ИННОВАЦИИ

https://www.mir-nayka.com

Original article

Economic Convergence in Sumatra Island: Stochastic Approach

Kurniati [1*], Azwardi [2], Sukanto [3]

[1–3] Sriwijaya University (UNSRI), Palembang (South Sumatra), Indonesia

Corresponding author: Kurniati, kurniatinia200196@gmail.com

Abstract

Purpose: *convergence occurs when regions with poor economies tend to grow faster than regions with rich economies, so poorer regions tend to catch up with rich regions in terms of GRDP or per capita products. The concept of convergence is divided into 3 (three) namely sigma convergence, absolute convergence, and conditional convergence. This study focuses on analyzing the trend of convergence based on the approach to the concept of convergence with a concern for analysis, namely stochastic convergence.*

Methods: *the analysis of convergence using a stochastic approach and a sigma and beta convergence approach for each province on the island of Sumatra during the 2011–2020 periods. This research data uses secondary data with a combination of time-series data and cross-sectional data obtained from the Central Statistics Agency, the Ministry of Finance, and the Investment Coordinating Board. Calculation of beta convergence is based on the equation model developed by Barro and Sala-I-Martin (1990) and stochastic convergence based on the measurement model by Ludlow and Enders (2000).*

Results: *the finding from this study shows that there is a stochastic convergence in all provinces on the island of Sumatra which is described based on the Sumatra. The economy has proven Beta convergence which explains the convergence with a relatively low rate of convergence, but the addition of determinant variables such as Domestic Investment and government spending has an impact on increasing the rate of convergence in the island of Sumatra.*

Conclusions and Relevance: *the recommendation for further research emphasizes the spatial interaction between regions because the stochastic stocked test has not been able to see the interdependence between regions that causes convergence.*

Keywords: *Sigma Convergence, Beta Convergence, Stochastic Convergence*

Conflict of Interes. *The Authors declare that there is no Conflict of Interest.*

Оригинальная статья

Аннотация

Цель. *Конвергенция, то есть экономическое сближение, проявляется, когда бедные регионы растут быстрее регионов с богатой экономикой. Менее развитые регионы, как правило, догоняют богатые регионы с точки зрения Валового регионального продукта (ВРП) или объема продукции на душу населения. Концепция конвергенции предполагает три направления, а именно, сигма-конвергенцию, абсолютную конвергенцию и условную конвергенцию. Целью представленного исследования является анализ тенденций экономического развития регионов Индонезии (острова Суматра), основанный на стохастическом подходе в рамках концепции конвергенции.*

Методы или методология проведения работы. *Анализ конвергенции выполнен с использованием стохастического подхода, а также подходов сигма- и бета-конвергенции для каждой провинции на острове Суматра в период 2011–2020 гг. Для исследовании использованы вторичные данные в сочетании с данными временных рядов и перекрестных данных, полученных по информации Центрального статистического управления, Министерства финансов и Координационного совета по инвестициям. Расчет бета-конвергенции основан на модели уравнений, разработанной Барро и Сала-и-Мартином (1990 г.), и стохастической сходимости на базе модели измерения Ладлоу и Эндерса (2000 г.).*

Результаты работы. *Исследование показывает, что во всех провинциях острова Суматра наблюдается стохастическая конвергенция, которая описана на основе Суматры. Экономика доказала бета-конвергенцию, что объясняет конвергенцию с относительно низкой скоростью сближения. Однако добавление определяющих переменных, таких как внутренние инвестиции и государственные расходы, влияет на увеличение скорости экономической конвергенции на острове Суматра.*

Выводы. *В качестве рекомендаций для дальнейших исследований подчеркивается необходимость анализа пространственного взаимодействия между регионами, поскольку стохастический накопительный тест не смог выявить взаимозависимость между регионами, которая вызывает конвергенцию.*

Ключевые слова: *сигма-конвергенция, бета-конвергенция, стохастическая конвергенция*

Конфликт интересов. *Авторы заявляют об отсутствии конфликта интересов.*

Introduction

The concept of convergence occurs when regions with poor economies tend to grow faster than regions with rich economies so that poorer regions tend to catch up with rich regions in terms of GRDP or per capita products. The concept of convergence is divided into 3 (three) namely sigma convergence, absolute convergence, and conditional convergence. Sigma convergence occurs when there is a decrease in the dispersion of GDP per capita over time. Absolute convergence occurs without considering the growth factors while conditional convergence occurs with the consideration of growth factors (Herrendorf et al. [1]). The convergence indicator can be seen from the difference in the contribution of the Gross Regional Domestic Product (GRDP) by region in Indonesia in 2020, dominated by Sumatra and Java islands can be seen in Figure 1.

Based on Figure 1, shows that GDP in Indonesia as a whole is distributed the highest on Java Island at 58.7 percent and Sumatra Island. The structure of the Indonesian economy, which is located on the islands of Sumatra and Java, causes the portion of the distribution of GRDP outside the islands to be very low at only 20 percent of the total. This condition shows that there are disparities between regions in Indonesia. Considering that Sumatra Island has the second largest distribution in Indonesia. Measurement of convergence can be seen from the growth pattern of GRDP per capita in each region. During the 2011–2020 period, it showed that the growth rate on the island of Sumatra was still below the national growth rate, in general, the trend of the growth rate of GRDP per capita on the island of Sumatra and the National experienced fluctuating movements but in 2020 there was a significant decline of -2.7 percent for the island. Sumatra, while nationally it is -3.2 percent. Differences also occur in each province on the island of Suma-
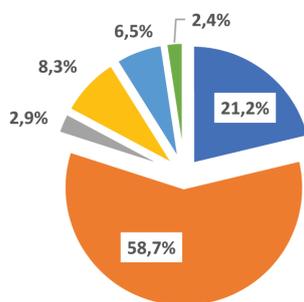
Source: Indonesian Central Statistics Agency (2021)

Fig. 1. Contribution of GRDP to Constant Prices by Island in Indonesia

Источник: Центральное статистическое агентство Индонезии, 2021 г.

Рис. 1. Вклад ВРП в постоянные цены, в разбивке по островам Индонезии

tra, where the average growth rate is contributed by the provinces of South Sumatra and Lampung.

