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Evaluating the role of infrastructure development on economic performance across Papua's regencies

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Abstract

The aim of this study is to evaluate the role of infrastructure investment on the economic performance of Papua regions. The Economic performance indicator measured in this study is labor productivity and employment. A panel dataset was created combining annual data, provided by BPS Papua, consisting of 29 regions between 2012-2018. The findings suggest that as road connection increases, employment return from infrastructure investment is higher while there is insignificant effect on labor productivity. Investment in education infrastructure is associated with an increase in labor productivity. Employment specialization is also incorporated in the analysis to understand the potential benefits from infrastructure investment, where we find that road connection increases labor productivity but less supportive for employment growth in agriculture specialized region. This suggests that road connection supports employment in bigger cities.

1. Introduction

1.1.Background

Infrastructure investment is one of the oldest forms of policy objectives. The fact that infrastructure condition remain as development issues in many countries would indicate that infrastructure investment is still an important today's policy agenda (Global Competitiveness Report, 2018). Advocates of spatially blind policies would suggest that any economies should benefit more for infrastructure investment as they are expected to generate positive externalities and contribute to growth. While infrastructure endowments are high in developed countries, one may suggest that developing countries should invest more in infrastructure due to larger expected return. Even though small economies need more investment, its economic characteristics have a serious economic implication with respect to investment flows as Lucas Paradox entails that investment may not flow to the lagging regions even when the economy is open. Moreover, knowledge spill over arises from more investment in larger regions may not be enough to stimulate economic activity in the lagging regions which may mean that attempts to increase infrastructure investment at regional level is necessary.

There are several reasons why researchers argue that infrastructure investment increases national competitiveness. The first benefit is that infrastructure investment increases national productivity. This is firstly pointed out in the prominent research of infrastructure investment by Ascheur (1989). Accordingly, the most 'basic infrastructure' has the strongest effect on national productivity. This suggests that more investment in basic infrastructure is very important for economic development. Although Seitz (2001) argued that the estimates of the Ascheur (1989) may be dependent on the estimation techniques, researchers still found that the positive link is robust. This is related to Biehl (1991) who found the relationship between productivity and infrastructure endowments being upward sloping. Some researches demonstrated that there is a positive long run relationship between physical infrastructure investment and income level (Barro, 1990; Canning & Bennathan, 2000). Moreover, Calderón and

Servén (2010) illustrated that infrastructure investment may reduce poverty. Oxford Business Report (2019) claimed that poor quality of infrastructure may impede economic growth. One of the basics of infrastructure is transport connectivity. Countries are interested to purchase goods and services that can provide lower costs. Conrad & Seitz (1994) found that provision of public infrastructure services lead to significant cost savings. As there is increasing connectivity, transportation costs become lower which may promote trade activity.

In addition, Munnell (1990) found that infrastructure investment increases employment. One idea is that more connectivity improves job accessibility which triggers employment generation in the region. Heintz, Pollin, and Peltier (2009) disaggregated sources of job creation as direct, indirect, and induced effect. The authors claimed that infrastructure investment is an effective job creation tool. As higher employment growth resembles better welfare, it seems that infrastructure investment will generate positive impact for competitiveness and a reliable development tool.

1.2.Research motivation

While research on the relationship between infrastructure investment and economic development has been done, most of the prominent studies only focused on a few regions, particularly on the developed economies such as the USA, and the EU. Research focusing on particularly small economies has less been explored. For this study, the sample focus will instead be on Papua regions from 2012 to 2018. Papua is an island in the most eastern part of Indonesia, the closest neighbor of Papua Guinea. It is the largest island in terms of land area. In fact, the province is among the largest tropical forest cover in the world which explain lacking research that focused specifically on Papua's regional performance. However, the government has been focusing on infrastructure investment in the region while previous research has demonstrated that infrastructure may improve economic conditions. The sample is relevant since Papua regions are lagging in infrastructure while. While Giap et al. (2017) assessed the competitiveness across Indonesian Islands and showed that Papua was the most lagging regions scoring the lowest for quality of life and infrastructure quality. These 2 low

scores may reflect deterrence to investment in the region which highlights the increasing government role to improve infrastructure endowments in Papua.

Currently, only few cities act as the largest contributor of economic growth in Papua, particularly Jayapura, the province's capital. As the city is among the economy that has the best infrastructure capital in the province, one may suggest that infrastructure quality is important for economic development, encouraging smaller regions to invest more in infrastructure. However, disparities remain in the quality and endowments of infrastructure across the regions whereas larger cities usually have better endowments compared to the smaller cities. Investment in road connectivity is usually targeted at regions that are the most congested since it reflects higher market potential. The city size may influence investment appetite. Duranton & Puga (2004) expected that there will be knowledge spill over from large population density, which is a crucial factor for economic performance. An economy with large population density undergoes an urbanization process which is linked to economic development. This phenomenon is known as agglomeration effect whereas urbanization allows matching, sharing, and learning which are expected to increase productivity. New Economic Geography discussed that positive externalities from high agglomeration in large cities may even penetrate to smaller cities which is known as the spread effect. This is related to the convergence theory with the notion that improvement in connectivity between smaller and larger regions will enhance the efficiency of the lagging regions and thus promoting economic convergence.

However, (Iammarino, Rodríguez-Pose, and Storper, 2017) claimed that there was no strong evidence to suggest that large agglomeration act as a catalyst to better economic activity of the lagging regions. An implication to the core-periphery model is that it is plausible that backwash effect dominates such that agglomeration attracts people away from periphery areas and thus contributing to larger disparities. Such outcome is less desirable since national growth should depend less on a single region to promote a more sustainable economic competitiveness. Button (1998) argued that little evidence on convergence may generate political difficulties in efforts to promote economic integration thus making it more difficult to reach equitable development. The author

claimed that efforts to promote proactive policies are meaningful to overcome economic differences across regions whereas infrastructure investment is an important factor. While infrastructure investment is positively related to economic performance, it is equally important to understand the regional socio-economic backgrounds to maximize potential economic benefits from infrastructure investment.

After reviewing the economic returns of infrastructure investment and acknowledging that the national government has shown increasing interests in economic development of the Papua economy, the following research question is formulated:

"How does infrastructure investment affect the economic performance of Papua's regions?"

In regards to evaluating economic performances, this study follows Frenken et al. (2007) and Dogaru et al. (2012) by using both labor productivity and employment as indicators. Our measure of infrastructure investment follows Sanchez-Robles (1981) suggestion of measuring infrastructure investment in physical units. The relationship analyzed will be measured by exercising panel regression. We focus on the analysis of both (physical) road connectivity and (institutional) education infrastructure for the physical infrastructure units. The aim is to understand whether certain regional characteristics have different infrastructure needs and have different impact on economic performance.

As mentioned before, the sample includes all regencies within Papua Province between 2012-2018. Labor productivity and employment data is collected from official Papua's statistical agencies. The dataset also includes variables such as population density, economic openness, and higher education level that are believed to be important factors influencing regional attractiveness that may stimulate higher investment flows.

The findings of the study indicate that infrastructure investment positively affect both employment and productivity, although it affects the latter stronger. Moreover, the effect of infrastructure investment on employment depends on the road infrastructure

as the interaction term show a significant positive effect while there is no significant joint effect for the productivity model. This implies that infrastructure investment is an effective job creation tool if the region increases its road endowments. We also added measures of sectoral specialization of the region in the regression. Overall, agriculture specialization remains a positive employment determinant compared to the service sector. However, our findings show that road investment in such regions is less supportive for employment generations although it is meaningful for more productivity. Lower employment is plausible since large land is required for agricultural production. Investment more in road means less land dedicated for agriculture making less people have land for cultivation thus reducing agriculture participation. At the same time, such investment supports higher labor productivity as it implies more competition that triggers efficient production. Moreover, less road infrastructure endowments characterize agriculture specialized region. Thus, the positive joint effect between agriculture specialization and road length on productivity conform (Biehl, 1991) findings. As the impact may differ depending on which set of variables included, this thesis proceeded by creating 5 different models for each economic performance evaluation.

