The Special Autonomy, Spatial Dependence and Regional Economic Convergence of Papua, Indonesia

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Abstract

This research aims to analyze the influence of government spending in the education sector sourced from special autonomy funds on regional economic convergence in districts/cities in Papua, using panel data from 29 districts/cities during the 2013-2021 period. The influence of education spending and spatial dependence was analyzed using the non-spatial MRW (Mankiw, Romer, Weil) model and the Spatial MRW Model with a spatial weighting matrix customized transportation route contiguity estimated using Spatial Durbin Model (SDM) panel data regression. This research proves that Papua's regional economic convergence will occur at a higher speed when the region considers the role of other regions that are connected via available transportation routes between regions in Papua.

Keywords: Regional Convergence, Special Autonomy, Spatial Dependence.

1. Introduction

This study aims to analyze the effect of district/city government education expenditure sourced from special autonomy funds on regional economic convergence in Papua. Referring to these objectives, this study was conducted following Alvarez & Barbero (2016) who developed Fischer (2011) spatial model. This study evaluates the special autonomy policy for Papua, especially special autonomy spending in the field of education on economic growth and economic convergence of the Papua region based on the Neoclassical Growth Model initiated by Mankiw et al. (1992) known as the MRW model, and further developed by Fischer (2011) by including spatial dependence whose model is known as spatial MRW. Various literatures on economic growth have strived to analyze the determinants of economic growth and convergence. Research conducted by Mankiw et al. (1992) and Barro & Sala-i Martin (2004) show the existence of conditional convergence where underdeveloped countries can grow at a faster rate than developed countries, when these underdeveloped countries can control the determinants that affect the process towards convergence. Convergence is a description of a situation where there is a decrease in economic disparities between countries or in the regional context between regions within a certain period. For the Indonesian regional context, Kharisma & Saleh (2013) emphasize that the concept of convergence is closely related to the regional development policies implemented, where regional development is an integral part of national development. There have been many studies to look at regional economic convergence in Indonesia both between provinces and between districts/cities, including those conducted by Aspiansyah & Damayanti (2019), Miranti & Mendez (2022), and Gunanto, et al. (2023). In the context of regional Papua, regional development policies, especially the special autonomy policy for Papua, are policies that pay special attention to economic progress in Papua so that it can be the same as other developed regions in Indonesia.

Regional economic development in Papua Province has a unique phenomenon, where development activities carried out must be faced with difficult geographical conditions, as well as limited accessibility and mobility between regions. It should be noted that only a few districts/cities have accessibility and mobility using road transportation routes. Meanwhile, most of the accessibility and mobility between districts/cities and even between sub-districts and villages in Papua Province can only be reached by sea and or air transportation.

Through the implementation of the special autonomy policy for Papua Province, which is strengthened by presidential instructions regarding the acceleration of welfare development in Papua Province, one of the sources of financing for district/city regional development in Papua Province comes from special autonomy funds. The availability of regional development funds in Papua Province sourced from special autonomy funds earmarked for education and development policies that focus on indigenous Papuans by taking into account the geographical conditions of Papua through the availability of transportation routes between regions, the economic development of districts/cities in Papua Province will lead to convergent economic conditions (convergence occurs).

2. Theoretical Model

The theoretical basis used as a conceptual framework in this study is the MRW model proposed by Mankiw et al. (1992) and developed by Fischer (2011) into a spatial MRW model which was later expanded by Alvarez & Barbero (2016). In this study, the regional economy in Papua Province is described by the Cobb-Douglas production function with the number of districts/cities as many as N during period T with the assumption of constant returns to scale, which is written:

$$Y_{it} = A_{it} K_{it}^{\alpha_K} H_{it}^{\alpha_H} L_{it}^{1-\alpha_K-\alpha_H} \quad (1)$$

where Y_{it} is the production (output) of district/city i in period t; K_{it} is physical capital; H_{it} represents human capital derived from education expenditure of Papua special autonomy fund, L_{it} is population, and parameter A_{it} describes the level of technological knowledge.

The regional economic growth model of Papua in equation (1) can be rewritten in the form of an output per labor equation by dividing both sides L_{it}, to become:

$$y_{it} = A_{it}k_{it}^{\alpha_K}h_{it}^{\alpha_H} \qquad (2)$$

where y_{it}, k_{it}, and h_{it}, respectively are output per worker, physical capital per worker, and human capital per worker in this case education expenditure of Papua's special autonomy fund.

Furthermore, equation (2) is translated into a technological knowledge equation as follows:

$$A_{it} = \Omega k_{it}^{\theta}h_{it}^{\gamma}\prod_{j=i}^{N} k_{jt}^{\theta\rho w_{ij}}h_{jt}^{\gamma\rho w_{ij}} \qquad (3)$$

where Ω reflects "the exogenous common knowledge", physical capital and human capital in the own region and other districts/cities, while θ and γ reflect technological parameters with the conditions $0 < \theta, \gamma < 1$. Furthermore, w_{ij} reflects the connectivity structure between districts/cities and ρ shows technological interdependence between districts/cities with the condition $0 < \rho < 1$.