The difference in acceleration between regions on the island of Sumatra is in line with the measurement of scotistic convergence which emphasizes differences in GRDP growth per capita in each region where this analysis studies the long-term behavior of differences in output per capita between regions in time frames (Bernard, Durlauf [2]). In this approach, economic convergence implies that differences in GDP per capita between regions t may contain stochastic trends (called stochastic convergence) (Bernard [3]). The phenomenon of stochastic convergence is an issue in the discussion of differences in GRDP per capita between regions in two-time frames conducted in various literature including a study by Ram [4] exploring stochastic convergence through a stationarity test in the US Region which discusses the existence of stochastic convergence, the same study was conducted by Heckelman [5] conducted a thorough study of convergence which found that the overall sigma and beta convergence had occurred over the last three decades. In the time series test, he found stochastic convergence in about half of the states which also indicates a trend towards beta convergence. Ganong and Shoag [6] document a large decline in the convergence rate of GRDP across the US states over the last 30 years due to factors such as government spending and investment causing high-income regions to slow down the convergence of income. Contrasting with Gama [7] found that investment has a positive and significant relationship to economic convergence. Meanwhile, according to the study of Jawaid and Raza [8] investment has a negative and significant relationship to economic convergence. Investment is a driving factor in reducing inequality between regions so that disparities are created for each province to observe this phenomenon. Domestic Investmentis needed to try to increase other trade sectors which are more to create jobs to reduce inequality in a region and increase investment in development in a region to accelerate the development of a region. Jayanthakumaran and Lee [9] conducted a scotistic convergence analysis which explains that a stable price of a region's output level can spur economic growth in a time frame dimension. This condition is expected to be a concern for the government to increase the allocation of government expenditures to be able to increase economic growth so that inequality is reduced, so if inequality is reduced the region can become a developed region. Achmad [10] show that life expectancy, the average length of the school, and the length of the road have a significant impact on the convergence of economic growth. Bernard and Durlauf [2] showed that in the long term stochastic convergence occurred in *OCD Countries*, while in the short term only a few countries experienced stochastic convergence.

Literature Review

Chatterji et al. [11] show that liberal regimes and Asian countries appear to have potentially high growth rates of real GDP per capita. Furthermore, Fukase and Martin [12] the result is that as convergence increases food supply growth less than demand, it appears to be driving upward pressure on world food prices. The existence of previous research prompted Gama [7] to research economic disparities and convergence. The findings show that domestic investment, working population, and level of education are determinants of economic convergence. Domestic Investment showed positive and significant results, while the number of working population and education level showed positive but not significant. Goel et al. [13] show that improving supply chain logistics performance results in growth dividends. Furthermore, the input and output dimensions of logistics performance have a growth effect, with some quantitative differences. Jawaid and Raza [8] found that investment has a positive and significant impact on economic convergence. Kutan and Yigit [14]. The results showed that there was stochastic convergence, both economic and monetary. Grandes [15] found are investment, trade, population growth and have a positive and significant effect on economic convergence. Nicolaou et al. [16] showed that there was stochastic convergence in all European Countries during the period 1950−2013. Nurhamidah and Suhartini [17] thus, human, and physical capital especially the length of the road needs to be optimized to hasten the convergence of income between districts/cities in the province of South Sumatra. Yulianita and Susetyo [18] examines conditional convergence with the results showing that all provinces in Indonesia are still experiencing divergence. Initial GDP per capita has a significant and positive effect on conditional convergence (β), an increase in government spending will increase conditional convergence (β). Domestic Investment is positive but not significant, inflation is significant and negative to conditional convergence (β), the number of high school graduates is negative and significant to conditional convergence (β). The decrease in the number of high school graduates increases the value of conditional convergence (β). Payne et al. [19] also tested the stochastic convergence of fossil fuel consumption per capita across US states (including the District of Columbia) using the LM and RALS-LM unit root tests with an allowance for endogenous structural damage. determined. The results show a stochastic convergence in the relative per capita consumption of fossil fuels in the US states. Quah [20] suggest the much-vaunted 2% convergence rate could arise for reasons unrelated to the dynamics of economic growth. The usual empirical analyzes − cross-sectional (conditional) convergence regression, time series modeling, panel

INNOVATION

MIR (Modernization. Innovation. Research). 2022; 13(1):60–72

data analysis – can be misleading to understand convergence; polarization model in economic growth. Convergence, unambiguous to sampling error, was observed across US states. Wau [21] Founding the domestic investment has a significant impact on economic convergence and has a positive effect. In line with the Yilanci et al. [22] found that there is a stochastic convergence for Australia, Fiji, Korea, Nepal, Pakistan, the Philippines, and Thailand. The implication is income stocks, economic transition deviations, and income inequality. Kutan and Yigit [14] that there was stochastic convergence, both economic and monetary. Wahiba's [23] researched convergence and divergence in developing countries. The analytical tool used is the within & system generalized method of the moment. This study shows that economic openness has a positive and significant effect on economic convergence in several developing countries. Jawaid and Raza [8] it was found that investment has a positive and significant effect on economic convergence. Kumo [24] founding investment, trade, population growth and have a positive and significant effect on economic convergence. Tiwari and Mutascu [25] show that investment and human capital have a positive and significant effect on economic convergence. Jamal (2017) researched the convergence of economic growth between provinces on the island of Sumatra, showed a divergent process, meaning that the province expanded less capable of pursuing more advanced provinces.

Based on Figure 2, the difference in GRDP per capita between regions is a common phenomenon, especially in developing countries. The difference in GRDP per capita in an area will result in the level of economic growth of a region and cause income inequality between regions. Because in essence regional economic growth is a series of efforts made to improve the welfare of the people's lives, expand job opportunities and equalize income distribution. The unequal distribution of GRDP per capita between regions will lead to groups of rich regions and groups of poor regions.
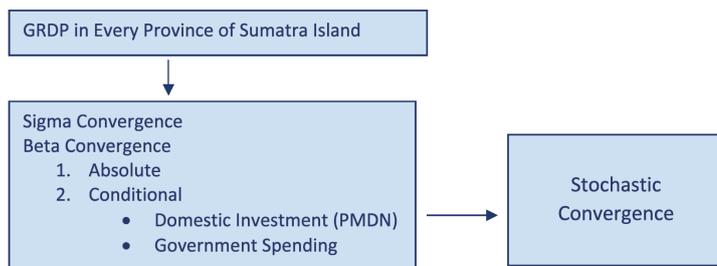
Where developed regions with high per capita GRDP have almost reached the full employment stage, while groups of poor and developing regions must make more efforts to reach the advanced regional economy stage. To analyze whether the groups of poor and developing regions can catch up with their economic backwardness from developed regions, a convergence analysis is carried out. Convergence is needed for groups of poor and developing regions to balance their economic growth with developed regions so that income inequality between regions can be reduced. Convergence can be achieved through increased per capita GRDP growth. To encourage the creation of such convergence, appropriate efforts are needed by using other factors that need to be identified to cause the convergence process. There are two convergence analyzes, the first is sigma convergence which is calculated using the logarithmic standard deviation of GRDP per capita and then looks at the dispersion (spread) of GRDP per capita whether it shows a declining result or vice versa.