The rest of the thesis outline is started by discussing Papua's growth and employment performance. Section 2 presents a review on the existing literature regarding determinants of economic performance for both labor productivity and employment and how they are affected by infrastructure investments as well as discussing previous approach in measuring infrastructure investment. Based on the literature findings, several hypotheses will be formulated. Section 3 will describe the data used and the methodology applied for answering the hypotheses. Section 4 presented the result findings. Finally, the thesis will conclude with a discussion on the findings, limitations, and implications for policy of this research in section 5.

1.3. Regional Disparity in Papua

The tables below show the average GDRP growth of Papua's regencies between 2010 and 2018. Overall, most regions experience higher growth in 2010-2014 period

compared to 2014-2018 period. Evaluating the GDRP growth with respect to the mean, less than 38% of the regencies have above average GDRP. Comparing between the 2 growth periods (2010-2014) and (2014-2018), there are slightly more than 41% and 51% regions that have GDRP above average respectively. This indicates less disparity of GDRP contribution between the top tier and low tier regions. With more regions above average GDRP, this means that the lower growth regions less burden the top tier regions in depicting the overall provincial growth. In addition, the coefficient of variation dropped substantially from 0.75 to 0.15 which may suggest that there is reduction of regional disparity. Similar conclusions are drawn when evaluating regional per capita income. The coefficient of variation between the 2-growth period increases from 0.62 to 0.43.

With respect to preliminary evidence of convergence, the coefficient of correlation of average 2014 growth and 2018 growth Is 0.54 and they are statistically significant. This implies that states that experienced growth in 2014 seems to continue to experience higher growth rate in 2018. Thus, there is no strong evidence to suggest that there is convergence.

Table 1: GDRP Growth

Regions	GDRP 10-14	GDRP 14-18	GDRP 10-18
Merauke	0.50	0.49	0.99
Jayawijaya	0.54	0.47	1.01
Jayapura	0.64	0.54	1.18
Nabire	0.49	0.43	0.93
Kepulauanyapen	0.42	0.38	0.80
Biaknumfor	0.46	0.28	0.73
Paniai	0.38	0.43	0.81
Puncakjaya	0.28	0.36	0.64
Mimika	-0.22	0.53	0.31
Bovendigoel	2.66	0.36	3.02
Mappi	0.44	0.46	0.91
Asmat	0.51	0.42	0.93
Yahukimo	0.61	0.40	1.00
Pegununganbintang	0.34	0.40	0.74

Tolikara	0.39	0.36	0.75
Sarmi	0.44	0.46	0.89
Keerom	0.54	0.36	0.90
Waropen	0.60	0.44	1.04
Supiori	0.40	0.30	0.71
Mamberamoraya	0.61	0.53	1.14
Nduga	0.67	0.46	1.14
Lannyjaya	0.78	0.43	1.21
Mamberamotengah	0.67	0.42	1.08
Yalimo	0.67	0.47	1.15
Puncak	0.57	0.52	1.09
Dogiyai	0.54	0.43	0.97
Intanjaya	0.83	0.46	1.29
Deiyai	0.68	0.51	1.20
Kotajayapura	0.60	0.39	0.99
Average	0.59	0.43	1.02
Coefficient variation	0.75	0.15	0.43

Table 2: Per Capita Income Growth at Constant Price

Regions	PCI 10-14	PCI 14-18	PCI 10-18
Merauke	0.21	0.23	0.44
Jayawijaya	0.24	0.17	0.41
Jayapura	0.36	0.24	0.61
Nabire	0.25	0.18	0.43
Kepulauanyapen	0.18	0.12	0.31
Biaknumfor	0.18	-0.03	0.15
Paniai	0.20	0.20	0.41
Puncakjaya	0.04	0.09	0.14
Mimika	-0.24	0.25	0.009
Bovendigoel	0.12	0.07	0.19
Mappi	0.15	0.36	0.31
Asmat	0.15	0.16	0.27
Yahukimo	0.28	0.17	0.45
Pegununganbintang	0.17	0.18	0.35
Tolikara	0.10	0.11	0.21
Sarmi	0.18	0.17	0.35
Keerom	0.27	0.16	0.43
Waropen	0.32	0.23	0.54
Supiori	0.20	0.02	0.22
Mamberamoraya	0.30	0.17	0.47
Nduga	0.33	0.21	0.54
Lannyjaya	0.44	0.18	0.62
Mamberamotengah	0.32	0.16	0.48
Yalimo	0.32	0.21	0.53
Puncak	0.23	0.20	0.43
Dogiyai	0.29	0.20	0.49
Intanjaya	0.44	0.14	0.64
Deiyai	0.38	0.21	0.59
Kotajayapura	0.33	0.19	0.51
Average	0.43	1.02	0.79
Coefficient of variation	0.62	0.43	0.45

1.3.Employment Characteristics of Papua

Most people in Papua have informal jobs with estimates around 78% of the economically active population (BPS,2019). Horticulture is Papua's most dominant

source of informal source income with more than 85%. The figures are reasonable since most of the population are still living in the rural areas characterized where land area is substantially large. Among the 22% of the formal jobs, these are mostly centralized in Kota Jayapura and Mimika where the share of formal activity is 62% and 57% respectively. In these 2 regions, agriculture was not the main source of occupation. In fact, agriculture was only ranked 4th after service jobs. Service sector domination is often in line with city characteristics. Cities are often characterized with large population density and high HDI, this is true for both regions. While both (Kota) Jayapura and Mimika are the most densely populated, their difference is striking. Comparing their population density, the former is about 3.3 times of the latter. The difference is less pronounced when comparing HDI level since they are relatively similar. Nevertheless, the difference in size indicated centrality of agglomeration activities in Jayapura which may demonstrates regional employment disparity and sorting.

As table 3 shows, overall both formal and informal jobs are experiencing positive growth while unemployment rates declined in 2018 from 2014 levels, which are desirable for the economy. Thus, one may suggest that the best regions are those generating the most job growth and reducing unemployment best. In this case, Supiori and Bovendigoel are the most outperforming in terms of employment conditions. However, its' good performance may be overstated when taking into account GDRP growth since jobs growth exceeds GDRP growth, which may show declining labor productivity. In fact, the wage level in 2018 for both Supiori and Bovendigoel are below the province median. Appendix A illustrates the changes in employment conditions by mapping - the darker the green color means more desirable outcome while the darker red color identifies the worst performing regions.

Table 3: Changes in formal and informal employment and unemployment rate

Regions	Formal jobs 14-18	Informal jobs 14-18	Unemployment 14-18
Merauke	0.04	-0.12	-2.08
Jayawijaya	0.05	0.00	0.35
Jayapura	0.28	0.25	-3.09
Nabire	0.10	0.28	2.22
Kepulauanyapen	0.03	-0.15	-0.45
Biaknumfor	0.11	0.30	-2.17
Paniai	-0.02	-0.13	0.60
Puncakjaya	0.21	0.14	0.01
Mimika	0.21	0.11	3.6
Bovendigoel	0.33	0.20	-3.91
Mappi	0.07	-0.08	-8.42
Asmat	0.16	0.14	0.29
Yahukimo	-0.01	-0.04	-0.20
Pegununganbintang	-0.05	-0.12	-1.42
Tolikara	0.19	0.15	-1.63
Sarmi	0.05	-0.13	-1.00
Keerom	0.05	0.22	3.8
Waropen	0.23	-0.07	-4.8
Supiori	0.40	0.31	-11.09
Mamberamoraya	-0.06	-0.07	2.58
Nduga	0.04	0.04	-4.81
Lannyjaya	0.01	-0.01	0.69
Mamberamotengah	0.05	0.04	0.00
Yalimo	-0.07	-0.12	-0.36
Puncak	0.16	0.01	-2.7
Dogiyai	0.15	0.15	1.3
Intanjaya	0.00	-0.01	0.51
Deiyai	-0.05	-0.11	0.59
Kotajayapura	0.21	0.36	0.62
Average	0.10	0.05	-1.1

Table 4: Degree of Specialization in Agriculture based on region and territorial custom area 2012