By inserting equation (3) into equation (2), the production function (output) per worker will be obtained, as follows:

$$y_{it} = \Omega k_{it}^{\alpha_K+\theta}h_{it}^{\alpha_H+\gamma}\prod_{j=i}^{N} k_{jt}^{\theta\rho w_{ij}}h_{jt}^{\gamma\rho w_{ij}} \qquad (4)$$

Equation (4) states that output per worker in a regency/city area does not only depend on production factors in the regency/city area itself but also depends on production factors from other regency/city areas.

The neoclassical economic growth model assumes that the workforce in district/city i grows by n_i. Meanwhile, the portion of income invested in physical capital and human capital is assumed to be constant at s_i^K and s_i^H respectively with an exogenous investment growth rate, while capital is assumed to depreciate at the same rate of δ. Changes in physical capital per worker and human capital per worker are expressed as:

$$\dot{k}_{it} = s_i^K y_{it} - (n_i + \delta)k_{it} \qquad (5)$$

$$\dot{h}_{it} = s_i^H y_{it} - (n_i + \delta)h_{it} \qquad (6)$$

In steady state, physical capital per worker and human capital per worker grow at a constant rate g:

$$\frac{\dot{k}_{it}}{k_{it}} = g \; ; \; \frac{\dot{h}_{it}}{h_{it}} = g \qquad (7)$$

By substituting equations (5) to (6) respectively into equation (7), the capital to output ratio will be obtained, as follows:

$$\frac{k_{it}^*}{y_{it}^*} = \frac{s_i^K}{n_i + g + \delta} \quad (8)$$

$$\frac{h_{it}^*}{y_{it}^*} = \frac{s_i^H}{n_i + g + \delta} \quad (9)$$

Where the sign (*) in the two equations above indicates the steady state. Next, equation (8) and equation (9) will be entered into equation (4) which is the production (output) function per worker, so that we will get:

$$y_i^* = \Omega^{\frac{1}{1-\eta}} \left(\frac{s_i^K}{n_i + g + \delta}\right)^{\frac{\alpha_K+\theta}{1-\eta}} \left(\frac{s_i^H}{n_i + g + \delta}\right)^{\frac{\alpha_H+\gamma}{1-\eta}} \prod_{j=1}^{N} \left(\frac{s_j^K}{n_j + g + \delta} y_j^*\right)^{\frac{\theta\rho w_{ij}}{1-\eta}} \left(\frac{s_i^H}{n_i + g + \delta} y_j^*\right)^{\frac{\gamma\rho w_{ij}}{1-\eta}} \quad (10)$$

where $\eta = \alpha_K + \alpha_H + \theta + \gamma$

Equation (10) above can be rewritten as:

$$y_i^* = \Omega^{\frac{1}{1-\eta}} \left(\frac{\left(s_i^K\right)^{\alpha_K+\theta} \left(s_i^H\right)^{\alpha_H+\gamma}}{(n_i + g + \delta)^{\eta}}\right)^{\frac{1}{1-\eta}} \prod_{j=1}^{N} \left(\frac{\left(s_j^K\right)^{\theta} \left(s_j^H\right)^{\gamma}}{\left(n_j + g + \delta\right)^{\eta}} \left(y_j^*\right)^{\theta+\gamma}\right)^{\frac{\rho w_{ij}}{1-\eta}} \quad (11)$$

Next, equation (11) will be written back into ln (natural logarithm) form so that it becomes:

$$\ln y_i^* = \frac{1}{1-\eta}\ln\Omega + \frac{\alpha_K+\theta}{1-\eta}\ln s_i^K + \frac{\alpha_H+\gamma}{1-\eta}\ln s_i^H - \frac{\eta}{1-\eta}\ln(n_i + g + \delta) + \frac{\theta}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln s_j^K + \frac{\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln s_j^H - \frac{\theta+\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln\left(n_j + g + \delta\right) + \frac{\theta+\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln y_j^* \quad (12)$$

Equation (12) is a production function (output) per worker in steady state conditions where y_i^* indicates steady state conditions.

Referring to the conditional convergence model from Alvarez & Barbero (2016) which is transformed into natural logarithmic form, the production function per worker is written as:

$$\frac{d\ln y_{it}}{dt} = (\alpha_K + \theta)\frac{d\ln k_{it}}{dt} + (\alpha_H + \gamma)\frac{d\ln h_{it}}{dt} + \theta\rho\sum_{j=1}^{N} w_{ij}\frac{d\ln k_{jt}}{dt} + \gamma\rho\sum_{j=1}^{N} w_{ij}\frac{d\ln h_{jt}}{dt}, \quad (13)$$

where $\frac{d\ln k_{it}}{dt}$, $\frac{d\ln h_{it}}{dt}$, $\frac{d\ln k_{jt}}{dt}$ dan $\frac{d\ln h_{jt}}{dt}$ is the difference in the form of a logartimal transformation of capital per worker.