If the dispersion of GRDP per capita decreases, it means that income inequality between regions also decreases, whereas if the dispersion of GRDP per capita increases, the income inequality between regions also increases. The second is beta convergence which is calculated by using panel data regression analysis and using the dependent variable of GRDP per capita. There are two beta convergence tests, namely absolute convergence, and conditional convergence. Absolute convergence is calculated by including the initial per capita GRDP as the only independent variable, while conditional convergence adds several independent variables that are thought to affect per capita GRDP growth. These independent variables include Domestic Investment and Government Expenditures.

Materials and Methods

This research focuses on the analysis of convergence with a stochastic approach and a sigma and beta convergence approach for each province on the island of Sumatra during the period 2011–2020. This research data uses secondary data with a combination of time-series data and cross-sectional data obtained from the Central Statistics Agency, the Ministry of Finance, and the Investment Coordinating Board. The beta convergence calculation is based on the equation model developed by Barro and Sala-I-Martin (1990). The equation model relates the per capita growth rate between two-time points with the initial per capita income. If we assume we have observations at two-time points 0, and T, then the Barro and Sala-I-Martin (1990) model can be written:

Developed by the authors.

Fig. 2. Conceptual Framework

Разработано авторами.

Рис. 2. Концептуальная основа исследования

МИР (Модернизация. Инновации. Развитие). 2022. Т. 13. № 1. С. 60–72

ИННОВАЦИИ

$$log\left(\frac{y_{iT}}{y_{io}}\right) = \alpha - \left[\frac{1-e^{-\beta T}}{T}\right].log(y_{io}) + U_{io,}T, \quad (1)$$

where i is the country or region, is the intercept, $\left(\frac{y_{iT}}{y_{io}}\right)$ is GDP per capita, y_{iT} and y_{io} is the GRDP per capita at the beginning and end of the period, $(1 - e^{-\beta T})$ is the coefficient of initial income which decreases with the length of the time interval. To obtain an absolute convergence model, the above equation can be rewritten as follows.

$$log\left(\frac{y_{iT}}{y_{io}}\right) = \alpha + b\log(y_{iT-1}). \quad (2)$$

Equation number 2 of Barro and Sala-I-Martin can be modified to determine the absolute convergence model after the implementation of regional autonomy, namely:

$$log\,y_{iT} = \alpha + \beta_1 \log Y_{iT-1} + e_{iT}, \quad (3)$$

where Y_{it} is GRDP per capita of each province, y_{iT} is GRDP per capita for each initial Regency/City, β_1 is a regression coefficient that can be used to calculate the speed of convergence, and e_{iT} = *error term*.

The conditional convergence model uses equation (1) plus the independent variables in this study, namely, Domestic Investment (PMDN) and Net Exports (EN), and becomes equation (4) as follows:

$$log\,y_{it} = \alpha + \beta_1 \log Y_{it-1} + \\ + \beta_2 \log PMDN_{it-1}\,\beta_3 \log GE_{it-1} + e_{it} \quad (4)$$

Where Y_{it} is GRDP per capita of each province, Y_{it} is the GDP per capita in each province beginning, α is the intercept parameter, $\beta_1 - \beta_3$ is the regression coefficient of each independent variable, domestic investment is a domestic investment, GE is government spending, i is the area t is the year and, e_{it} = *error term*.

Stochastic convergence is measured based on the measurements of Christopoulos et al. [26] based on the Fourier unit root approach with the following equation (5):

$$y_{iT} = \alpha_0 + \sum_{k=1}^{G} \alpha_{1\,sin}^k\left(\frac{2\pi kt}{t}\right) + \sum_{k=1}^{G} \alpha_{2\,cos}^k\left(\frac{2\pi kt}{t}\right) + e_{iT}$$

Here k denotes the number of frequencies, t is the trend term, T is the size sample, π = 3.1416, and $v_t \sim N(0,\sigma)$ Ludlow and Enders [27] shows that a single frequency in Equation 1 is sufficient to estimate the Fourier expansion, so Equation 1 can be rewritten as follows (6):

$$y_{iT} = \alpha_0 + \alpha_1 sin\left(\frac{2\pi kt}{t}\right) + \alpha_2 cos\left(\frac{2\pi kt}{t}\right) + e_{iT} \quad (6)$$

Since the value of k, representing the corresponding frequency, is generally not recognized as a priority, Equation 2 must be estimated using all the frequencies in the interval [0,1,0,2,0,3, ..., 4,8,4,9,5] and choose k which gives the minimum value = k of the Bayesian information criteria. Further testing is carried out. Tests are carried out by testing the unit root test with the hypothesis H_0: $\gamma = 0$ (there is a unit root).

In the regression equation to estimate the model Pesaran et al. [28]:

1. Model with intercept:

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + a_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \quad (7)$$

2. Mode with intercept and time trend:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + a_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \quad (8)$$

That is, Δ is the differentiating factor; β_1 is the intercept (constant); $\beta_2 t$ is the time trend; is the optimal *lag* period that creates residual white noises; εt is the residual white noise. Determining the period *lag* is also very important to create an accurate estimate and a residual *white noise*. There are 2 methods used in this study to determine the period) *lag* optimal (Greene [29]).

1. SBC (*Scwartz Bayesian Criterion*)

2. AIC (*Akaike Information Criterion*)

T is the total sample; C is an infinite number of parameters that must be estimated; k is the total of the estimated parameters, and SSE is the total square of the residuals. The next test determines the best model choosing three models, namely: *Common Effect model*, *Fixed Effect model*, and *Random Effect model*. In determining the model to be estimated, Breusch-Pagan Lagrange Multiply (LM) test is performed for *Random Effects*, the Hausman test is selected infused the *Fixedmodel is or Random Effect* (Greene [29]).

