no access to electricity and nearly 200 million do not have direct access to telecommunications or connections to a sewerage network. Moreover, the general scarcity of infrastructure services in rural areas, particularly outside Java and Bali, has contributed to significant regional disparities in development (ADB 2006).

Several factors have contributed to Indonesia's infrastructure deficiencies (World Bank 2005). First, the economic crisis of 1997–1998 dramatically reduced the country's financial capacity to maintain existing infrastructure or invest in new infrastructure. The bank estimated, for example, that only 3% of GDP was allocated to infrastructure maintenance and development in 2002, down sharply from 7% in 1996. Second, even before the crisis, infrastructure development was impeded by Indonesia's poor institutional and regulatory framework as well as corruption. Third, although local governments have been assigned control of infrastructure within regional economies, they have not been provided with adequate funding; in addition, there are overlaps between the various levels of government in the provision of infrastructure. McLeod (2005) suggests that government pricing policies that apply to infrastructure services have also contributed to infrastructure deficiencies. Infrastructure projects in several areas, involving roads, water, electricity and telecommunications, often operate under non-market conditions, with services provided at regulated prices set well below costs and with correspondingly limited prospects for realizing profits. This forces the government to carry a greater budgetary burden as the need for and provision of infrastructure increases.

The development literature recognizes that infrastructure serves as a catalyst for economic development, by improving access to resources and enhancing the impact of policy intervention (Aschauer 1989, World Bank 1994). Infrastructure is the aggregate of resources in terms of facilities and mechanisms that support education, health care, community development, income distribution, employment and social welfare. Infrastructure services affect people in many ways. People use such services to warm and light their homes, consume and produce products, and communicate with each other. In addition, the availability of infrastructure services, such as transportation, that are needed for the distribution of raw materials to factories and of finished products to markets affects business profitability and competitiveness (see e.g. Jacoby 2002).[1]

Despite the importance of infrastructure to economic and human development, the related literature features very little research designed to quantify the magnitude of its impact. Several extensive surveys on the status of infrastructure in Indonesia have been conducted, including the World Bank (2005), McLeod (2005), Soesastro and Atje (2005), Narjoko and Jotzo (2007), Sen and Steer (2005) and Lindblad and Wie (2007). Nevertheless, very few studies have analyzed the relationship between infrastructure and human (or economic) development (the few exceptions include Mawardi 2004 and Mustajab 2009). This research is therefore a first attempt to fill this gap by exploring the relationship between the availability of infrastructure networks and the level of human development in Java.

This paper is organized as follows. Section 2 provides a literature review on human development and infrastructure. Section 3 explains the methodology and dataset used in this study. Section 4 presents the empirical results. Finally, Section 5 provides concluding remarks and policy implications.

2. Infrastructure and human development

In recent decades, the general approach to economic development has changed dramatically because of two issues that have emerged in the literature: human development and sustainable development (World Bank 1991, Todaro and Smith 2006). The human development (HD) paradigm developed by the UNDP focuses on how development can enlarge people's social, economic and political choices by expanding freedoms and capabilities. The human development paradigm is based on the concept of human well being (see e.g. Sen 1985).

The UNDP began collecting data to support the publication of an HDI at the aggregate level in 1990. The HDI has become a major instrument for measuring human welfare. The UNDP annually produces an HDI for every country in the world. In addition, country-based human development indices make it possible to assess regional levels of development within countries. Under this approach, human development is concerned not only with personal income but also with other welfare variables that directly influence the quality of human life. These variables include health and education. The index implies that human development rises as people become better educated and lead longer lives as well as enjoy higher income per capita.

Infrastructure has been defined in terms of physical facilities (e.g. roads, airports, utility supply systems, communication systems, water and waste disposal systems, education and public health facilities) and services (water, sanitation, transportation and energy) flowing from those facilities (ESCAP and AITD 2003). Therefore, we can evaluate the impact of infrastructure investment on development by measuring how the availability of infrastructure can increase opportunities, directly or indirectly, for people to raise income levels and obtain access to education and healthcare facilities. For example, easier access to infrastructure increases profits by lowering input costs. This should lead to increased income.