As is characteristic of the conventional neoclassical growth model, output per worker is predicted to converge towards a steady state. If y_i^* is the steady state condition and y_{it} s the actual value of output per worker in year t, then:

$$\frac{d\ln y_{it}}{dt} = -\lambda_{it}[\ln y_{it} - \ln y_i^*] \qquad (14)$$

where λ shows the speed of convergence. Next, equation (2.14) will be solved by reducing both sides by the output per worker at the beginning of the period $\ln y_{it-T}$, so that we will obtain:

$$\frac{\ln y_{it} - \ln y_{it-T}}{T} = -\frac{1-e^{-\lambda_{it}}}{T}\ln y_{it-T} + \frac{1-e^{-\lambda_{it}}}{T}\ln y_i^* \qquad (15)$$

In essence, equation (15) predicts convergence, because in fact the growth of real output per worker is a negative function of output at the beginning of the period. Therefore, the economy of poor districts/cities grows faster than rich districts/cities. This shows that there is convergence in economic growth, after controlling for the factors determining the steady state. Finally, by substituting equation (12), namely the production function (output) per worker at steady state conditions into equation (15), then equation (15) can be rewritten as:

$$\begin{aligned}\frac{\ln y_{it} - \ln y_{it-T}}{T} = &-\frac{(1-e^{-\lambda_{it}})}{T}\ln y_{it-T} + \frac{(1-e^{-\lambda_{it}})}{T}\frac{1}{1-\eta}\ln\Omega + \frac{(1-e^{-\lambda_{it}})}{T}\frac{\alpha_K+\theta}{1-\eta}\ln s_i^K \\ &+ \frac{(1-e^{-\lambda_{it}})}{T}\frac{\alpha_H+\gamma}{1-\eta}\ln s_i^H - \frac{(1-e^{-\lambda_{it}})}{T}\frac{\eta}{1-\eta}\ln(n_i+g+\delta) \\ &+ \frac{(1-e^{-\lambda_{it}})}{T}\frac{\theta+\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln y_{it-T} + \frac{(1-e^{-\lambda_{it}})}{T}\frac{\theta}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln s_j^K \\ &+ \frac{(1-e^{-\lambda_{it}})}{T}\frac{\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln s_j^H \\ &- \frac{(1-e^{-\lambda_{it}})}{T}\frac{\theta+\gamma}{1-\eta}\rho\sum_{j=1}^{N} w_{ij}\ln\left(n_j+g+\delta\right) \\ &+ \frac{(1-e^{-\lambda_{it}})}{T}\frac{\theta+\gamma}{1-\eta}\rho\sum_{j=1}^{N}\frac{1}{(1-e^{-\lambda_{it}})} w_{ij}\ln y_{jt} \\ &- \ln y_{jt-T} \qquad (16)\end{aligned}$$

3. Literature Review and Empirical Studies

Alvarez & Barbero (2016) analyzed convergence among 47 provincial regions in Spain during the period 1980-2011, by combining the public sector and the spillover of technological knowledge within the framework of the Neoclassical Growth Model, by applying a new estimation method, namely the Spatial Durbin Model for panel data based on instrumental variables and maximum-likelihood estimation.

Research by Perovic et al. (2018) in 28 European Union countries during the period 2004-2013 analyzed the spatial impact of government spending on education on economic growth, using a spatial panel model: Spatial Durbin Model and Spatial Weight Matrix that allows estimation of spatial spillover, and the results showed that government spending on education significantly and positively affects GDP growth.

Flores-Chamba et al. (2019) analyzed the effect of increasing human capital investment through public spending on education infrastructure on regional economic convergence in Ecuador, using data on government spending on education at the provincial level during the period 2001-2015. The results show that public expenditure on education has a positive and significant effect on regional economic convergence of provinces in Ecuador.

Aspiansyah & Damayanti (2019) using panel data of all Indonesian provinces over the period 1990-2015, explored the role of spatial dependence in Indonesia's regional economic growth. Using a spatial durbin model, this study found that spatial dependence plays an important role in regional economic progress in Indonesia. The model of regional economic growth in Indonesia considering the spatial dependence factor obtained better estimation results than the model without the element of spatial dependence. In addition, this study also found that an increase in initial per capita income, population growth, and economic growth in other regions causes positive spatial spillovers to Indonesia's regional economic growth.

Miranti & Mendez (2022) evaluated the occurrence of social and economic convergence in 514 districts/cities in Indonesia during the period 2010-2018, using human development index (HDI) data as a social indicator and GDP per capita as an economic indicator, which were analyzed using spatial panel data methods. This study found that the process of social and economic convergence is strongly influenced by spatial dependence. The performance of other regions tends to accelerate the convergence of HDI and GDP per capita. The results of the Durbin spatial model show that the HDI convergence process is slightly faster than GDP per capita both when using a spatial weighting matrix based on distance and based on Thiessen polygon contiguity. Among the determinants of social convergence, the share of industry and service sector are significant. In contrast, only initial per capita income has a significant effect on economic convergence.