Results

The first discussion is related to the measurement of sigma convergence, namely calculating the value of the logarithmic standard deviation of GRDP growth for all provinces on Sumatra Island in 2010−2020. If the dispersion shows a decrease every year, it indicates a convergence.

Based on Figure 3 shows that there is a divergence based on an increase in the dispersion value in 2011−2015 while in 2016−2019 there is a decrease in the dispersion value which describes the state of convergence on the Island. Sumatra. The highest dispersion value occurred in 2020 which illustrates the state of significant economic divergence on the island of Sumatra in 2020, which is 0.689 which

INNOVATION

MIR (Modernization. Innovation. Research). 2022; 13(1):60–72
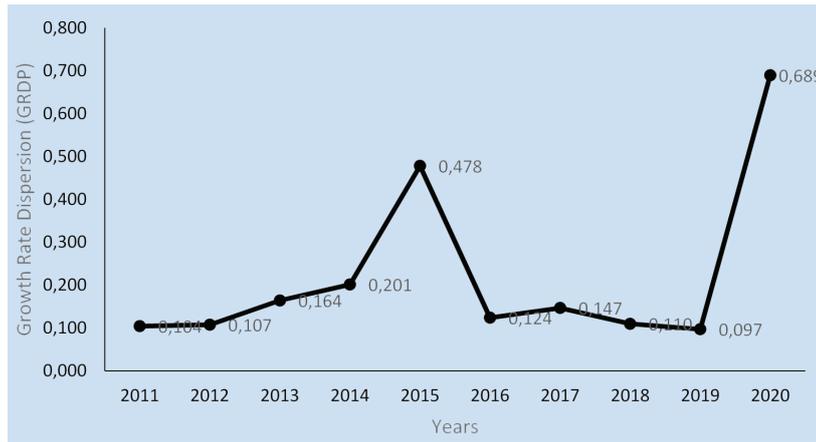
Source: Processed Data, 2021

Fig. 3. Dispersion of GRDP Growth Rate on Sumatra Island in 2011–2020

Источник: обработанные данные, 2021 г.

Рис. 3. Дисперсия темпов роста ВВП на острове Суматра в 2011–2020 гг.

illustrates the impact of Covid 19 providing a very high gap between regions.

Sigma convergence calculations are calculated to explain that the resulting GRDP growth rate will be positively correlated with GRDP growth. The occurrence of sigma convergence is following previous studies that have calculated the level of sigma convergence, namely Kummo and Cieslik (2011), Jawaid et.al [8], and Wahiba [23] which state that there is economic convergence in developing countries. Sigma convergence also indicates that reducing the level of inequality cannot be done quickly. However, it requires a comprehensive development

process in each region to increase economic growth and reduce the level of inequality such as the development of transportation infrastructure, education, agriculture, and health (Tiwari et.al, [25]).

Beta convergence is calculated by two analyzes, namely Absolute convergence analysis and conditional convergence. Both are calculated based on econometric analysis based on panel data analysis. To calculate the convergence Absolut regression analysis of panel data-based approach *Fixed Effect* produced by the model selection is based on the calculation of the *F* test and test Hausman, and *Test Lagrange Multiplier*.

Table 1

Model Test Results

Таблица 1

Результаты испытаний модели

No	Test	Absolute Model		Conditional Model	
		Statistik	Probabilitas	Statistik	Probabilitas
1	Chow Test	5530.48	0,0000	1682.347	0.000
2	Hausman Test	0,0000	1,0000	20.009	0.002
3	LM Test	442.791	0,0000	427.8326	0.002

Source: Processed Data, 2021

Источник: Обработанные данные, 2021 г.

Before estimating the necessary election regression method, the first to test the chow, which is comparing the Pooled Least Square (PLS) with *Fixed Effect Model* (FEM). Based on the results of the *chow test*, the absolute and conditional convergence models show the probability value is 0.000, meaning that the best model chosen is the Fixed Effect Model because the probability value of the chi-square is less than the 5% significance level. The next test is to choose the best

model between *Fixed Effect Model* and *Random Effect Model* by performing *Hausman Test*.

Based on the results of the *Hausman test*, the Chi-Square probability value in the absolute and conditional models is, meaning that the best model is *Random Effect*. The results of these tests there are differences in the results of the selection in each test so that the test is carried out *Langgrange Multiplier*

МИР (Модернизация. Инновации. Развитие). 2022. Т. 13. № 1. С. 60–72

ИННОВАЦИИ

using the *Breusch-Pagan* test which shows that the probability value of "both" is smaller than the 5% significance level (0.0001 < 0.05) so that the model used selected is *Random Effect Model* (REM). However, the estimation output shows that it is not statistically in line with the theory, so the statistical choice is based on the first test, namely Fixed Effect Model for the two models.The calculation of Absolute convergence is based on the equation model developed by Barro and Sala-I-Martin (1990). The equation model connects the GRDP log between two-time points with the initial GRDP log.

$$Log\ (Yit\ ) \ = \ 1{,}613 \ + \ 0{,}556\ Log\ (Yit-1) \qquad (9)$$

Based on Table 2 shows that the log GRDP coefficient for each province on Sumatra Island in the previous year was 1.61, which means that an increase/decrease in the log GRDP for each province on Sumatra Island in the previous year by 1 percent, will have an impact on increasing/decreasing the GRDP for each province on Sumatra Island. by 0.566 percent. The effect of the GRDP Log on Sumatra Island the previous year was positive and (significantly significant) indicated by a significance level of 0.000 (< 0.05). The value of R = 0.997 means that the relationship between the GRDP per capita of each province on the island of Sumatra and the GRDP of each province on the island of Sumatra in the previous year is very strong (because it is almost close to number 1). The value of $R^2 = 0.995$ means that 99.5 percent of the variation in the ups and downs of the GRDP of each province on the island of Sumatra is influenced by the GRDP of each province on the island of Sumatra in the previous year, while the remaining 0.5 percent is influenced by other factors.