Very few studies in the literature have analyzed the infrastructure transmission mechanism as it affects human development. The effectiveness of alternative infrastructure investments varies across regions and sectors. For example, Leung and Meisen (2005) find that raising electricity consumption per capita can directly stimulate faster economic growth and indirectly achieve enhanced social development, especially in countries in which the UNDP rates the level of human development as medium or low. Ali and Pernia (2003) show that rural infrastructure investments can improve farm and non-farm productivity and increase human development by raising average income and consumption. Duffy-Deno and Eberts (1991) also show that public infrastructure has positive and statistically significant effects on per capita personal income. According to Fan and Zhang (2004), rural infrastructure and education play an important role in explaining rural non-farm productivity. The rural non-farm economy is a major determinant of rural income, so increasing investment in rural infrastructure is a key to increasing the income of rural populations. Ezcurra *et al*. (2005) find that public infrastructure can reduce private costs and increase productivity. Estache and Fay (1995) show that improved access to road networks and sanitation has been a key factor in income convergence across the poorest regions in Argentina and Brazil. Moreover, infrastructure access can increase the value of poor people's assets, leading to higher income.

Angrist and Lavy (1999) and Case and Deaton (1999) summarize some evidence pertaining to the causal relationship between spending on school facilities and improvement in attendance, especially among poor children. Lokshin and Yemtsov (2005) also find that improvement in school infrastructure produces nontrivial benefits in school enrollment rates, increases school attendance and reduces health risks for school-age children. Better transportation systems and roads also help raise school attendance. In terms of healthcare facilities, access to safe water and sanitation plays a key role. The consumption of infrastructure services, such as clean water and sanitation, at the household level contributes to economic welfare, because it is essential to health and creates environmental amenities. Behrman and Wolfe (1987) and Jalan and Ravallion (2003) summarize this connection in showing that access to safe water has contributed significantly to reducing child mortality.

3. Methodology

3.1. *Model*

To analyze the impact of infrastructure on the Javanese HDI, we specify a dynamic panel-data model as follows:

$$\mathrm{lnHDI_{it}} = \alpha_0 + \alpha_1 \mathrm{lnHDI_{it-1}} + x_{\mathrm{it}}{}'\beta + \mathrm{u_{it}}, \tag{1}$$

$$\mathrm{u_{it}} = \mu_{\mathrm{i}} + \varepsilon_{\mathrm{it}}. \tag{2}$$

In Equation (1), the dependent variable is the logarithm of the HDI in regency *i* at time *t* and x_{it} represents a set of independent variables. The variable lnHDI_{it-1} is the first lag of lnHDI. The first-order dynamic specification allows us to distinguish between the short-run and long-run effects of the independent variables. In the equation, α_1 is the coefficient on the lagged lnHDI and represents the speed of adjustment. Static models assume that this parameter is equal to zero.[2] The independent variables include $\mathrm{LnELECT}_{it}$, the logarithm of the share of households using electricity; $\mathrm{LnWATER}_{it}$, the logarithm of the share of households with access to tap water, packaged water, water pumps or protected springs that are at least 10 m in distance from a septic system; LnROAD_{it}, the logarithm of total road length per square kilometer; and LnEDUC_{it}, the logarithm of the number of classrooms in senior high schools per total population from 16 to 18 years old. The unobserved country-specific effects are captured by μ_i and the mean-zero transitory shock is specified as ε_{it}.

3.2. *Estimation*

There is a problem with the estimation of Equation (1) due to correlations between the independent variables and the error term. The variables in x_{it} may be correlated with $u_{it;}$ moreover, the lagged HDI, lnHDI_{it-1}, is also correlated with $u_{it} = \mu_i + \varepsilon_{it}$ by construction. Therefore, estimating the model using ordinary least squares (OLS) will produce a biased and inconsistent estimator. Estimating the model thus requires instrumental variables (IVs) that are correlated with the independent variables but uncorrelated with the error term. If the IVs are weak, however – poorly correlated with the explanatory variables – even IV estimates will be biased and inconsistent. Anderson and Hsiao (1982) proposed employing the model with first differencing and using the twice-lagged level or the twice-lagged difference of the dependent variable (lnHDI) to instrument the once-lagged difference of the lagged variable. Arellano and Bond (1991) proposed a generalized method of moments (GMM) estimator for panel data, which includes instruments providing additional information about potentially endogenous explanatory variables. The regression equations are expressed in terms of first differences, thus eliminating the time-invariant effects (in our case, u_i), and endogenous explanatory variables are instrumented with suitable lags at their own levels.