Region	Location Quotient Agriculture	Territorial Custom
Asmat	1.22	Anim Ha
Bovendigoel	0.88	Anim Ha
Mappi	1.15	Anim Ha
merauke	0.71	Anim Ha
Jayawijaya	1.15	La pago
LannyJaya	1.36	La pago
MamberamoTengah	1.37	La pago
Nduga	1.37	La pago
Pegununganbintang	1.32	La pago
Puncak	1.36	La pago
PuncakJaya	1.32	La pago
Tolikara	1.31	La pago
Yahukumo	1.31	La pago
Yalimo	1.33	La pago
jayapura	0.66	Mamta
keeorm	0.88	Mamta
KotaJayapura	0.09	Mamta
MamberamoRaya	1.37	Mamta
Sarmi	1	Mamta
Deiyai	1.36	Mee Pago
Dogiyai	1.34	Mee Pago
IntanJaya	1.34	Mee Pago
Mimika	0.32	Mee Pago
Nabire	0.5	Mee Pago
Paniai	1.25	Mee Pago
BiakNumfor	0.27	Saereri
KepulauanYapen	0.66	Saereri
Supiori	0.88	Saereri
Waropen	0.79	Saereri

Table 4 depicts the degree of agricultural sector specialization measured by location quotient index. It is measured as the ratio of employment share of the region over the provincial employment share in agriculture. As can be seen from the table, more than

50% of the regions are highly specialized in agriculture since its location quotient index ≥ 1. There are several ways to understand this specialization. If the regions are disaggregated in terms of territorial custom area, La Pago and Mee Pago territory are more isolated as they are located in the highland area whereas there are more empty spaces compared to the lowland territory. These are the regions that have large concentration of informal sector. While most of the regions in the highland area is specialized in agricultural production, there is an exception for Mimika as it is the only region that is not specialized in agricultural production. This is due to large concentration of mining production in this region. Saraeri is a territory located in the north, coastal area. There is no single region that specialized in agriculture in this territorial area. Based on the location quotient, if a region is highly specialized in agriculture production, they will not be specialized in other sectors such as industrial and service sector. Moreover, regions that are not specialized in agricultural production are specialized in both industrial and service sector which is the case in Saraeri. The Mamta territory have mixed specialization whereas the province capital, Jayapura, and Keerom region are less specialized in agriculture compared to Sarmi and Mamberamo Raya. One should understand which regions are specialized in which production to ensure that investment does not distort their economic activity.

2.Theoretical Framework

2. 1 . Infrastructure and economic performance.

This section will review previous findings on the relationship between economic performance and infrastructure investment. Research from Munnell (1990) shows that public infrastructure positively effects employment at state level. Similarly, Eberts, & Stone (1992) found positive effects on labor demand and labor supply. Dalenberg & Partridge (1995) employed fixed effect estimation while also controlling for regional and year dummies, socio-demographic characteristics, and government fiscal expenditure. They found that at lower levels of public capital stock, infrastructure positively affects employment growth while there was no positive effect when measuring infrastructure at

marginal level. This means that the positive effect of additional public capital stock on labor demand diminishes if the level of public stock is large. This is related to (Nijkamp,1986) whom discussed that creation of public capital is extremely important for development of lagging regions. In application, investment in road length is one way to represent public capital stock which is intended to improve connectivity in the region. Dijkstra et al. (2013) indicated that improvement in connectivity is an important factor explaining productivity. While this was initially found by McCann and Acs (2011) whom suggested that better connectivity improves performance of cities, this may be applied into smaller regions as one may expect that it should reduce transaction and logistic costs.

For the case of social infrastructure, education infrastructure is expected to generate positive return in human capital, which is often cited as positive determinants to regional performance. Duflo (2001) evaluated the effectiveness of the Indonesian government schooling program that targets equity across provinces. The program aimed for increasing the school stocks while also maintaining quality of the teachers. She concluded that the combined effect of both quantity and quality of the schooling program positively increases wages. Sulistyowati (2013) applied a 2SLS model relating infrastructure expenses on employment and poverty and found that infrastructure expenses were mostly effective in increasing agricultural and industrial employment and reducing poverty. This aligns to the idea that while agriculture is considered as the primary source of income in Indonesia's 6 poorest provinces, the poor infrastructure was blamed to explain the low agricultural productivity (Booth, 2004). The research from Booth, 2004 is applicable for Papua economy due to large participation in agricultural sector.

2.2. Measuring infrastructure investments

IMF distinguished infrastructure into "economic infrastructure" and "social infrastructure". The former is defined as capital inputs that allow the economy to function better while the latter means capital that delivers social services. From the definition, we can learn that infrastructure provision are capital intensive projects. The

World Economic Forum added soft infrastructures into the definition which concerns more the institutional quality. Since infrastructure is a broad term, it is often that researchers evaluate infrastructure investment projects differently. Some researchers are more interested in monetary values of the infrastructure investments (Munnell, 1992; Gramlich, 1994). Data availability with respect to monetary values dedicated for each infrastructure type is often unavailable. Sanchez-Robles (1998) argued that one may apply changes in physical units as proxies for infrastructure investment. In application, Looney & Friederiksen, (1981) evaluated the impact of infrastructure investment in Mexico regions. They used public telephone lines, electricity and surfaced road density as representative variables for the economic infrastructure, while health care and education facilities were used for the social infrastructure. In the European regional setting, Crescenzi & Pose (2012) connected infrastructure and regional growth in Europe by treating kilometer of motorways as a proxy for transport infrastructure. In cross-country studies, Summers & Heston (1991) used infrastructure variables such as telephone main lines, kilometer of paved roads, access to safe water, households with electricity on GDP per capita.

In the most recent business economic studies, gross fixed capital formation (GFCF) is often used as a proxy for infrastructure investments (European Investment Bank, (2019); Asian Development Bank, (2017); Park, Lee & Lee, (2015); Mayer et al. (2018); Vilks et al, (2017)). Hulten & Peterson (1984) studied its' association with the US national productivity. They could not reject the idea that deterioration of capital affects national productivity. Dash & Sahoo (2010) combined both GFCF and an infrastructure-created index that was estimated from the physical infrastructure variables to study economic growth of India. Sahoo et al. (2010) discussed this similarly in the context of Chinese economic growth. They found that the share of infrastructure in total investments have increased substantially in 2006 from the 1998 level. Wagenvoort et al. (2010) claimed that GFCF is the closest one can get to proxy infrastructure investment. However, one should be aware that GCFC considers all fixed assets that may not all be part of infrastructure assets. Thus, the true value of infrastructure investment may be overstated.

2.3. Determinants of Labor Productivity

Roback (1988) related productivity with wages such that if local productivity increases, then wage increase. Treating wage as a proxy for productivity, the analysis went further in its attempt to measure agglomeration effects by suggesting that regions with higher population are more productive. Combes et al. (2008) realized that density alone is not enough to measure productivity since the association may be reverse causal meaning that workers may choose to live in regions that are the most productive. To tackle this endogeneity issue, they add sectoral observable characteristics like sex, education, and age while incorporating fixed effects and instrumental variables. While adding control variables improve the prediction of unexplained wage variation, this adds to the argument that including regional characteristics are important in addition to agglomeration forces.

While Roback (1988) focused on the USA which is a representative study of a developed country, Sahn & Alderman (1987) studied wage determination for the case of Sri Lanka separating urban and rural areas using OLS estimation. They found that nutrition intake expressed in calories positively affects labor productivity, which they tested after the theory was popularized from earlier studies (Deolalikar, 1984; Strauss, 1986). In addition, some other socio-demographic variables such as high education, age and marital status appeared to be significant for both rural and urban areas while significant coefficient estimates of proximity to Colombo for urban areas appeared in the wage equation. In a more recent study, Belorgey, Lecat, & Maury (2006) estimated labor productivity focusing on 3 main groups of indicators which were public infrastructure, education, ICT spending, and macroeconomic variables. Though they applied it at the national level, the measures could be applicable to regional context.