Table 2

Estimation Results of Absolute Convergence Regression on Sumatra Island with Fixed Effect Approach

Таблица 2

Результаты оценки регрессии абсолютной конвергенции на острове Суматра с использованием подхода с фиксированным эффектом

Dependent Variable: LOGYit				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.613721	0.114753	14.06251	0.0000
LOGYit-1	0.566073	0.022232	25.46164	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
R-squared	0.995308	Mean dependent var		4.535327
Adjusted R-squared	0.994780	S.D. dependent var		0.187012
S.E. of regression	0.013511	Akaike info criterion		-5.667166
Sum squared resid	0.016247	Schwarz criterion		-5.380597
Log likelihood	294.3583	Hannan-Quinn criter.		-5.551186
F-statistic	1887.812	Durbin-Watson stat		0.526562
Prob(F-statistic)	0.000000			

Source: Processed Data, 2021

Источник: Обработанные данные, 2021 г.

Table 3 shows that the absolute beta convergence value on Sumatra Island is 0.0556 which means that the economic convergence rate on Sumatra Island is 75.56 percent. These results indicate that the economic growth of the provinces in Sumatra Island with low GRDP experienced a growth of 5.56 percent.

Tabel 3

Nilai β Converegence Absolute on Sumatra Island

Таблица 3

Абсолютная конвергенция Nilai β на острове Суматра

No	Converegence	Rate of β Converegence
1	Absolute	0.0556

Source: Processed Data, 2021

Источник: Обработанные данные, 2021 г.

To calculate conditional convergence, it is done using the econometric regression technique which consists of explanatory variables of the initial per capita GRDP log then added with variables as determinants of the GRDP growth rate consisting of Domestic Investment (PMDN) and government spending.

The estimation results of conditional convergence based on the Fixed Effect Model (FEM) approach were analyzed based on hypothesis testing including: *F-test*, *t-test*, and coefficient of determination. The results of the *F-statistic* test show that the *F-statistical* probability value is smaller than the 5% significance level (0.0000<0.05), so that simultaneously the variables Log Y_{it-1}, LNPMDN, and LNGE have a significant effect on Log Y. Meanwhile, to analyze the effect simultaneously Partial *t-test* was carried out using the *t-test* shown in Table 4.

INNOVATION

MIR (Modernization. Innovation. Research). 2022; 13(1):60–72

МИР

Results of Conditional Convergence Regression Estimation on Sumatra Island with Fixed Effect Approach

Результаты оценки регрессии условной конвергенции на острове Суматра с использованием подхода с фиксированным эффектом

Dependent Variable: LOGYit				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.206549	0.183112	-6.589129	0.0000
LOGYit-1	1.391647	0.041531	33.50854	0.0000
LNPMDN	0.000774	0.000680	1.138972	0.2579
LNGE	0.004612	0.001534	3.007411	0.0035
Effects Specification				
Cross-section fixed (dummy variables)				
Weighted Statistics				
R-squared	0.998791	Mean dependent var		7.773649
Adjusted R-squared	0.998623	S.D. dependent var		3.642684
S.E. of regression	0.021017	Akaike info criterion		-5.328766
Sum squared resid	0.037989	Schwarz criterion		-4.987992
Log likelihood	276.7739	Hannan-Quinn criter.		-5.190888
F-statistic	5921.457	Durbin-Watson stat		1.172778
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.996696	Mean dependent var		5.168341
Sum squared resid	0.037989	Durbin-Watson stat		0.549246

Source: Processed Data, 2021

Источник: Обработанные данные, 2021 г.

The probability value of the Log Y_{it-1} is smaller than the 5% significance level (0.0000<0.05) so that partially Log Y_{it-1} has a significant effect on Log Y. The probability of the LNPMDN variable is smaller than the 5% significance level (0.2579>0.05) so that partially LNPMDN has no significant effect on Log Y. The LNGE variable has a probability value smaller than the 5% significance level (0.000<0.05) so partially the LNGE sector has a significant effect on equity. The next test is to test the coefficient of determination to determine how much variation in the Log Y_{it-1}, LNPMDN, and LNGE variables in determining the variation of the Log Y variable with the results of R^2 that is equal to 0.996 or 99.6% of the variation of these variables determines the variation of Log Y and 0.4 percent influenced by variables outside the research model.

Based on these results, further discussion in this study will analyze the effect of the relationship of each variable, namely. Interpretation of the coefficient results can be described as follows:

Log Y_{it-1}, LNPMDN, and LNGE on Log Y with the following equation model:

(10)

$$Log (Y_{it}) = -1,206 + 0,556 \ Log (Y_{it-1}) + 0,0074 \ LNPMDN + 0,00464 LNGE$$

The constant value ($\beta0$) = 1.203 can be interpreted if the variables Log Y_{it-1}, LNPMDN, and LNGE are considered constant or zero, then Log Y is 1.203 percent. That is, LogY without the variables Log Y_{it-1}, LNPMDN, and LNGE is 1.203 percent.

The value of the coefficient ($\beta1$) = 1.394 can be interpreted if the variable Log Y_{it-1} has a negative effect on Log Y, if there is an increase in GRDP in the previous years by 1%, it will increase GRDP by 1.394 percent.

The coefficient value ($\beta2$) = 0.00074 can be interpreted if the LNPMDN variable is to Log Y, if there is an increase in PMDN by 1% it will increase GRDP by 0.00074 percent.

The value of the coefficient ($\beta3$) = 0.00462 can be interpreted that the LNGE variable having a positive effect on Log Y, if there is a government expenditure of 1% it will increase GRDP by 0.032 percent. Based on the estimation results, the study will compare the absolute and conditional convergence.

МИР (Модернизация. Инновации. Развитие). 2022. Т. 13. № 1. С. 60–72

ИННОВАЦИИ

Table 5 shows that the beta convergence value analyzed is based on a comparison of the absolute and conditional convergence rates. In general, after adding determinant variables such as PMDN and Government Expenditures, it significantly increases the rate of convergence as seen from the value of Convergence by 13.91 percent. These results indicate that with an increase in PMDN and government spending, the economic growth of provinces on the island of Sumatra with low GRDP will grow by 13.91 percent.

Table 5

Values of β Absolute and Conditional Convergence

Таблица 5

Значения абсолютной и условной конвергенции β

No	Converegence	Rate of β Converegence
1	Absolute	0.0556
2	Conditional	0.1391

Source: Processed Data, 2021

Источник: Обработанные данные, 2021 г.