The GMM estimator achieves significant gains in efficiency as compared with the estimator used by Anderson and Hsiao (1982), but it also has a weakness. When the lagged levels are weakly correlated with the difference of the explanatory variables, the supplementary instruments included by the estimator are not very useful. Arellano and Bover (1995) suggest an improved panel-data GMM estimator, which is fully developed by Blundell and Bond (1998). Arellano and Bover's panel-data GMM estimator, in which they arrange the regression equations in levels, expresses the additional instruments in lagged differences. Blundell and Bond (1998) augment the original differences between the GMM estimators with the level-equation estimator to form a system of equations known as 'system GMM'. The resulting system of regression equations, arranged in differences as well as levels, has better asymptotic and finite sample properties than the Arellano and Bond (1991) differences GMM estimator. In the context of our study, system GMM allows us to deal with endogeneity and regency-specific effects.

To help overcome difficulties linked to endogenous explanatory variables, system GMM uses a potentially large matrix of available instruments and weights them appropriately. However, the inclusion of extra instruments requires additional moment conditions. In our case, the additional moment conditions can be formalized as follows:

$$E(\Delta u_{it} \ln HDI_{i,t-k}) = 0, \quad E(\Delta u_{it} x_{it-k}) = 0, \quad \text{where } t = 3, \ldots, T \text{ and } k \geq 2. \tag{3}$$

$$E(u_{it} \Delta \ln HDI_{i,t-k}) = 0, \quad E(u_{it} \Delta x_{it-k}) = 0, \quad \text{where } t = 4, \ldots, T \text{ and } k \geq 1. \tag{4}$$

Equation (3) comes from the difference GMM estimator's need for orthogonality between the differences of the errors and the lagged levels of the variables, which serve as instrumental variables. Equation (4) comes from the level-equation GMM estimator's need for orthogonality between the error term (and the regency-specific effect) with the lagged differences of the variables. We assume that all independent variables introduced in our study are endogenous. For example, improvements in infrastructure can increase the HDI, while changes in the HDI can in turn contribute to changes in infrastructure. It is therefore a case of simultaneity running between HDI and infrastructure.

In this study, we first analyze the effect of infrastructure availability on the HDI (Table 5). We then investigate the relationship between infrastructure and each of the components of HDI, which include life expectancy (LIFE), adult literacy rate (LITERACY), mean years of schooling (SCHOOLING) and real per capita expenditure (PPE). For comparison purposes, we also estimate static models that assume that the HDI responds instantaneously to changes in infrastructure. Thus, the model represents long-run relationships between the variables. We estimate the static model using the fixed-effects method.

3.3. *Data*

The human development measurement used in this study is the aforementioned HDI compiled by the UNDP. The HDI measures the average achievements of a country or a region along three dimensions of human development:

- longevity, as measured by life expectancy at birth;
- knowledge, as measured by a combination of the adult literacy rate (weighted at two-thirds), and mean years of schooling (weighted at one-third);
- standard of living, as measured by real per capita income.

The study focuses its analysis on four basic types of infrastructure in Java: electricity, clean water, roads and schools. The data in the HDI are obtained from BPS-Statistics Indonesia, the National Development Planning Agency (Bappenas) and the UNDP. The data on household electricity use and safe water access were collected from BPS-Statistics Indonesia. The data on the total length of roads were gathered from the Ministry of Public Works and the Ministry of Transportation. The data on number of classrooms were obtained from the Ministry of Education.

The dataset in this study covers all regencies or municipalities on the island of Java except for the Kepulauan Seribu regency, as there were no data on roads in this regency available. Java consists of six provinces and 115 regencies/municipalities. The models are estimated with a panel dataset for 114 regencies/municipalities in Java. Reflecting the availability of data, the dataset covers the 2002–2005 time interval. Table 2 shows sample statistics for each variable.

Before discussing the main empirical results, we explore the relationship between the distribution of per capita regional income and the distributions of social and infrastructure indicators. For this purpose, we implement a simple regression analysis where regency-level per capita income is regressed on the social indicators – life expectancy (LIFE), adult literacy rate (LITERACY) and mean years of schooling (SCHOOLING) – and the infrastructure indicators – electricity (ELECT), access to water (WATER), total road length per square kilometer (ROAD) and the number of classrooms (EDUC). We use a between estimator to explore how the cross-regional differences in per capita income are associated with differences in the indicators across regencies rather than a within estimator that would investigate how a change in per capita income within a regency is related with a change in other variables within the same regency over time. Tables 3 and 4 show the results of the regressions. We find that per capita income is positively related to life expectancy, literacy and mean years of schooling. When a given regency has a per capita income that is 1% greater than that of other regencies, its life expectancy, literacy and mean years of schooling are greater by 0.02%, 0.056% and 0.19%, respectively, than those of other regencies. We

Table 2. Sample statistics.