2.4. Determinants of Regional Employment

Nayyar (2014) argued that in the last 2 decades, the world economy was experiencing crises and growing economic inequality. Accordingly, economic policies should target employment which is detrimental in explaining growth and may resolve the inequality

problem. The effect is more pronounced especially in poor economies where, increasing employment opportunities are the only sustainable means in reducing poverty. This is in line with Syafitri (2013) whom found that regional poverty is associated with increased migration as people are looking for better employment alternatives outside their home economy. Similarly, if poverty increases then one should expect that regional employment decreases. While improving employment is good for well-being for the regional economy, it is meaningful to analyze the drivers of employment.

Comola & Mello (2009) used a multinomial selection approach in estimating determinants of employment in Indonesia in 1996 and 2004 while controlling for provinces and sectoral dummies. They analyzed employment for both formal and informal workers for which some of the variables used are similar for the productivity measures like age, sex, marital status and education, which are statistically significant at 1%. Yet, the magnitude directions may be different depending on the employment status. In addition, they added the dependency ratio as a measure which was also significant. Dependency ratio is the ratio of those not in the labor force and those typically in the labor force. This implies that high dependency ratio suggests larger pressure to the economically active population to provide support to those who are economically dependent. Number of factors may lead to higher dependency ratio. UN (2007) suggested that lower birth rate leads to lower dependency ratio although that it potentially increases if it continues to decline together with increasing old-age population. If high dependency ratio stands, this signals the need to maintain and improve the healthcare services and social security whereas investment in more schools are necessary if high fertility is the contributing factor. Suryadarma, Suryahadi, and Sumarto (2007) accounted for measures explaining urban, rural, and total employment using sectoral GDP contribution for both rural and urban while also adding participation rates. All the estimates showed positive and significant relations. However, the research was not interested in capturing small economies including Papua due to data incompleteness.

2.5.Hypotheses Development

As mentioned in the introduction section, the research question of the study is "How does infrastructure affect the economic performance of papua regions". Following the previous studies on economic performance, the paper focuses on evaluating the infrastructure effect on employment and labor productivity.

Existing literature has provided similar results with respect to infrastructure effect on employment. Prominent scholars expect that infrastructure spending will bring positive effect both on employment and labor productivity Dalenberg & Partridge (1995) ; Munnell (1992) ; Eberts & Stone (1990); Aschaeur (1989). However, all of these studies are conducted in the US in the last decade 20st century. While the Central Java studies by Sulistyowati (2013) may be more applicable to assess the economic performance of Papua as Central Java has similar national regulatory framework to Papua. According to the study one should expect that infrastructure investment will have a positive effect on employment. While studies by Syafitri (2014) suggested that poverty increases migration which will reduce employment. However, Papua is isolated in terms of geography compared to Central Java. Arguing that increased poverty will translate to larger migration in Papua's case is a strong assumption without taking into account geographical disadvantage and individual capability especially knowing that most people are classified under informal jobs and work in agricultural sector which are low income. Nevertheless, it is expected that infrastructure investment in the region boosts employment as it creates more job alternatives other than agriculture.

Hypothesis 1: Infrastructure investment will have a positive effect on employment.

Research has suggested that connectivity matters for employment growth (Asher & Novosad, 2014; Jin & Paulsen, 2018). The most intuitive measure of connectivity is road length. As connectivity improves, it is expected that region has better job accessibility increases which will generate more employment.

Hypothesis 2: Additional increase in road length has positive effect on employment

Based on the previous literature we will use gross fixed capital formation (GFCF) infrastructure as a proxy for general infrastructure investment. While GFCF comprised of all investments, to better measure infrastructure effect, an interaction term with physical infrastructure measured in unit is applied. It is expected that the relationship between investment and road length are positive for employment and productivity. With larger investments and road length in the region, one may expect that connectivity becomes more meaningful for employment since more investment in the region boosts location attractiveness.

Hypothesis 3A: Investment and road length have a joint positive effect on employment

Hypothesis 3B: Investment and road length have a joint positive effect on labor productivity

As we expect that better road connectivity increases employment, it is meaningful to check whether the effect becomes stronger when interacted with location quotient of agriculture. A positive joint effect indicates that adding road connectivity supports employment of the region that specializes in agriculture sector. Although the joint effect between road length and employment are positive, we expect that the effect is more positive for labor productivity. As there is more road in the region, it is expected that economic production to increase from better accessibility. As connectivity increases, an agriculture economy may benefit from lower transport costs as travel time is lower which may affect agricultural sales of inputs and outputs which increases productivity (Dorosh et al., 2012).

Hypothesis 4: Additional increase in road infrastructure increases productivity in regions that are specialized in agriculture.

Other than transport infrastructure variable, the paper will also evaluate the impact of investment in school units on regional performance. As literatures have linked the importance of education on productivity and as Sanchez-Robles (1981) argued that evaluation based on physical units are good measures of infrastructure investment, it is

expected that investment more in schools positively increase labor productivity. Some economies need more skilled labor pool than the others. While (Dogaru et al., 2011) have found that higher education coincides with higher productivity and employment growth in the European regions, the impact from educational units is less explored even though Bröcker & Rietveld (2009) emphasized that physical measures make more sense than monetary units. It can be argued that region invests in schools since they understood that basic educational infrastructure is still limited. As investment in school is a way to show commitment in boosting the quality of the human capital, this leads to hypothesis 5.

Hypothesis 5: Investment in educational infrastructure increases labor productivity.

3. Data & Methodology

3.1. Data Source

Table 5 and 6 summarize the variables used for answering the research question. All of the data was retrieved from Badan Pusat Statistik of Papua. BPS Papua is chosen since it is the only statistics agency that provides information across Papua's 29 regencies. The national BPS (BPS Indonesia) aggregated data into a province level which provides less fruitful information for regional analysis.

3.2. Descriptive Statistics

To understand the nature of the variables in the model, summary statistics and correlation coefficient of all variables are presented. The descriptive statistics of employment and productivity of labor force in Papua can be found in table 7 below.

Table 7. Descriptive Statistics of Dependent Variables

	Observations	Mean	Std.Dev.	Min	Max

lnemployment	203	10.72879	.7620367	8.474912	11.8499
lnproductivity	203	3.622751	1.056595	1.967252	6.623357

Employment is the sum of formal and informal employment. Appendix B gives full overview of which employment status with respect to main occupation are accounted as formal and informal employment. The variable ln-productivity shows higher standard deviation suggesting that there are more imbalances with respect to labor productivity across regions compared to employment.

The statistics for the infrastructure variables can be found below

Table 8. Descriptive Statistics of Infrastructure Related Variables

	Observations	Mean	Std.Dev.	Min	Max
lninvestment	203	13.38849	.9096549	12.29838	16.26571
lnSchool	203	4.75336	.7559773	2.772589	6.916715
lnroadlength	203	4.873169	1.246024	1.862529	7.457551

The detailed statistics of the infrastructure variables are used to evaluate labor performance in Papua's province. According to the table above, schools have the smallest standard deviation while road length has the highest standard deviation. Thus, school endowments are relatively similar across regions even though some regions have more endowment in transport infrastructure. Schools are represented in number of physical units of the social infrastructure variable. In addition, road length is the transport infrastructure representative which falls under hard infrastructure. The summary statistics of the sociodemographic characteristics are illustrated below.

Table 9. Statistics of Sociodemographic Variables

	Observations	Mean	Std.Dev.	Min	Max
lnpopdensity	203	2.548242	1.245697	-.4155155	5.747225
lnopenness	203	-.1346853	.3936078	-2.516583	.5751404

lnhighereducation	203	8.915267	1.239493	5.02388	11.37834
LQA	203	1.013021	.3775968	.09	1.476015
LQS	203	.9562401	.8964845	0	3.697674

Among all the summary statistics, the largest and the smallest imbalances are all found in the sociodemographic variables with population density for the former and agriculture specialization for the latter. It seems that LQA are consistent across regions which shows that most regions are specialized in agriculture. However, there is more difference in regional service specialization compared to LQA. The imbalances may be triggered as some urbanized rich cities usually have more service jobs than agriculture while smaller rural cities heavily depend on agriculture or none of them working in service. The population density variables exhibit the largest standard deviation and this happens as it has the largest maximum value and the lowest minimum value. This may be the outcome of sorting effects where there are some regions that act as dominant center for jobs making most of the people in the Papua staying in that dominant regions as they have better working opportunities and living conditions. The most apparent example to illustrate sorting effect can be taken from Kota Jayapura which is the province capital of Papua. One may argue that Kota Jayapura is the most densely populated in the province because Human Development Index is also the highest. This fact may be captured in the analysis since we also control the quality of labor force in the region which according to the summary statistics are imbalanced across the regions as well. The negative sign of ln-population density can be attributed from very low population density in Mamberamo Raya with values less than 1 across years. Another observation is that Mamberamo Raya also the same region that has the largest percentage of poor people while Kota Jayapura is the region which has the lowest percentage of poor people. Similarly, observation holds when dependency ratio is considered. In this case, most pressures for the productive population by the economically dependent population is found in Mamberamo Raya while the least dependent is found in Kota Jayapura. It may be another evidence to show that the rich sort themselves into the big city. The correlation matrix of all independent variable is presented in the appendix. Multicollinearity is not a major concern. However, including

both specialization measure biased the coefficient upwards. Thus, we proceed by including the location quotient separately.