Gunanto et al. (2023) analyzed spatial interactions between districts/cities in Central Java on their economic growth, using the Durbin Spatial Model (SDM) analysis. The results showed that the convergence of the Central Java regional economy occurred faster in the non-spatial model than in the spatial model even though there were significant spatial interactions between districts and cities in Central Java. This study also suspects that the education curriculum is still not in accordance with industry needs so that the influence of human capital variables is not significant, and there is also an anomaly where physical capital has a negative impact.

4. Data and Research Methods

This research's empirical model was developed from Fischer (2011) Spatial MRW model by modifying Alvarez & Barbero (2016) and Perovic et al. (2018) on the Spatial Durbin Model (SDM) to analyze the impact of spatial dependence with a model written as follows:

$$[\ln y_{it} - \ln y_{it-1}] = \beta_0 + \beta_1 \ln y_{it-1} + \beta_2 \ln s_{it}^{K} + \beta_3 \ln s_{it}^{H} + \beta_4 \ln(n_{it} + g + \delta) + \rho_1 \sum_{j=1}^{N} w_{ij} \ln y_{jt-1} + \rho_2 \sum_{j=1}^{N} w_{ij} \ln s_{jt}^{K} + \rho_3 \sum_{j=1}^{N} w_{ij} \ln s_{jt}^{H} + \rho_4 \sum_{j=1}^{N} w_{ij} \ln\left(n_{jt} + g + \delta\right) + \rho_5 \sum_{j=1}^{N} w_{ij} [\ln y_{jt} - \ln y_{jt-1}] + \varepsilon_{it} \quad (17)$$

where y_{it} is the per capita Income (GRDP) variable for region i; y_{it-1} is the Initial per capita income (GRDP) variable for region i; s_{it}^{K} is the education expenditure variable from the special autonomy fund as human capital for region i; n_{it} s the population of area i; s_{jt}^{K} is variable physical capital investment in other regions; s_{jt}^{H} adalah is the education expenditure variable from the special autonomy fund as human capital for other regions; n_{jt} is the population of other regions; $g + \delta$ is technological growth and depreciation which is assumed to be a constant value of 0.05 following Mankiw et al. (1992) and also Alvarez & Barbero (2016); w_{ij} is a spatial weighting matrix indicating spatial connectivity; and $y_{jt} - y_{jt-1}$ is the economic growth of other regions.

This research was conducted over the period 2013-2021. This research observation covers 29 districts/cities spread across Papua Province. This research data was obtained from various sources such as the Papua Province Central Statistics Agency, the Papua Province Regional Planning and Development Agency, and the Directorate General of Financial Balance of the Republic of Indonesia.

This research uses general to specific analysis techniques by estimating a general empirical model, namely the Panel Data Regression Model, to test the Non-Spatial Model, and continues by estimating a specific empirical model, namely the Spatial Durbin Model (SDM) with customized spatial contiguity weighting based on the availability of transportation routes. to test the Spatial Model. Customized spatial contiguity weighting is based on the availability of transportation routes, namely based on information on accessibility and population mobility in carrying out various activities via land, sea and/or air transportation routes. This is due to the large amount of accessibility between districts/cities which can only use sea and/or air transportation routes as the main means of connection due to the unavailability of land transportation routes. For this reason, districts/cities that are connected via land, sea and/or air transportation routes will be given a weighting value of 1, while other districts/cities that are not connected at all will be given a weighting value of 0.

This research was estimated using panel data estimation techniques with the Quasi Maximum Likelihood Estimation (QMLE) method, namely a parameter estimation method that maximizes the likelihood function which will also maximize the log-likelihood function, so that the best model is the model that produces the largest log-likelihood (Burnham & Anderson, 2002; Greene, 2003), while the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are measures that indicate the quality of a model relative to other models, that the smaller the AIC and BIC values of a model will be. better than other models (Burnham & Anderson, 2004; Belotti et al., 2017; Miranti & Mendez, 2022).

5. Results and Discussion

Based on the estimation results of the fixed effect model as a non-spatial MRW model, a spatial dependence test is then conducted using the CD-test or Cross-Sectional Dependence test (Pesaran, 2004) to see the existence of spatial dependence between districts/cities in Papua Province. CD-test is used on panel data when the time series element (T) is smaller than the cross-section element (N) or T < N (De Hoyos & Sarafidis, 2006; Pesaran & Tosetti, 2011). This study uses panel data where there is a time series element (T) of 8 years (2013-2021) and a cross-section element (N) of 29 districts/cities spread across five indigenous regions in Papua Province. The estimation results show a CD-test value of 20,254 with Pr = 0.0000 proving the existence of spatial dependence. This is reinforced by the very high average absolute value of the off-diagonal elements of 0.458.

Table 1. Pesaran's Test of Cross-sectional Dependence

Variable	
Pesaran's Test statistics	20.254
Average absolute value	0.458
p-value	0.000***

Note: *p<0.10; **p<0.05; ***p<0.01

Source: Research Data processed, 2024.