Variable	Mean	Median	Standard deviation	Maximum	Minimum
Human development index (HDI)	68.183	68.350	4.59	77.900	49.700
Life expectancy (LIFE)	67.640	68.100	3.21	73.100	57.500
Adult literacy rate (LITERACY)	88.754	89.200	7.73	99.600	56.200
Mean years of schooling (SCHOOLLING)	7.219	6.700	1.67	11.000	2.900
Real per capita expenditure (PPE)	612.248	614.350	14.54	640.500	579.400
Share of household using electricity (ELECT)	96.992	98.435	4.26	99.920	69.350
Share of households with access to water (WATER)	53.111	51.620	15.68	99.460	19.850
Total road length per square kilometer (ROAD)	2.719	0.800	28.31	17.630	0.250
Number of classrooms per student (EDUC)	0.019	0.012	0.03	0.135	0.005

Table 3. Per capita GRDP and social indicators (between estimator).

Dependent variable	GRDP per capita	*R*-squared	Number of observations (number of groups)
LnLife	0.017 (2.83)*	0.066	460 (115)
LnLiteracy	0.056 (5.42)*	0.207	460 (115)
LnSchooling	0.191 (8.55)*	0.392	460 (115)

Notes: (1) The numbers in parentheses are *t*-statistics. (2) *Significant at the 1% level.

also find that differences in the distribution of infrastructure indicators are affected by cross-regional differences in per capita income. ELECT, WATER, ROAD and EDUC are greater by 0.018%, 0.13%, 0.17% and 0.29%, respectively, when a given regency has a 1% greater per capita income.

4. Empirical results

Table 5 presents the estimation results of the dynamic model for the determinants of HDI and its components. The first column represents the effects of the infrastructure variables on HDI. The result shows that all infrastructure availability variables do show significant positive correlations with the HDI in Java. Among the infrastructure indicators, the share of households using electricity, denoted by ELECT, exerts the greatest influence on improvement in the HDI. Conversely, this suggests that the lack of infrastructure can pose a significant hindrance to human development and erode the quality of human life. According to the World Bank (2005), for example, 43% of the population in Indonesia, roughly 90 million people, is without power. In particular, over 6000 villages – mostly in rural areas outside of Java–Bali – still do not have electricity connections. To reverse the trend toward infrastructure deterioration, Indonesia has adopted several reform initiatives, such as a modern electricity law and new oil and natural gas laws, but the impact of such reforms has been limited because the government has not developed a broad enough infrastructure strategy and its overall policy approach has been unpredictable (see the World Bank 2005).

The dynamic model used here not only accounts for endogeneity using the instrumental variables but also distinguishes between the short-run and long-run effects of infrastructure. For example, a 1% change in the share of households with electricity at time *t* will lead to a 0.059% change in the current HDI in the short run, as the magnitude of HDI can be calculated using the estimated coefficient on ELECT. Similarly, 1% changes in household

Table 4. Per capita GRDP and infrastructure indicators (between estimator).

Dependent variable	GRDP per capita	*R*-squared	Number of observations (number of groups)
LnElect	0.018 (3.51)**	0.098	458 (114)
LnWater	0.130 (3.90)**	0.118	458 (114)
LnRoad	0.168 (3.28)*	0.261	456 (114)
LnEduc	0.287 (2.96)*	0.072	460 (114)

Notes: (1) The numbers in parentheses are *t*-statistics. (2) *Significant at the 5% level and **significant at the 1% level.

Table 5. Regression results (dynamic model).