3.3. Dependent variables

To measure regional performance of Papua, insights from literatures as described in the first section of the theoretical framework are important to decide which variables are important to be included in statistical analysis. The dependent variable of interests are employment and productivity. In the BPS dataset, distinction between formal employment and informal are available. The distinction is important to get a more complete picture on whether regional infrastructure along with its socioeconomic demographic variables affect labor conditions differently. It is expected that after conducting relevant statistics, the analysis will be useful in understanding which infrastructure variables give desirable impacts for the economy.

Table 5. Summary of Dependent Variables used

Variable	**Measure**	**Description**	**Source**
Employment	Number of people working	Formal Work+ Informal Work	BPS
Productivity	Labor Productivity	GDRP at constant price/Employment	BPS

3.4. Independent Variables

The independent variables applied in this paper are the same for all the dependent variables of interests as the independent variables are expected to have influences for all dependent variables. Evaluating associations using the same parameter will be more consistent in explaining how infrastructure investment helps improving economic development while also showing the boundary of the research. Since the paper is interested in evaluating the infrastructure impact, we used road length and school as a proxy for investment in infrastructure units as Sanchez-Robles (2008) suggested. We

combined with the insights from the European model indicator of regional growth (Dijkstra, 2013; Crescenzi & Pose, 2012; Frenken, 2007) which include specialization measure, urbanization, economic openness and other observable regional characteristics for control variables such as sexratio, specialization measures, since Comola & Mello (2009) used sex indicator for Indonesia's case. The summary of the variables used are presented in the table 5 below.

Table 6. Summary of Independent Variables used

Variable	**Measure**	**Description**	**Source**
Openness Economy	Trade oriented or not	(Export+ Import)/ GDP	BPS
PopDensity	Agglomeration	Population/$land\ size\ (KM^2)$	BPS
GFCF	Infrastructure expenditure Proxy	Investment in capital goods that have more than 1-year life span	BPS
LQA	Specialization Agriculture	$\frac{\%employment\ in\ agriculture\ in\ region_i}{\%employment\ in\ agriculture\ of\ province}$	BPS
LQS	Specialization Service	$\frac{\%employment\ in\ service\ in\ region_i}{\%employment\ in\ service\ of\ province}$	BPS
Roadlength	Transport Infrastructure	Length of road in km^2	BPS
Schools	Education Infrastructure	Sum of Kindergarten, Elementary, Middle, High Schools	BPS

3.5. Estimation method

To find out how infrastructure investment affects economic performance, we included road length and school to capture infrastructure variables in physical units. In addition, as shown in the literature, GFCF is also often used as proxy for infrastructure investment. Thus while (Frenken et al., 2007) used investment as main control variables, this paper treated this indicator as infrastructure related variables. For the main control variables, we included population density, specialization to evaluate agglomeration effect. The base model of economic performance as follows:

$$\begin{aligned}\ln(y_{it} - \bar{y}_i) = a + \beta_1 \ln(Investment_{it} - \overline{Investment_i}) + \beta_2 ln(popdensity_{it} \\ - \overline{popdensity_i}) + \beta_3 ln(openesseconomy_{it} - \overline{openesseconomy_i}) \\ + \beta_4 ln(Schools_{it} - \overline{Schools_i}) + \beta_5 ln(LQ_{it} \\ - \overline{LQ_i}) + \beta_6 ln\left(Roadlength_{it} - \overline{RoadlengthI_i}\right) \\ + + \beta_7 ln\left(Highereducation_{it} - \overline{Highereducation_i}\right) + (u_{it} - \overline{u_i})\end{aligned}$$

Where y:

(1) Employment

(2) Labor Productivity

Subscript i indicates region and t is year. As the variables have time series dimension across entities, panel data estimation method will be exercised.

3.6. Missing data

Some of the variables have missing data. The most common situation is that the data is available one year before or after the year of interest. There are no specific patterns regarding the socioeconomic characteristics of the missing data. Some of them are high growing regions and some of them are the poorest regions. To deal with missing data, interpolation and extrapolation are applied.

4.Findings

4.1. Employment model

Table 9 provides results for the employment by type model using the fixed effect estimation as the Hausmann test shows significant result. Table 1 and 2 are regression result with differences only in the specialization measure included while table 3 and 4 added interaction effect between investment and road length. Model 5 used interaction term between agriculture specialization and road length. We do not include both measures of specialization in one model as the variables are highly correlated. According to model 1 and 2, *hypothesis 1* that higher infrastructure investment leads to higher employment is confirmed. It is also shown to contribute on employment the most regardless of specialization specification. However, our *hypothesis 2* that road length leads to job creation is indeterminate**.** Our road connectivity measurement is shown to have no significant influence on job creation in model 1 and 2 while having negative effect in model 3 and 4. Moreover, there is a positive joint significant effect between road length and investment meaning that *hypothesis 3A* cannot be rejected. This suggests that adding road length is necessary for employment as long as there investment also increases in the region which implies that accepting the idea that adding more road infrastructure has a direct effect on employment generation is misleading.

However, the impact of road length becomes lower when interaction term with agriculture location quotient is considered. As the region specializes more in agriculture, the impact of road connectivity on job generation decreases which follows that the impact of road connectivity on employment increases when non-agriculture employment increases. The result suggests that investment in road connectivity becomes more meaningful for employment generation in smaller number of regions as most regions in Papua are predominantly specialized in agriculture. As it was explained earlier that service specialized regions are usually located in richer cities, the result confirms that road investment triggers larger employment in richer cities. Moreover, it is important to note that as service jobs require better educated workforce relative to agriculture, one can expect that increase in service specialization implies growth in better quality of labor force. This follows that investment in road attracts skilled

employment more than unskilled workforce which is a desirable case for improving competitiveness.

With all the result of the table, we can conclude that adding road connectivity in region has positive implication in generating jobs as long as investment also increases. Specifically, it is necessary that road infrastructure investment increases in non-agriculture specialized regions to attract higher quality of employment. Even though agriculture specialization remains an important regional employment determinant, the statistical findings found that the impact decreases when investment in road increases.. On the other hand,. there should be more careful planning with respect to land use since in this place neutral analysis, all else equal, investment more in road in place with agriculture as a dominant source of income reduces labor supply. With less careful planning investment in road can threaten welfare.

Our education infrastructure variable school are statistically significant in the 4 models even though they are contrary to the expected sign as regions with more schools are associated with less employment. However, this does not mean that reduction in education investment is necessary since the quality of employment is important for employment generation which can be shown from the positive and statistically significant effect of our higher education variable. This suggests that efforts to promote higher education enrollment will be favorable while investment in more school could be reduced. Moreover, even though economic openness is often associated with higher employment, the result from the model cannot find any significant positive effect which suggests that trade integration does not guarantee employment growth. In addition, population density has significant negative effect on employment which shows that cities create less job opportunities. This suggests that there are more jobs when there is higher ratio of land compared to the population size which smaller cities stimulate economic activities.