The results of the estimation in this study indicate that the determinants of economic convergence originating from the region itself such as physical and human capital investment and population growth have an impact on the occurrence of regional economic convergence districts/cities in Papua.

This research is in line with the theory as Mankiw et al. (1992) and proves empirically that the determinants of a district/city such as physical capital investment and human capital investment have a positive effect on its own economic convergence, while initial per capita income and population growth have a negative effect.

The regional economic convergence model of districts/cities in Papua that considers aspects of spatial dependence produces better estimates than the non-spatial economic convergence model (conventional model). Judging from the goodness of the model test, namely from the coefficient of determination (R-square), Akaike Information Criterion (AIC) value, Bayesian Information Criterion (BIC) value and Log-Likelihood value in table 4.9, it can be seen that the spatial MRW convergence model based on the availability of transportation routes is better than the non-spatial MRW convergence model. The greater the R-square value of a model, the better the model because the independent variables can explain variations in changes in the dependent variable in the model. The coefficient of determination of the spatial MRW convergence model has a greater value (0.94) when compared to the non-spatial MRW convergence model whose value is only 0.92. Based on the AIC value, the spatial MRW convergence model of the transportation route is the best model compared to the non-spatial MRW convergence model. The AIC value of the non-spatial MRW convergence model (-905.77) is greater than the AIC value of the spatial MRW convergence model of the transportation route (-1010.97). The smaller the AIC value of a model, the relatively better the quality of the model compared to other models (Burnham & Anderson, 2002; Belotti et al., 2017; Aspiansyah & Damayanti, 2019; Miranti & Mendez, 2022; Gunanto et al., 2023). Furthermore, if reviewed based on the log-likelihood value, the model that produces the log-likelihood with the largest value is the best model (Greene, 2003; Aspiansyah & Damayanti, 2019; Husada & Yuhan, 2022). Thus, the transportation route spatial MRW convergence model with the largest log-likelihood (521.49) is the best model compared to the customary area spatial MRW convergence model (log-likelihood = 515.84) and the non-spatial MRW convergence model (log-likelihood = 460.89).

Table 2. Hasil Estimasi Model Spasial dan Non-Spasial

$[\ln y_{it} - \ln y_{it-1}]$	MRW Non-spatial (Panel Fixed Effect)	MRW Spatial (SDM-Fixed Effect)
Constant	6.0828*** (0.000)	
$\ln y_{it-1}$	-0.8474*** (0.000)	-0.9088*** (0.000)
$\ln s_{it}^{K}$	0.1755*** (0.000)	0.0677** (0.034)
$\ln s_{it}^{H}$	0.0280*** (0.008)	0.0397** (0.017)
$\ln(n_{it} + g + \delta)$	-1.0013*** (0.000)	-0.9570*** (0.000)
$W \ln y_{jt-1}$		0.5826*** (0.000)
$W \ln s_{jt}^{K}$		0.0686* (0.099)
$W \ln s_{jt}^{H}$		-0.0311* (0.057)
$W \ln(n_{jt} + g + \delta)$		0.4707*** (0.000)
$W[\ln y_{jt} - \ln y_{jt-1}]$		0.5859*** (0.000)
Speed of Convergence (%)	23.51%	29.94
The Half-life of Convergence (Year)	2.95	2.23
Observation (N)	232	232
R-square	0.9193	0.9441
Log-Likelihood	455.0028	516.6019
AIC	-900.0056	-1013.204
BIC	-882.7719	-978.7365

Note: *p<0.10; **p<0.05; ***p<0.01

Numbers in brackets ( ) p-value of t-statistic (non-spatial model) and z-statistic (spatial model).

Source: Research data processed, 2024.

The results of the estimation of the regional economic convergence model of districts/cities in Papua are shown in Table 2. Convergence of the regional economy of districts/cities in Papua will occur when each region considers the role of other regions and when the regions ignore them. This is evidenced by the initial per capita income coefficient ($\ln y_{it-1}$) which is negative and significant, both in the non-spatial model and in the spatial model that considers the role of the availability of land, sea and or air transportation routes between districts/cities in Papua. However, the magnitude of the initial per capita income coefficient ($\ln y_{it-1}$) in the non-spatial model is smaller than that in the spatial model, resulting in a lower speed of convergence in the non-spatial model of 23.51% per year, while the spatial model has a higher speed of convergence of 29.94% per year. Moreover, the difference in the magnitude of the initial per capita income coefficient also has an impact on the period needed to cover half the gap (the half-life of convergence) towards convergence, where the non-spatial model takes 2.95 years, while the spatial model that considers the role of the availability of inter-regional transportation routes only takes 2.23 years to cover the gap towards the achievement of regional economic convergence of districts/cities in Papua. Thus, the negative direction of initial per capita income ($\ln y_{it-1}$) in the spatial model strengthens the evidence that spatial dependence or inter-regional linkages support and even accelerate the regional economic convergence of districts/cities in Papua. This occurred through a technology spillover mechanism between districts/cities that were closely linked because they were connected through available transportation routes, so that districts/cities that were once poor were increasingly able to catch up, while rich districts/cities began to experience a lag in economic growth, indicating a catching-up process (Barro & Sala-i-Martin, 1992; Ertur & Koch, 2007; Alvarez & Barbero, 2016; Aspiansyah & Damayanti, 2019; Gunanto et al., 2023).