Variable	LnHDI	LnLIFE	LnLiteracy	LnSchooling	LnPPE
Lagged dependent variable	0.709 (42.45)***	0.794 (43.29)***	0.556 (21.48)***	0.565 (19.20)***	0.544 (19.09)***
LnELECT	0.059 (3.13)***	0.016 (1.260)	0.052 (1.73)*	0.339 (4.33)***	0.025 (0.73)
LnWATER	0.010 (4.12)***	0.002 (1.34)	0.001 (0.20)	0.012 (1.38)	0.006 (1.62)
LnROAD	0.003 (2.60)***	0.001 (0.86)	0.025 (8.09)***	0.015 (1.65)*	0.062 (6.51)***
LnEDUC	0.006 (3.46)***	0.005 (3.64)***	0.002 (0.71)	0.027 (3.58)***	0.009 (2.13)**
Constant	0.954 (10.82)***	0.812 (9.35)***	1.761 (12.11)***	−0.633 (−1.94)*	2.841 (13.55)***
Number of observations	342	342	342	342	342

Notes: (1) The numbers in parentheses are *t*-statistics. (2) *Significant at the 10% level, **significant at the 5% level and ***significant at the 1% level.

Table 6. The long-run effects of infrastructure on HDI.

Variable	HDI	LIFE	Literacy	Schooling	PPE
ELECT	0.203	0.078	0.117	0.779	0.055
WATER	0.034	0.010	0.002	0.028	0.013
ROAD	0.010	0.005	0.056	0.034	0.136
EDUC	0.021	0.024	0.004	0.062	0.020

Note: The numbers indicate the percentage change in HDI components corresponding to a 1% change in each infrastructure indicator.

shares of those having access to water (WATER), total road length (ROAD) and the number of classrooms per student (EDUC) at time *t* will contribute to 0.01%, 0.003% and 0.006% changes in the current HDI, respectively. Meanwhile, we can also estimate the long-run effects using the estimated parameters. The long-run effects are estimated by dividing the estimated individual parameters by one minus the size of the parameter estimated on the lagged HDI (see, for example, Greene 2008, p. 679). For instance, the long-run effect of electricity on the HDI becomes 0.059/(1 – 0.709). Therefore, for every percentage point increase in the share of households using electricity (ELECT), the HDI will increase by 0.203% over the long run. Meanwhile, every 1% change in household shares with water access (WATER), total road length per household (ROAD) and educational facilities per student (EDUC) leads to an increase in the HDI by 0.034%, 0.01%, 0.021%, respectively (see Table 6).[3]

We also report the results of the static model, which assumes that the coefficient of the lagged HDI equals zero in Equation (1), in Appendix 1. The model suggests that any HDI response corresponding to a change in any infrastructure variable is instantaneous. The magnitudes of the coefficients obtained in the static model may be incorrect, however, as the parameter estimates are inconsistent when the static model does not account for the endogeneity between infrastructure and the HDI. Also, from the dynamic model, we reject the null hypothesis that the coefficient of the lagged HDI is not zero.

The figures shown in columns 2–5 in Table 5 represent the results for each component of the HDI. We find that the coefficients of the lagged dependent variables are highly significant, while the effects of short-run contemporary changes on the independent variables are insignificant in many cases. This suggests that it takes time for the effects of infrastructure improvements to produce changes in the HDI. Therefore, the long-run effect is much greater than the short-run effect. For example, in the short run, a 1% change in the share of households with access to electricity will lead to a 0.052% change in adult literacy while, in the long run, it will cause a 0.12% change in adult literacy (see also Table 6).[4] We find that the share of households with electricity (ELECT) has a dominant effect on each HDI component. It is surprising that the share of households with electricity (ELECT) has a greater influence on adult literacy (LITERACY) than the availability of educational facilities (EDUC) or mean years of schooling (SCHOOLING).

Our results verify that infrastructure is a key determinant of conditions in which the quality of life in Indonesia can increase. A remaining issue is then how to provide such infrastructure. The World Bank (2005) suggests that a comprehensive strategy is required for the successful provision of infrastructure, and that such a strategy should target better public management, better planning and more consistent infrastructure development policies. The report also suggests that, while the public sector is likely to remain dominant in terms of infrastructure development, the private sector must play a role by providing expertise, fostering competition, improving efficiency and easing finance constraints. A comprehensive plan for mobilizing infrastructure financing is also required. Narjoko and Jotzo (2007) indicate, for example, that the public sector's capacity to generate electricity expanded by a mere 1.4% per year between 1998 and 2005. Moreover, it is predicted that an annual investment of $2–3 billion until 2010 is needed to achieve modest growth in electricity demand, and that Indonesia needs to increase infrastructure investment by about 2% of GDP (World Bank 2005). Improved tax collection and reallocation of unproductive spending would enable the central government to increase public infrastructure spending. Over the long run, sources of financing should be diversified to include tapping into domestic savings such as pension and insurance funds. More subnational borrowing in domestic markets can be stimulated by strengthening local government institutions and capacities.