	(1)	(2)	(3)	(4)	(5)
	lnemployment	lnemployment	lnemployment	lnemployment	lnemployment
lnroadlength	0.01	0.01	-0.15**	-0.14**	0.07***
	(0.00)	(0.00)	(0.07)	(0.07)	(0.01)

lninvestment	0.15**	0.14**	0.08	0.08	0.13**
	(0.06)	(0.06)	(0.07)	(0.06)	(0.05)
lschool	-0.01*	-0.01*	-0.01*	-0.01*	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
lnhighereducation	0.04*	0.04*	0.04*	0.04*	0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
LQA	0.06*		0.05*		0.36***
	(0.03)		(0.03)		(0.07)
lnopenness	-0.00	-0.00	-0.01	-0.01	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
lnpopdensity	-0.07***	-0.07***	-0.09***	-0.09***	-0.09***
	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
LQS		-0.02*		-0.02*	
		(0.01)		(0.01)	
lnroadlength # lninvestment			0.01**	0.01**	
			(0.01)	(0.01)	
lnroadlength # LQA					-0.06***
					(0.01)
Constant	8.62***	8.72***	9.48***	9.55***	8.53***
	(0.74)	(0.72)	(0.90)	(0.89)	(0.70)
Observations	203	203	203	203	203
R^2	0.21	0.21	0.22	0.22	0.26
Adjusted R^2	0.18	0.18	0.19	0.19	0.23

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2. Productivity Model

Table below provides results for productivity as the dependent variable. The result show that investment, school, and population density have positive and significant effect to productivity which is as expected. While *hypothesis 5* of the study cannot be rejected, the result also implies that densely populated areas are more productive because labor competition is triggered dye to abundance of labor. Moreover, agriculture specialization is significant but negatively related to productivity. This means that while agriculture specialization positively supports job creation, it reduces productivity which indicate that striving for more agriculture specialization may hamper competitiveness. In the

productivity model, we cannot find any significant positive effect between road connectivity and productivity even when interaction term with investment is included. This suggests that we can reject *hypothesis 3B*: road length and investment have joint significant effect on productivity.

While endogenous growth theory predicts that having more educated background translates to higher productivity, the model shows no significant effect. However, education infrastructure is positively related to productivity (*hypothesis 4)*. The positive effect of schools shows that investment in physical social infrastructure is necessary for competitiveness. Moreover, the model a positive joint significant effect between road length and agriculture specialization. This suggests that the impact of adding road length on productivity increases when a region's specialization of agriculture increases which means that road endowments support agricultural productivity.

	(1)	(2)	(3)	(4)	(5)
	lnproductivity	lnproductivity	lnproductivity	lnproductivity	lnproductivity
lnroadlength	-0.00	-0.00	0.09	0.08	-0.06***
	(0.00)	(0.00)	(0.08)	(0.08)	(0.01)
lninvestment	0.72***	0.73***	0.76***	0.76***	0.74***
	(0.07)	(0.07)	(0.09)	(0.09)	(0.07)
lschool	0.03**	0.02**	0.03**	0.02**	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
lnhighereducation	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
LQA	-0.09**		-0.09**		-0.34***
	(0.04)		(0.04)		(0.08)
lnopenness	-0.04	-0.04	-0.04	-0.04	-0.04
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
lnpopdensity	0.10***	0.10***	0.11***	0.11***	0.11***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
LQS		0.04**		0.04**	
		(0.01)		(0.01)	
lnroadlength # lninvestment			-0.01	-0.01	
			(0.01)	(0.01)	

LQA # lnroadlength					0.05***
					(0.01)
Constant	-6.13***	-6.30***	-6.66***	-6.79***	-6.05***
	(1.00)	(0.98)	(1.21)	(1.20)	(0.98)
Observations	203	203	203	203	203
R^2	0.66	0.65	0.66	0.66	0.67
Adjusted R^2	0.64	0.64	0.64	0.64	0.65

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.3. Model Inspection

We tested in each model whether pooled OLS model is appropriate using Breusch Pagan Lagrange Multiplier test. The result show p value of 0.00 which means that the random effect is more superior compared to OLS model. However, when Hausman test is applied, the result also show significant result which means that the fixed effect model is appropriate.

4.3.1. Cross sectional dependence

To make sure that the fixed effect model is appropriate, several test statistics are conducted. In panel data time series model, one may implement mean group estimator by averaging individual coefficients (Henningsen & Henningsen, 2019). As common unit factors that are correlated with the regressors, are omitted from the model, then the fixed effect estimator is inconsistent (Henningsen & Henningsen, 2019). This is called cross sectional dependence whereby all units in the same cross section are correlated. To check if there is cross sectional dependence, Pesaran test of cross-sectional dependence is applied with the null of "no cross-sectional dependence" cannot be rejected at 5% level of significance. While other tests may show conflicting results, the paper also applied the Frees and Friedman test on cross-sectional data. Nevertheless, similar result is obtained as both tests give insignificant result. This means that there is no cross-sectional dependence meaning that there is no evidence to suggest that there are interdependencies between cross sectional units. The cross-sectional dependence test is used to test whether there is spatial correlation. The test is similar to Moran's spatial autocorrelation test, but at a simpler way as it does not need to determine the spatial

weight matrix especially in the models where space is not a neutral metric and economic factors are more important (Pesaran, 2004)

4.3.2. Robustness test

As explained by (Pesaran, 2004), the CD test is quite robust to the presence of unit roots and structural breaks. As Baum (2001) suggested, fixed effect assumes that error process is independently and identically distributed. However, this assumption may be violated under the condition called groupwise heteroskedasticity in the residuals of fixed effect regression. The presence of groupwise heteroskedasticity means that while the error process is independently and identically distributed within a cross section, its variance appeared to be different across units. When conducting the modified Wald test for groupwise heteroskedasticity, the result appeared to be significant. This means that the residuals are correlated. As such, the result was due to the absence of robust cluster standard error. However, the result output presented in table 9 and table 10 have corrected the issues by adding the robust option. As standard errors are adjusted, the coefficient estimates are trustworthy. Moreover, Woolridge test for autocorrelation have been applied. Similarly, the result appeared to be insignificant which suggests that the model does not suffer from serial correlation.

4.4. Infrastructure investment evaluation using monetary units.

In the previous section, we employed fixed effect for employment and productivity model to evaluate the relationship between investment and economic performance of Papua. While we employed GFCF as a proxy for infrastructure investment and Sanchez-Robles (1981) suggested to measure in physical units, we evaluated Road length and Number of schools as infrastructure development indicators. However, we are also interested in estimating infrastructure investment using monetary values as some researches in the past have used them as well. (Elburz, Nijkamp & Pelz, 2017) claimed that infrastructure measurement technique may affect conclusions on impact of regional development differently. This thesis will follow Antle (1983) on capturing infrastructure variables. Specifically, to capture transport infrastructure variable the author suggested

using GDP contribution of transport industry relative to the area size. The result of the model is found in table 12 below.

	(1)	(2)	(3)	(4)	(5)
	lnemployment	lnemployment	lnemployment	lnemployment	lnemployment
lntransportinfrastructure	-0.00	-0.00	-0.11	-0.07	0.01
	(0.01)	(0.02)	(0.23)	(0.24)	(0.02)
lninvestment	0.15***	0.15**	0.06	0.09	0.15**
	(0.05)	(0.05)	(0.21)	(0.22)	(0.06)
lnschool	-0.02**	-0.02**	-0.02**	-0.02**	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
lnhighereducation	0.03*	0.04*	0.04*	0.04**	0.03*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
LQAgriculture	0.06*		0.06*		0.17
	(0.03)		(0.03)		(0.15)
lnopenness	0.00	0.00	0.00	0.00	0.00
	(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
lnpopdensity	-0.08***	-0.08***	-0.08**	-0.08***	-0.08***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
LQService		-0.02*		-0.02*	
		(0.01)		(0.01)	
lntransportinfrastructure # lninvestment			0.01	0.01	
			(0.02)	(0.02)	
lntransportinfrastructure # LQAgriculture					-0.01
					(0.01)
Constant	8.62***	8.72***	9.80***	9.50***	8.62***
	(0.75)	(0.72)	(2.80)	(2.92)	(0.73)
Observations	203	203	203	203	203
R^2	0.20	0.20	0.20	0.20	0.20
Adjusted R^2	0.17	0.17	0.17	0.17	0.17

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

While measuring transport infrastructure in physical units show significant impact in both employment and productivity model, using measures of monetary units based on Antle(1983) show no significant effect on employment model even when the interaction effect with investment is included. This means that there is no statistical evidence to suggest that the impact of transport infrastructure depends on the level of investment nor specialization while other variables show similar coefficient and sign to the original model. This pattern holds when we evaluate using the productivity model. Therefore, it confirms that evaluation using monetary units are less effective than physical units for measuring infrastructure investment impact.