Physical capital investment has a significant impact on the economic convergence of districts/cities in Papua. Physical capital investment has a smaller impact when a region considers the important role of other regions connected through the availability of inter-regional transportation routes, than when the region ignores the role of these other regions. This is indicated by the magnitude of the coefficient of physical capital investment ($\ln s_{it}^{K}$) in the non-spatial model (0.1755) which exceeds the spatial model (0.0677) as shown in Table 2. The coefficient of physical capital investment ($\ln s_{it}^{K}$) whose direction is positive and significant proves that an increase in physical capital in a district/city will increase production capacity and cause an increase in regional income/output which ultimately spurs increased economic growth. Each district/city in Papua needs to increase physical capital investment through the construction of various basic infrastructure, roads, bridges, clean water networks, electricity networks, telecommunications networks, and other facilities and infrastructure that are in direct contact with the needs of the people in each district/city to spur high economic growth.

Looking further at the direct effect in the short and long term, physical capital investment still has a positive and significant impact (see Table 3). The magnitude of the coefficient of physical capital investment in the short term provides a larger direct effect (0.0812) compared to the long term (0.0431). This shows that the massive physical capital investment currently being carried out in the form of construction of various basic infrastructure, roads, bridges, electricity networks, telecommunications networks, and other facilities and infrastructure that are in direct contact with the needs of the community in each district/city in Papua will have a direct impact on regional economic growth. The availability of adequate infrastructure in the future will reduce the influence of physical capital investment on the convergence of the regional economy of districts/cities in Papua.

Focusing on the role of education variables that reflect the importance of human capital, the findings of this study are in line with the findings of previous economic convergence research by Mankiw et al. (1992), Islam (1995), Alvarez & Barbero (2016) , Perovic et al. (2018), Aspiansyah & Damayanti (2019), and Gunanto et al. (2023) where human capital has a positive and significant impact on the achievement of economic convergence. In this study, education as a tangible form of human capital investment is reflected by the education expenditure variable from the special autonomy fund ($\ln s_{it}^{H}$), whose direction of influence is positive and significant, both when the spatial dependence aspect is ignored and when the spatial dependence aspect is included in the economic convergence model as shown in Table 2. It can also be seen that, the magnitude of the effect of human capital investment on regional economic convergence of districts/cities in Papua decreases when spatial dependence is ignored (non-spatial model), while the magnitude of the effect increases when spatial dependence is included (spatial model). This shows logical thinking, as Mankiw et al. (1992) added the effect of human capital investment to the Solow (1956) model. When the inter-regional linkage aspect is not included in the non-spatial model, the effect of human capital investment appears larger because it still contains the influence of other omitted variables, namely the inter-regional linkage aspect. However, on the contrary, when the inter-regional linkage aspect is considered in the spatial model, the effect of human capital investment is cleared from the influence of inter-regional dependency.

Education expenditure from the special autonomy fund ($\ln s_{it}^{H}$), which is positive and significant, proves that the special autonomy fund given to each district/city government can be managed properly, especially in its allocation for education expenditure, which can encourage the improvement of the quality of primary and secondary education and higher education, especially for indigenous Papuans, thus having a positive impact on regional economic growth. When examined further from the effect (direct effect) in the short and long term, human capital investment still has a positive and significant impact (see Table 3). The magnitude of the coefficient of human capital investment in the short term provides a greater direct effect (0.0386) than in the long term (0.0202). Therefore, efforts to increase education spending from special autonomy funds need to be made by each district/city in Papua in order to achieve economic convergence.

Population growth $[\ln(n_{it} + g + \delta)]$ of each district/city in Papua has an important effect on regional economic convergence in Papua both when a region ignores the role of other regions (non-spatial model), and when a region considers the role of other regions connected through the availability of inter-regional transportation routes (spatial model). This can be seen from the coefficient which shows a negative and significant direction of influence in both models. The negative and significant direction of population growth $[\ln(n_{it} + g + \delta)]$ is in line with the empirical findings by Mankiw et al. (1992), Ertur & Koch (2007), Alvarez & Barbero (2016), Aspiansyah & Damayanti (2019); and Gunanto et al. (2023). The population growth of each district/city in Papua has a significant impact in contracting the economic convergence of the region when the population growth rate cannot be controlled by the region. When the population of a region increases more than the increase in regional income (GRDP), the large population will cause a decrease in the per capita income of the region, for this reason the population growth rate must be controlled by each district/city in Papua so that the economic growth of the region is not in a stagnant condition or experiencing negative growth.