5. Conclusion

The aim of this study is to explain the relationship between infrastructure availability and the HDI. For this purpose, we employ panel data that cover 114 regencies in Java from 2002 to 2005. We estimate both static and dynamic panel-data models.

First, we investigate the relationship between infrastructure availability and the HDI in Java. We then examine the relationship between infrastructure availability and each component of the HDI. The infrastructure we consider includes electricity, clean water, roads and the number of classrooms.

The results of the empirical analysis show that all infrastructure availability variables show significant positive correlations with the HDI in Java over the long run. We find that electricity has the greatest influence on improvements in the HDI. For every 1% increase in the number of households with electricity, the HDI will increase by 0.2% over the long run. Meanwhile, a 1% increase in the WATER, ROAD and EDUC variables leads to corresponding increases in the HDI by 0.03%, 0.01% and 0.02%, respectively. We also find that the HDI responds to changes in infrastructure with a time lag. Therefore, we need to distinguish between the long run and the short run in evaluating the influence of infrastructure. For example, a 1% change in the number of households with electricity at time t is related to only a 0.06% change in the current HDI. Changes in other variables at time t will each contribute to an approximately 0.01% change or less in the current HDI. Therefore, improvements in infrastructure will eventually lead to improvements in the HDI.

The main implication of the study is that infrastructure development deserves more attention from the government. A comprehensive strategy for the provision of infrastructure should include diversifying financial resources and increasing private sector participation. Furthermore, in an era marked by regional autonomy, the institutions and capacities of local governments need to be strengthened by designing policies that reinforce infrastructure development. The availability of sound infrastructure in a region can attract private and public investment, which in turn can lead to accelerated rates of economic and human development.

Notes

1. In this paper, we are mainly concerned with how infrastructure affects human development (or economic development). We nevertheless acknowledge that there is an endogeneity issue between infrastructure and human development in the sense that human development can influence infrastructure and infrastructure can influence human development.

2. Without the lagged HDI variable, the independent variables represent the full set of information that produces an observed outcome $\ln HDI_{it}$. With the lagged lnHDI, all the information about the previous history of x_{it}, where $t = 1,2, \ldots, t-1$, is captured by $\ln HDI_{it-1}$ and any impact of x_{it} represents the effect of new information. See Greene (2008, p. 469).
3. When we alternatively use the length of paved road instead of total road length, the coefficients in the regression models decrease slightly. The coefficients on total roads range from 0.001 to 0.062 across the full models and from 0.003 to 0.053 in the static models. Meanwhile, the sizes of the coefficient on paved roads range from 0.001 to 0.030 in the full models and from 0.001 to 0.024 in the static models.
4. To check the sensitivity of the results we found, we exclude the four largest urban areas – Jakarta, Semarang, Bandung and Surabaya – as they are likely to have better infrastructure than other areas. We find that our results are robust with the exclusion of these areas. It seems therefore that the relationship between infrastructure and human development holds, in general, across regencies with varying levels of development.

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Appendix 1. Regression results (static model)

Variable	LnHDI	LnLIFE	LnLiteracy	LnSchooling	LnPPE
LnELECT	0.248	0.080	0.145	0.463	0.172
	(5.767)***	(4.375)***	(3.92)***	(5.84)***	(4.45)***
LnWATER	0.018	0.009	0.014	0.038	0.008
	(2.729)***	(3.086)***	(2.38)**	(3.11)***	(1.32)
LnROAD	0.046	0.016	0.014	0.053	0.043
	(6.030)***	(4.927)***	(2.07)**	(3.75)***	(6.21)***
LnEDUC	0.055	0.015	0.019	0.018	0.058
	(10.617)***	(6.586)***	(4.33)***	(1.86)*	(12.47)***
R-squared	0.512	0.349	0.191	0.218	0.535
Number of observations	456	456	456	456	456

Notes: (1) The numbers in parentheses are *t*-statistics.
(2) The static models are estimated by the fixed-effect models.
(3) *Significant at the 10% level, *significant at the 5% level and ***significant at the 1% level.