5. Conclusion

5.1. Discussion and Policy Implication

The goal of this thesis is to understand the mechanism of infrastructure in influencing economic performance of regions across Papua since infrastructure is often shown in development studies to have significant impact on growth. Different scholars have different ways in measuring infrastructure variables. Our main approach is to measure infrastructure based on physical units. The main contribution of this paper is showing that the result is sensitive to infrastructure measurement. Moreover, we included variables that are strongly linked to regional economics. This allows us to make more robust conclusion regarding the significance of the included infrastructure variables since factors that capture urbanization, specialization, and human capital aspects are shown in many literatures to influence growth. Based on the literatures, we are inspired to make some expected signs of the coefficient which were formulated in hypotheses.

Overall, the thesis found mixed result regarding the impact of infrastructure on economic performance. The transport infrastructure variable is found to depend on the level of domestic investment as they have positive joint significant effect. This means that road connectivity is necessary to support infrastructure investment as a job generating tool . However, we also found that road connection supports more employment in region that is less specialized in agriculture**.** With these 2 results on

employment, we infer that road connectivity should increase in denser areas to maximize employment return from more infrastructure investment as a policy tool. Investment in road connectivity is also shown to support the productivity of the province's largest specialization as the impact of agriculture specialization on productivity rises when road connectivity increases. This statistical finding confirms the notion that road connectivity improves agricultural productivity (Dorosh et al., 2012) signalizing improvement in the living conditions. However, we cannot find any joint effect between investment and road connectivity on productivity. This seems to show that when road connectivity increases, the impact of infrastructure investment on labor productivity is indeterminate while the impact on employment is clear. While most other variables have reverse signs compared to the employment model and still exhibit statistically significant effect, only infrastructure investment proxy variable are both positively influencing employment and productivity. This confirms that our infrastructure investment proxy is desirable for both measures of economic performance.

An economy is often interested in understanding the determinants of labor productivity as it is closely linked to competitiveness which is desirable. Subsequently, it follows that if the region increases their education infrastructure, investment, urbanization, and specialization in service, productivity rises. Moreover, the impact of road length on employment increases when specialization in agriculture decreases. However, the impact of road length on productivity increases when specialization in agriculture increases. This shows tradeoff between less employment with more productivity when there is more road infrastructure in agriculture specialized region. This implies that road connectivity supports higher employment for region that is less dominant in agriculture jobs.

The findings of the thesis have several policy implications. First of all, improvement to education access is important as more schools are positively related to productivity and higher education background is important employment determinant which suggests that investment in both education infrastructure and human capital are desirable. Place-based analysis suggests that regional characteristics of region has strong implication for

effectiveness of policy making. Without taking into account the regional characteristics, policy makers may suggest that investment more infrastructure in any region in Papua is an important policy tool to support more economic growth. In this thesis, we found that the impact of infrastructure investment depends on employment specialization. Based on the joint significant negative effect between road length and agriculture specialization, we infer that investment more in road infrastructure is more meaningful for employment generation in large cities as cities specialize less in agriculture. On the other hand, investment of road infrastructure in a highly concentrated agriculture region is necessary to boost their productivity since these regions still have low infrastructure endowments. While it is in the interest of policy makers to design policies that improve the economic performance of regions, the thesis has discussed that regional specialization is important to understand how employment and labor productivity can be triggered from infrastructure investment. This means that it is expected that more road infrastructure in larger cities generate more employment while the effect from more investment in a more agriculture specialized region is larger productivity.

5.2. Limitation and recommendation for future research

This study has brought extensive knowledge about factors affecting economic performance of Papua focusing on 2 crucial indicators which are labor productivity and employment. While there is limited literature assessing Papua's economic performance, the paper tried to establish economic model inspired from European model of economic performance (Frenken et al., 2007; Crescenzi & Rodriguez-Pose, 2012; Dogaru et al., 2012; Raspe & Van Oort, 2006). In our knowledge, this is the first paper that focused studies across Papua economic performance regions.

While fixed effect controls for time invariant characteristics, there may still be time varying unobservable variables that not included in the model and correlated with both infrastructure variables and economic performance. This may be solved by adding more time varying variables. For example, it might be interesting to include R&D as a representative of innovation activity especially as it is shown in (Frenken et al., 2007)

that they are positively correlated with both employment and productivity. R&D spending is expected to improve investment decision whereas one may understand better which investment is necessary for each region to foster their economic development. However, due to data unavailability, the effect of R&D cannot be controlled thus the infrastructure variables may be overstated. Moreover, as the goal of the thesis is to understand the role of infrastructure development, it is interesting to capture more physical unit variables such as telecommunication or health centre. We did not include in the dataset since the data is incomplete for some regions. Hopefully, this and many more data will be available in the near future as quality of data is important to have more reliable inferences for economic development.

This paper gives meaningful insights in understanding how infrastructure variables are meaningful for competitiveness in Papua. While we have controlled time invariant characteristics, I would suggest future research to apply different estimation techniques that is more powerful for policy evaluation tool such as instrumental variable strategy that solves bias the best. However, good instrument is difficult to find since not only that the assumptions have to be met but also need to be backed up by economic theories which become more challenging with limited datasets. Investment and productivity are very closely related thus it may be reasonable that the direction is reverse causal. The challenge is to find variables that affect economic performances only through investment. For example, tight regulation may deter investment but it is less likely to affect labor productivity of Papua since most of them are working in informal sector. If the correlation between regulation and investment is negative, it can be expected that the value of investment in OLS model is understated. Similarly, if the correlation between the instrument and investment is positive, the relationship between investment and economic performance is overstated. Moreover, it will be more interesting if one can analyze at neighborhood or village level to have a more precise impact evaluation.

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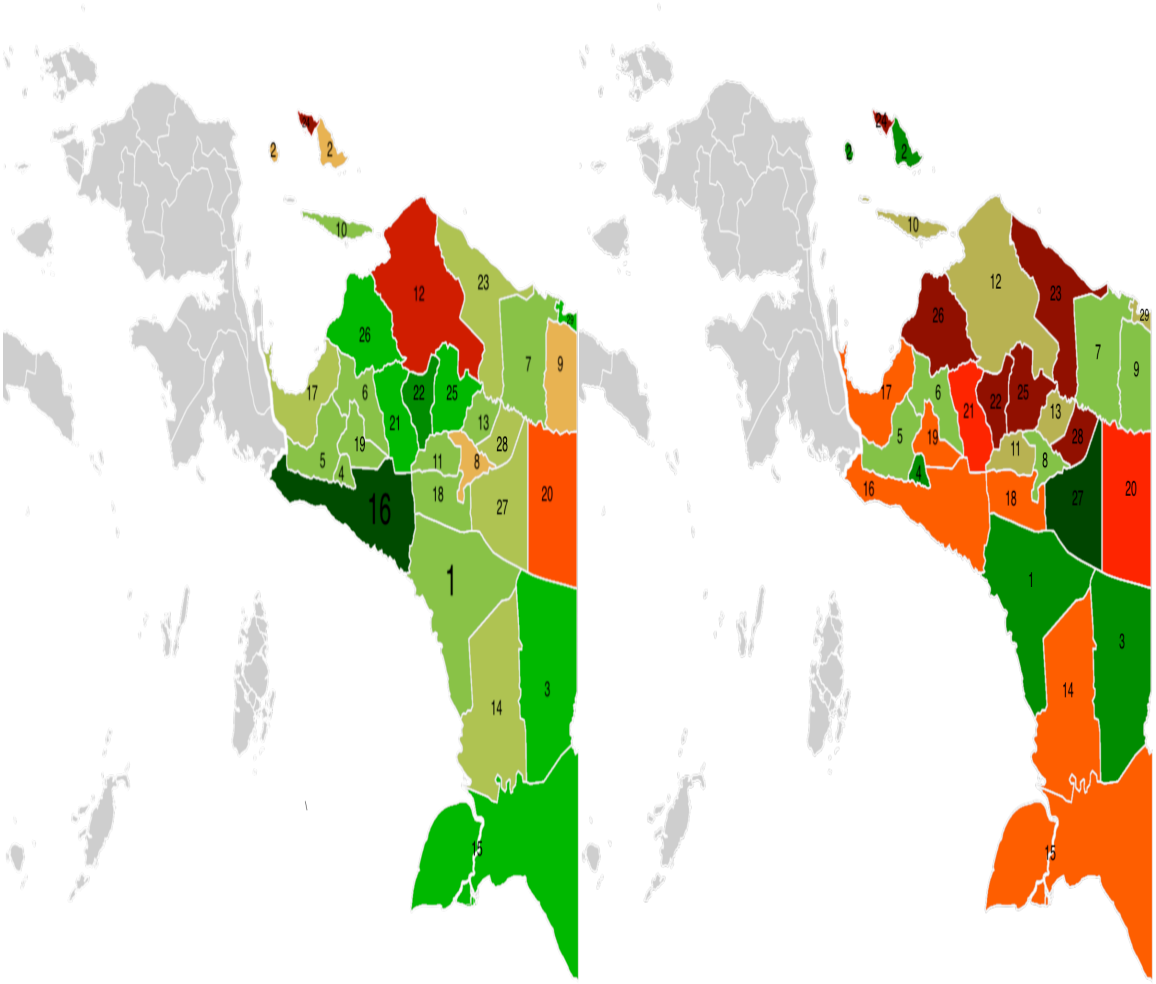
Appendix