The initial per capita income of other regions ($W \ln y_{jt-1}$) has a significant impact on the economic convergence of districts/cities in Papua. This is evidenced by the coefficient of initial per capita income of other regions ($W \ln y_{jt-1}$) which is significant and positive, in the spatial model by considering the role of the availability of transportation routes between regions (see Table 2). Similar empirical findings have been previously produced by Ertur & Koch (2007) for a cross-country study, Alvarez & Barbero (2016) and Sun et al. (2017) for provincial regional convergence studies in Spain and in China, respectively, where the initial per capita income of other regions has a significant effect on the economic growth of a region. Aspiansyah & Damayanti (2019) also found the same thing for the study of provincial regional economic convergence in Indonesia, and Gunanto et al. (2023) for a regional study of districts/cities in Central Java province, Indonesia. The positive and significant initial per capita income of other regions indicates a positive spatial spillover of per capita income on the economic convergence of districts/cities in Papua. Economic activity levels in neighboring districts/cities through the connectivity of available transportation routes between regions, will have a positive impact on regional economic development in districts/cities in Papua, because in fact that neighboring more developed districts/cities that are connected can provide benefits for the economic activities of other regions.

The regional economic convergence of districts/municipalities in Papua experienced a positive spillover effect from physical capital investment in other regions ($W \ln s_{jt}^{K}$). This is indicated by the positive and significant direction of influence on the coefficient of physical capital investment in other regions ($W \ln s_{jt}^{K}$) as in Table 2. The significant impact of physical capital investment in other regions ($W \ln s_{jt}^{K}$) illustrates that when a region invests in technology and makes its economic productivity increase, neighboring regions will also enjoy the spillover of productivity (Amidi et al., 2020). In line with this, neighboring regions that also enjoy the spillover of productivity from a region, in this study, are districts/cities that are interconnected through the availability of transportation routes between regions, both land and sea and or air transportation. The estimation results of this study are in line with the empirical findings of Sun et al. (2017) who found a positive spillover of physical capital investment from other regions to regional economic growth in China, which is thought to be one of the important reasons why China's economic growth is growing so rapidly.

If we look further, in terms of indirect influence or spillover effects in the short and long term originating from investment in physical capital in other regions, it still shows a positive and significant influence (see Table 3). The magnitude of the physical capital investment coefficient in other regions in the short term has a greater spillover effect (0.2526) when compared to the long term (0.1425). This shows that physical capital investment in the form of development of various infrastructure and public facilities and infrastructure which is currently being carried out massively by each district/city that is neighboring or connected through the availability of transportation routes between regions will have a mutually positive impact on the economic growth of their respective regions. respectively, so that the availability of adequate infrastructure in the future will reduce the influence of investment in physical capital in other regions on the economic growth of a region.

Another phenomenon found in the estimation results of this research is that the regional economic convergence of districts/cities in Papua does not experience positive spillover impacts originating from investment in human capital in other regions ($W \ln s_{jt}^{H}$). This is indicated by the direction of the negative and significant influence on the human capital investment coefficient ($W \ln s_{jt}^{H}$) as seen in Table 2. Meanwhile, if viewed from the influence (spillover effect) in the short and long term, the investment coefficient human capital ($W \ln s_{jt}^{H}$) is also negative but not significant (see Table 3). Other negative regional human capital variables were also found in the research of Ertur & Koch (2006) for a study of various countries in the world, Aspiansyah & Damayanti (2019) for a regional study of provinces in Indonesia, and Miranti & Mendez (2022) for a regional study of districts/city in Indonesia. This shows that there is no spatial spillover originating from special autonomy fund education spending on regional economic convergence in Papua. This is because there is no link that can influence the economic growth of other regions, where education spending from special autonomy funds in a region is only enjoyed by the region itself with increasing economic growth, as evidenced by the positive and significant coefficient ($W \ln s_{jt}^{H}$) is the same as in the findings of Aspiansyah & Damayanti (2019). If we look at government policy, the indigenous Papuan people consider that special autonomy is a policy that shows siding with indigenous Papuans as a form of affirmative action for regional development policies in Papua. For this reason, the regional government regulates the management of special autonomy funds through Special Regional Regulations, where education spending, funds from special autonomy for each district/city area are used for educational services, at least 30 percent of which is budgeted to finance the completion of illiteracy, early childhood education, and basic education nine years, secondary education, non-formal education, and higher education in each of these areas.

Table 3. Direct Effect dan Indirect Effect pada Model SDM-Fixed Effect (MRW Spasial)

Variable	Short Run Effect			Long Run Effect		
	Direct	Indirect	Total	Direct	Indirect	Total
$\ln s_{it}^{K}$	0.0812*** (0.006)	0.2526*** (0.000)	0.3338*** (0.000)	0.0431*** (0.006)	0.1425*** (0.000)	0.1856*** (0.000)
$\ln s_{it}^{H}$	0.0386** (0.013)	-0.0168 (0.458)	0.0217 (0.311)	0.0202** (0.013)	-0.0083 (0.486)	0.0118 (0.297)
$\ln(n_{it} + g + \delta)$	-0.9649*** (0.000)	-0.2144*** (0.002)	-1.1794*** (0.000)	-0.5071*** (0.000)	-0.1497** (0.025)	-0.6568*** (0.000)

Note: *p<0.10; **p<0.05; ***p<0.01

Numbers in brackets ( ) p-value of t-statistic (non-spatial model) and z-statistic (spatial model).