The statistical value shows that the Domestic Investment (PMDN) variable has at-statistical probability value (*P-value*) 0.2579, so PMDN is declared significant to Economic Convergence on the Island of Sumatra. Based on Table 7 the coefficient value of LNPMDN = 0.00074 means that every 1 percent increase in PMDN, will increase Economic Convergence by 0.0074 percent. The results of the study are in line with research conducted by Gama (2006) and Malik (2004) showing that Domestic Investment has a positive and significant effect on regional economic growth. This contrasts with the study of Kumo [24] and Tiwari et.al [25] who found that investment and convergence are positive and significant. this study is in line with the study of Jawaid et.al [8] who found that investment has a negative and significant relationship.

The positive relationship between PMDN and GRDP on Sumatra Island is caused by an increase in PMDN which indicates that every province in Sumatra is an attraction for domestic investors to invest their capital. In addition, several factors that led to the increase were infrastructures such as ports and transportation as well as primary sector conditions such as oil, coal, natural gas, and power generation.

Related arguments insignificant effect caused by increased investment is not a determinant of overall economic growth which may mean that the overall investment has not been a significant impact on the increase in the GDP in Sumatra Island.

Estimation results show that government expenditure variable has a value of *t-statistic* probability (*P-value*) 0.000, then government spending is declared significant to Economic Convergence in Sumatra Island. Based on Table 7 coefficient value *LNGE* = 0.00462, meaning that for every 1 percent increase in government spending, it will increase Economic Convergence by 0.00462 percent. The results are consistent with research conducted Gama (2006) and Malik (2004) showed that government spending and significant positive effect on growth but an inconsistent economy. Kumo study [24] and Tiwari et.al [25] found that the effect of government spending is negative and significant.

This corresponds to. *Rostowtheory* and *Musgrave's* relate the development of government spending to the stages of economic development, namely the early, intermediate, and advanced stages. In the early stages of economic development, the percentage of investment to total investment is large because at this stage the government must provide infrastructure such as education, health, transportation infrastructure. In the middle stage of economic development, government investment is still needed to increase economic growth to take off, but at this stage, the role of private investment is getting bigger.

The discussion that becomes a comprehensive analysis based on sigma and beta convergence analysis is the measurement of scotistic convergence which is the concern of this research. The stochastic convergence was calculated using the *Unit Root Test*. Tables 6 and 7 present the results of the most commonly used unit root tests in time series, the ADF and DF-GLS unit root tests for level series. In general, the results of the unit root test show that the entire area on the island of Sumatra is constantly not stationary at a significance level of 5% or 10%. The results of the unit root ADF test can be seen in Table 6.

Based on Table 6 shows the results of the linear Unit Root Test which shows that the GRDP log in each province of Sumatra Island is constantly not stationary at both the 5 percent and 10 percent significance levels. As for the GRDP log, the trend is for each province of the island of South Sumatra. It is concluded that there are no stationary provinces in the ADF Test, so the next test using the DF-GLS allows a more significant trend compared to the ADF.

Test. The results of the Linear unit root test (DF-GLS) can be seen in Table 6.

Test. The results of the Linear unit root test (DF-GLS) can be seen in Table 7:

Based on Table 7 shows the results of the *linear Unit Root Test* using the DF-GLS which shows that the GRDP of the Provinces on Sumatra Island is categorized as stationary, namely Aceh, West Sumatra, Lampung, Bangka Belitung Islands, and

INNOVATION

MIR (Modernization. Innovation. Research). 2022; 13(1):60–72

Result Linear unit root test (ADF)

Результат теста линейного единичного корня (ADF)

Province	Unit Root Test (ADF)	
	ADFC	ADFt
Aceh	0.3809	0.2126
Sumatera Utara	0.2390	0.8560
Sumatera Barat	0.2121	0.9997
Riau	0.8713	0.9981
Jambi	0.0443	0.9238
Sumatera Selatan	0.4407	0.3156
Bengkulu	0.2126	0.3809
Lampung	0.6836	0.4608
Kepulauan Bangka Belitung	0.8713	0.9996
Kepulauan Riau	0.1153	0.9751

Source: Processed Data, 2021 (*Significant on 10%. **Significant on 5%)
Источник: Обработанные данные, 2021 г.

Result Linear unit root test (DF-GLS)

Результат теста линейного единичного корня (DF-GLS)

Province	Unit Root Test (DF-GLS)	
	DF-GLSC	DF-GLSt
Aceh	-1.8474*	-3.12359*
Sumatera Utara	-1.4791	-2.03794
Sumatera Barat	-1.68039*	-1.42903
Riau	-0.7766	-3.29511*
Jambi	-1.48542	-1.28801
Sumatera Selatan	-1.1383	-3.5283**
Bengkulu	-1.37724	-1.590174
Lampung	-1.8474*	-3.12359*
Kepulauan Bangka Belitung	-1.79138*	-1.3638
Kepulauan Riau	-1.6088*	-1.303879

Source: Processed Data, 2021
(***Significant on 1%. **Significant on 5% and *Significant 10%)
Источник: Обработанные данные, 2021 г.

Riau Islands. Meanwhile, the trend is Aceh, Riau, South Sumatra, and Lampung. It is concluded that it shows that of the 10 provinces on the island of Sumatra based on constant values, only half are categorized as stationary. Meanwhile, the trend shows that there are 4 provinces categorized as stationary. It can be concluded that for constants and trends, most of them are not stationary, so this study uses the *Non-Linearity Test* to see the *Stock Economy* between Provinces on the Island of Sumatra. The trend *stock economy* can be seen based on the *Non-Linearity Root Test (KSS) which* can be seen in Table 8:

Table 8 shows the results of the non-linear ADF test (KSS or NLADF). The results of the SSC test show that all provinces on the island of Sumatra are categorized as stationary. This shows that GRDP is stationary and shows an asymmetric or nonlinear stationary mean. In general, this condition explains that all provinces on the island of Sumatra based on the GRDP log show an increasing trend. This is relevant to *unit root tests* based on NLADFT. Empirically, the findings of the *unit root test* using the *de-trended series test* show that only all provinces indicate non-linear stationery and an asymmetric average. This means that it can be said that all provinces are stationary on both constant and trending data.

The results of the SSC test show that the overall GRDP on the island of Sumatra has a relationship with *asymmetric non-linear mean reversion* or stationary. This is in line with the model developed by Kapetanios et al. (2003) is a stationarity test for nonlinear models, and is considered to have better power than the test unit root ADF standard for nonlinear series.