Appendix A. Growth map of papua based on employment condition

LHS: Map of Papua based on Total Work Growth (2010-2018)
RHS: Map of Papua based on Unemployment growth (2010-2018)



1.Asmat
2.Biak Numfor
3.Boven Digoel
4.Deiyai
5.Dogiyai
6.Intan Jaya
7.Jayapura
8.Jayawijaya
9.Keerom
10.Kepulauan Yapen
11.Lanny Jaya
12.Mamberamo Raya
13.Mamberamo Tengah
14.Mappi
15.Merauke
16.Mimika
24.Supiori
25.Tolikara
26.Waropen
27.Yahukimo
28.Yalimo
29.Kota Jayapura

17.Nabire
18.Nduga
19.Paniai
20.Pegunungan Bintang
21.Puncak
22.Puncak Jaya
23.Sarmi

Appendix B: Formal and Informal Classification

	Occupation									
Employment Status	Professional Technical & Related Workers	Administrative & Managerial Workers	Clerical & Related Workers	Sales Workers	Services Workers	Agricultural Workers	Production Workers	Operators	Laborers	Others
Self-employed	**F**	**F**	**F**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**
Self employed assisted by family or temporary worker	**F**	**F**	**F**	**F**	**F**	**INF**	**F**	**F**	**F**	**INF**
Employer	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**
Employee	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**	**F**
Agricultural Freelance Worker	**F**	**F**	**F**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**
Non Agriculture Freelance Worker	**F**	**F**	**F**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**	**INF**

Unpaid Worker	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF

Source: BPS

Appendix C: Population According Sectors,Education Background, and Region.

Economic sector	Elementary School and below	Junior High School	High School	College and above	Total
Agriculture	942360	128724	119132	11967	1202183
Manufacture	25836	16894	49700	8962	102392
Services	65189	59619	206938	138709	470455
Total	1034385	205237	375770	159638	1775030

Source: National Labor Force Survey

Region	2019 Population Working According to Economic Sectors and Regions (People)			
	Agriculture	Manufacture	Services	Total
Merauke	55000	12960	42699	110659
Jayawijaya	105988	2023	25487	133498
Jayapura	21775	5569	30229	57573
Nabire	20171	7969	44244	72384
Kepulauan Yapen	24037	3831	19439	47307
Biak Numfor	19026	7430	31734	58190
Paniai	95640	1700	11428	108768
Puncak Jaya	65466	302	8919	74687
Mimika	19670	22117	53427	95214
Boven Digoel	17323	7091	10028	34442
Mappi	29633	1957	11668	43258

Asmat	37698	1998	10579	50275
Yahukimo	100690	525	4643	105858
Pegunungan Bintang	38794	330	6608	45732
Tolikara	77267	1401	9702	88370
Sarmi	6861	2592	8147	17600
Keerom	19665	3264	8235	31164
Waropen	4803	1536	6406	12745
Supiori	4642	826	3374	8842
Mamberamo Raya	7603	196	2353	10152
Nduga	60471	0	0	60471
Lanny Jaya	108277	0	2719	110996
Mamberamo Tengah	28827	0	1716	30543
Yalimo	35584	40	2885	38509
Puncak	64437	523	1075	66035
Dogiyai	55283	0	2345	57628
Intan Jaya	24557	173	2674	27404
Deiyai	47435	27	676	48138
Kota Jayapura	5560	16012	107016	128588
Papua Province	1202183	102392	470455	1775030

Source: National Labor Force Survey

Appendix D: Correlation Matrix

	lnroadlength	lninvestment	lnschool	lnhigherducatiion	LQA	LQS	lnopenness	lnpo sity
lnroadlength	1							
lninvestment	0.2595^{***}	1						
lnschool	0.1917^{***}	0.6598^{***}	1					
lnhighereducation	0.2204^{***}	0.7803^{***}	0.6413^{***}	1				
LQA	-0.2484^{***}	-0.6123^{***}	-0.4826^{**}	-0.5420^{***}	1			
LQS	0.2382^{***}	0.5862^{***}	0.483^{***}	0.5462^{***}	-0.976^{***}	1		

lnopenness	0.3543***	0.4965***	0.4913***	0.5530***	−0.510***	0.4919***	1	
lnpopdensity	0.0157	0.3641***	0.0746	0.4478***	−0.1824***	0.1903***	0.1360**	1

Appendix E: Variance Inflation Factor

Variable	**VIF**	**1/VIF**
LQA	23.45	0.042642
LQS	22.32	0.044797
lnroadlength	1.17	0.855255
lnhighereducation	3.53	0.283163
lninvestment	3.45	0.290217
lnschool	2.23	0.448467
lnopenness	1.76	0.568020
lnpopdensity	1.44	0.694008
Mean VIF	7.42	

Appendix E: Post Estimation Test Statistics

Hausman	P-value: 0.0002

Modified Wald Test	P-Value: 0.000

Pesaran Test	P-Value: 0.5749

Woolridge Test	P-Value:0.1037

Appendix F: Least Squares Dummy Variable

LSDV Estimation

	(1)	(2)	(3)	(4)	(5)
	lnproductivity	lnproductivity	lnproductivity	lnproductivity	lnproductivity
lninvestment	0.70***	0.71***	0.73***	0.74***	0.72***
	(0.06)	(0.06)	(0.07)	(0.07)	(0.06)
lnroadlength	-0.00	-0.01	0.07	0.06	-0.05***
	(0.01)	(0.01)	(0.08)	(0.09)	(0.02)
lnschool	0.03*	0.03	0.03*	0.03	0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
lnHigherEducation	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)
LQA	-0.09**		-0.09**		-0.31***

	(0.04)		(0.04)		(0.10)
lnopenness	-0.03	-0.03	-0.03	-0.03	-0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
lnpopdensity	0.10***	0.10***	0.10***	0.10***	0.10***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)
LQS		0.03**		0.03**	
		(0.02)		(0.02)	
lnroadlength # lninvestment			-0.01	-0.00	
			(0.01)	(0.01)	
lnroadlength # LQA					0.04**
					(0.02)
Constant	-7.12***	-7.33***	-7.54***	-7.71***	-7.10***
	(0.74)	(0.72)	(0.94)	(0.93)	(0.73)
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	168	169	168	169	168
R^2	0.99	0.99	0.99	0.99	0.99
Adjusted R^2	0.99	0.99	0.99	0.99	0.99

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$