Source: Research data processed, 2024.

Population growth in other regions [$W \ln(n_{jt} + g + \delta)$] has a positive impact on the economic convergence of districts/cities in Papua. This is evidenced by the population growth coefficient of other regions [$W \ln(n_{jt} + g + \delta)$] which is positive and significant in the spatial model taking into account the role of the availability of transportation routes between regions (see Table 2). This shows that there is a positive spatial spillover from population growth to regional economic convergence in Papua. This positive spatial spillover phenomenon is in stark contrast to the influence of regional population growth itself (the influence is negative), although various other studies have also found the same thing (Ertur & Koch, 2007, Alvarez & Barbero, 2016, Sun et al., 2017; Aspiansyah & Damayanti, 2019; and Gunanto et al., 2023). Positive spatial spillover of population growth between districts/cities in Papua is thought to occur because an increase in the population of a region will increase demand for goods and services as well as employment opportunities. This is an opportunity that can be exploited by other regions that are connected via available transportation routes between regions, to meet this increase in demand so that it will increase regional income and regional economic growth.

If we look further in terms of indirect effects or spatial spillovers in the short and long term, a phenomenon occurs which is the opposite in accordance with growth theory, where population growth in other regions has a negative and significant impact on the economic convergence of districts/cities in Papua (see Table 3). This shows that there is a negative spatial spillover from population growth to regional economic convergence in Papua, which is also in line with population growth in the region itself. Negative spatial spillover of population growth between districts/cities in Papua has a significant impact in contracting Papua's regional economic convergence when the rate of population growth cannot be controlled by each region. When the population of a region increases and migrates to other regions through the availability of land, sea and/or air transportation routes between regions, it will cause an increase in the population of that region, where if this number exceeds the increase in regional income (GRDP), the population will be large. will cause a decrease in regional per capita income, for this reason the population growth rate must be able to be controlled by each district/city in Papua so that regional economic growth does not remain in a stagnant condition or experience negative growth.

This research found that the regional economic convergence of districts/cities in Papua is also influenced by aspects of spatial dependence, namely when regions consider the role of land, sea and air transportation routes available between regions. This is proven by the significant influence of economic growth in other regions ($W[\ln y_{jt} - \ln y_{jt-1}]$) on achieving regional economic convergence in districts/cities in Papua. The findings regarding the positive impact of economic growth in other regions are in line with empirical findings from various previous studies such as those conducted by Ertur & Koch (2007) for studies between various countries in the world, Alvarez & Barbero (2016) for studies between provinces in the Spanish regional region, Sun et al. (2017) for a study between provinces in regional areas of China, Aspiansyah & Damayanti (2019) for a study between provinces in Indonesia, Miranti & Mendez (2022) for a study between districts/cities in Indonesia, and Gunanto et al. (2023) for a study between districts/cities in Central Java Province which also produced a positive coefficient.

6. Conclusion

First, the education expenditure variable from special autonomy funding sources as a representation of human capital has a significant impact on the regional economic convergence of districts/cities in Papua, both when regions consider the role of other regions (with spatial elements), and when regions ignore the role of other regions (without spatial elements).

Second, the education expenditure variable from special autonomy funding sources as a representation of the implementation of central government and regional government policies specifically intended for indigenous Papuans, such as the education expenditure variable from special autonomy funds, turns out to have a significant impact on district regional economic convergence. / cities in Papua both in the short and long term.

Third, the economic convergence of regency/city areas in Papua is not only influenced by determinants originating from within the regency/city area itself, but is also influenced by the same determinants but originating from other areas because of the interaction between regency/city areas in Papua which is supported by with proximity or connectivity between regions through transportation routes available between regions.

Fourth, regional economic convergence of districts/cities in Papua will occur with varying speeds of convergence and the half-life of convergence. Economic convergence will occur at a lower convergence rate and will take a longer time to cover half the gap (the half-life) towards convergence, when one region ignores the role of other regions (without spatial elements). On the other hand, economic convergence will occur at a higher rate of convergence and requires a shorter time to cover half the gap (the half-life) towards that convergence, when one region does not ignore the role of other regions (with spatial elements).

Fifth, spatial dependence turns out to have an effect in increasing or increasing the speed/rate of convergence and shortening the time needed to cover half the gap (the half-life) towards economic convergence in district/city areas in Papua. Thus, this influential spatial dependence can prove that the availability of inter-regional transportation routes, as a characteristic of the development of Papua Province, plays an important role in increasing the rate of convergence and shortening the time needed to cover half the gap (the half-life) towards regional economic convergence in Papua.

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