These results also show that all provinces on the island of Sumatra in 2011–2020 experienced stochastic convergence. This condition causes *stock* a permanent economic to economic conditions in the Sumatran region. Based on the Linear Unit Root Test (DF-GLS) shows that there is a negative stock economy, after a *negative stock occurs*, the GRDP trend returns to normal and has an increasing trend seen from the root test coefficient in the SSC test.

The results of the study show that all provinces on the island of Sumatra have a GRDP log which on average has a stationary asymmetric or nonlinear relationship which explains the existence of stochastic convergence throughout the region. Thus, economic conditions tend towards regions to grow together. However, this does not necessarily mean that regional disparities will disappear, considering that the regions as a whole do not yet fully have spatial interactions in narrowing regional disparities.

This finding is following the research of Yilanci et.al [22] who found that most countries in East Asia and

МИР (Модернизация. Инновации. Развитие). 2022. Т. 13. № 1. С. 60–72

ИННОВАЦИИ

Table 8

Result Non-Lineariy unit root test (KSS)

Таблица 8

Результаты теста нелинейного единичного корня (KSS)

Province	Unit Root Test (KSS)	
	NLADFC	NLADFt
Aceh	0.40282*	0.16618*
Sumatera Utara	0.44684*	0.15817*
Sumatera Barat	0.44297*	0.4238*
Riau	0.4918*	0.5000***
Jambi	0.44295*	0.16082**
Sumatera Selatan	0.4504*	0.5000***
Bengkulu	0.4477*	0.166255*
Lampung	0.4028*	0.16618**
Kepulauan Bangka Belitung	0.4436*	0.14458*
Kepulauan Riau	0.3944*	0.16628*

Source: Processed Data, 2021
(***Significant on 1%. **Significant on 5% and *Significant 10%)
Источник: Обработанные данные, 2021 г.

the Pacific experienced Skotastic Convergence. This finding also explains that countries in East Asia and the Pacific follow *steady-state* their own and the difference in per capita income only causes a *stock economy* in most countries, because this income difference causes small regional disparities and is a process towards economic convergence.

Conclusions and Relevance

The results of the discussion during 2010–2021 have occurred stochastic convergence in all provinces on the island of Sumatra. This convergence is caused by an increase in the GRDP log which economically shows a negative stock economy, after which the GRDP log trend returns to normal and has an increasing trend. The picture of economic convergence is proven based on Beta convergence analysis which explains the existence of convergence with a relatively low rate of convergence, but with the addition of determinant variables such as PMDN and Government Expenditures, the rate of convergence has increased. The recommendation for further research emphasizes the spatial interaction between regions because the stochastic stocked test has not been able to see the interdependence between regions that causes convergence, besides that the policy implications are also related to strategic policies in managing Domestic Investment and government spending so that the rate of economic convergence can be even higher.

References

1. Herrendorf B., Rogerson R., Valentinyi A. Chapter 6 – Growth and Structural Transformation. *Handbook of Economic Growth.* 2014; 2:855–941. https://doi.org/10.1016/B978-0-444-53540-5.00006-9 (In Eng.)

2. Bernard A.B., Durlauf S.N. Convergence in international output. *Journal of Applied Econometrics.* 1995; 10(2):97–108. https://doi.org/10.1002/jae.3950100202 (In Eng.)

3. Bernard A.B., Durlauf S.N. Interpreting tests of the convergence hypothesis. *Journal of Econometrics.* 1996; 71(1-2):161–173. https://doi.org/10.3386/t0159 (In Eng.)

4. Ram R. Income convergence across the US states: further evidence from new recent data. *Journal of Economics and Finance.* 2021; 45(2):372–380. https://doi.org/10.1007/s12197-020-09520-w (In Eng.)

5. Heckelman J.C. Income convergence among the US states: cross-sectional and time-series evidence. *The Canadian Journal of Economics / Revue Canadienne d'Economique.* 2013; 46(3):1085–1109. URL: http://www.jstor.org/stable/42705913 (In Eng.)

6. Ganong P., Shoag D. Why Has Regional Income Convergence in the US Declined? *Journal stocked of stock Urban Economics.* 2017; 102:76–90. https://doi.org/10.1016/j.jue.2017.07.002 (In Eng.)

7. Gama, USA. Disparity and Convergence of Gross Regional Domestic Product (GRDP) Per Capita Between Regencies/Cities in Bali Province. INPUT. *Journal of Economics and Social Affairs.* 2009; 1(2).

8. Jawaid T., Raza S.A. Foreign Direct Investment, Growth and Convergence Hypothesis: A Cross Country Analysis. 2012. URL: https://mpra.ub.uni-muenchen.de/39000/ (In Eng.)

9. Jayanthakumaran K., Lee S.-W. Evidence on the Convergence of Per Capita Income: A Comparison of Founder Members of the Association of South East Asian Nations and the South Asian Association of Regional Cooperation. *Pacific Economic Review.* 2013; 18(1):108–121. https://doi.org/10.1111/1468-0106.12013 (In Eng.)

INNOVATION   MIR (Modernization. Innovation. Research). 2022; 13(1):60–72

МИР

10. Achmad L. Convergence Analysis and Spatial Linkage of District/City Economic Growth in Central Sulawesi. *E-Journal of Catalogs.* 2017; 5(1):153–164 (In Eng.)

11. Chatterji M., Gilmore B., Strunk K., Vanasin J. Political economy, growth, and convergence in less-developed countries. *World Development.* 1993; 21(12):2029–2038. https://doi.org/10.1016/0305-750X(93)90074-J (In Eng.)

12. Fukase E., Martin W. Economic growth, convergence, and world food demand and supply. *World Development.* 2020; 132:104954. https://doi.org/10.1016/j.worlddev.2020.104954 (In Eng.)

13. Goel R.K., Saunoris J.W., Goel S.S. Supply chain performance and economic growth: The impact of COVID-19 disruptions. *Journal of Policy Modeling.* 2021; 43(2):298–316. https://doi.org/10.1016/j.jpolmod.2021.01.003 (In Eng.)

14. Kutan A.M., Yigit T.M. Nominal and real stochastic convergence of transition economies. *Journal of Comparative Economics.* 2004; 32(1):23–36. https://doi.org/10.1016/j.jce.2003.09.008 (In Eng.)

15. Grandes M. Macroeconomic Convergence in Southern Africa: The Rand Zone Experience. OECD Development Centre Working Papers 231, OECD Publishing. 2003.

https://doi.org/https://doi.org/10.1787/731274772335 (In Eng.)

16. Nicolaou A., Mauro C., Urquhart P., Marelli-Berg F. Polyunsaturated fatty acid-derived lipid mediators and T cell function. *Frontiers in Immunology.* 2014; 5:75. https://doi.org/10.3389/fimmu.2014.00075 (In Eng.)

17. Nurhamidah R., Suhartini A.M. Income Convergence in South Sumatra Province. *Indonesian Journal of Economics and Development.* 2014; 15(1):71–90.

18. Yulianita A., Susetyo D. Human Capital and Economic Convergence in Indonesia: An Empirical Analysis. *International Journal of Scientific and Research Publications.* 2017; 7(7):439–2250. URL: http://ijsrp.org/research-paper-0717/ijsrp-p6752.pdf (In Eng.)

19. Payne M., Croxen M.A., Lee T.D., Mayson B., Champagne S., Leung V., Bariso S., Hoang L., Lowe C. MCR-1–positive colistin-resistant Escherichia coli in a traveler returning to Canada from China. *Emerging Infectious Diseases.* 2016; 22(9):1673. https://doi.org/10.3201/eid2209.160177 (In Eng.)

20. Quah D.T. Empirics for economic growth and convergence. *European Economic Review.* 1996; 40(6):1353–1375. https://doi.org/10.1016/0014-2921(95)00051-8 (In Eng.)

21. Wau T. Convergence of Economic Development Between Regencies and Cities in North Sumatra. *South Nias College of Economics.* SNEMA. field. 2015.

22. Yilanci V., Saridogan E., Artar O. A stochastic convergence analysis for selected East Asian and Pacific countries: A Fourier unit root test approach. *Theoretical and Applied Economics.* 2014; 18(598): 51–60. URL: https://avesis.comu.edu.tr/yayin/dd12f8e0-bcd6-43a0-8cd4-48648cde17a4/a-stochastic-convergence-analysis-for-selected-east-asian-and-pacific-countries-a-fourier-unit-root-test-approach

23. Wahiba N.F. Convergence and divergence among countries. *Asian Economic and Financial Review.* 2015; 5(3):510–520. https://doi.org/10.18488/journal.aefr/2015.5.3/102.3.510.520 (In Eng.)

24. Kumo W.L. Growth and macroeconomic convergence in Southern Africa. 2011. URL: https://www.afdb.org/sites/default/files/documents/publications/working_130_growth_and_macroeconomic_convergence_.pdf (In Eng.)

25. Tiwari A.K., Mutascu M. Economic growth and FDI in Asia: A panel-data approach. *Economic Analysis and Policy.* 2011; 41(2):173–187. URL: https://core.ac.uk/download/pdf/6494677.pdf (In Eng.)

26. Christopoulos D., León-Ledesma M., Gente K., Gosling A., Krolzigstocked H.-M., Paterson B., Cette G., Satchi M., Shibayama K. International Output Convergence, Breaks, and Asymmetric Adjustments. *Studies in Nonlinear Dynamics & Econometrics.* 2011; 15. https://doi.org/10.2202/1558-3708.1823 (In Eng.)

27. Ludlow J., Enders W. Estimating non-linear ARMA models using Fourier coefficients. *International Journal of Forecasting.* 2000; 16(3):333–347. https://doi.org/10.1016/S0169-2070(00)00048-0 (In Eng.)

28. Pesaran M.H., Shin Y., Smith R.J. Structural analysis of vector error correction models with exogenous I(1) variables. *Journal of Econometrics.* 2000; 97(2):293–343. https://doi.org/10.1016/S0304-4076(99)00073-1 (In Eng.)

29. Greene W.H. Econometric Analysis (7th ed.). Prentice-Hall. 2012 (In Eng.)

30. Anderson E., d'Orey M.A.J., Duvendack M., Esposito L. Does Government Spending Affect Income Poverty? A Meta-regression Analysis. *World Development.* 2018; 103:60–71.

https://doi.org/10.1016/j.worlddev.2017.10.006 (In Eng.)

31. Arazmuradov A., Martini G., Scotti D. Determinants of total factor productivity in former Soviet Union economies: A stochastic frontier approach. *Economic Systems.* 2014; 38(1):115–135.

https://doi.org/10.1016/j.ecosys.2013.07.007 (In Eng.)

32. Marques A., Soukiazis E. Per capita income convergence across countries and across regions in the European Union: Some new evidence. *Journal of Economic Surveys.* 1998; 19(3):389–420. URL: http://www4.fe.uc.pt/ceue/working_papers/iconver.pdf (In Eng.)

33. Skidmore M., Deller S. Is local government spending converging? *Eastern Economic Journal.* 2008; 34(1):41–55. URL: https://www.jstor.org/stable/20642392 (In Eng.)

34. Indonesian Central Bureau of Statistics. Indonesian statistics 2020.

35. Faqieh H.R.P. Analysis of Convergence of Economic Growth Between Districts on Madura Island. 2016.

About the authors:

Kurniati, Faculty Economics, Sriwijaya University (UNSRI), Palembang (South Sumatra), Indonesia (Ilir Barat 1, Palembang, South Sumatera, 30128), kurniatinia200196@gmail.com

Azwardi, Faculty Economics, Sriwijaya University (UNSRI), Palembang (South Sumatra), Indonesia (Ilir Barat 1, Palembang, South Sumatera, 30128)

Sukanto, Faculty Economics, Sriwijaya University (UNSRI), Palembang (South Sumatra), Indonesia (Ilir Barat 1, Palembang, South Sumatera, 30128)

All authors have read and approved the final manuscript.

Об авторах:

Курниати, Экономический факультет, Университет Шривиджая (UNSRI) Палембанг (Южная Суматра), Индонезия (30128, Южная Суматра, Палембанг, Илир Барат 1), kurniatinia200196@gmail.com

Азварди, Экономический факультет, Университет Шривиджая (UNSRI) Палембанг (Южная Суматра), Индонезия (30128, Южная Суматра, Палембанг, Илир Барат 1)

Суканто, Экономический факультет, Университет Шривиджая (UNSRI) Палембанг (Южная Суматра), Индонезия (30128, Южная Суматра, Палембанг, Илир Барат 1)

Авторы прочитали и одобрили окончательный вариант рукописи.