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ENRICHING THE SOCIO-ECONOMIC INEQUALITY MODEL BY USING ALTERNATIVE INDICES

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ABSTRACT. This study aims to investigate regional socio-economic inequality (SEI) using alternative indices. The fruitful indices of the SEI with a different perspective from those found in previous studies are the main contribution to the literature. Afterward, a dynamic spatial panel model (GMM) is used to analyze the effect of human capital, economic growth, and spatial distance for the regions on the SEI. To simplify the ideas, it uses Aceh Province with 23 regencies, as one of the appropriate regions, for this study. Data are obtained from various government sources for the period 2010-2018. The results show that the indices demonstrate the economic strengths and weaknesses, economic capability, environmental input efficiency, and conditional weighted SEI of the regions' human capital. These indices explain that human capital has a critical role on the effect of natural resources, government income, conflict, and natural disasters on the SEI. Besides, the spatial distance of regions also plays an important role in reducing the SEI of regions. Therefore, the regional development policies should underline the important role of those in supporting the quality of the SEI of the regions. For future research, it suggests involving a spatial distance of regions in determining the SEI of a region.

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Introduction

We investigate whether socio-economic inequality (henceforth "the SEI") in a region can be explained by regional socio-economic characteristics, such as natural resources, government income, conflict levels, and the frequency of natural disasters, in which the four unique characteristics depend on the human capital, particularly the educational and health levels. There are strong reasons why the regional socio-economic and intrinsic characteristics must be considered in a model that analyzes SEI. They are the most crucial ones for determining SEI because these characteristics are inherent in the regions. Problems that arise are sometimes unavoidably related to natural resources, government income, as well as the conflict levels and the frequency and types of natural disasters. These are the unmanageable natural resources (Mader, 2018; McCarthy, 2007); natural disasters (Brown, Daigneault, Tjernström, & Zou, 2018); political conflicts (Hillman, 2013; McCarthy, 2007), low budget realizations, the inaccurate use of budgets, corruption (Berdiev, Goel, and Saunoris, 2020); the low quality of the communities' human capital related to their educational and health levels (Werfhorst, 2018, Melamed & Samman, 2015; Binelli et al., 2015; Hazari & Mohan, 2015); and the differences in the natural topography (Guo, Zhu, & Liu, 2018). This signifies that the economic indicators are not the only factors that can explain the SEI, as formulated in the Gini, Williamson, and Theil models. We make an inquiry whether regional socio-economic characteristics depend on human capital.

The theory of endogenous growth states that human capital plays a direct role in driving a sustainable economy of a region in the long term. Human capital reflects education which is the accumulation of knowledge and new ideas in creating and developing technology. Subsequently, a higher level of human capital drives the sustained reproducible production factors having non-decreasing returns without a steady level of income or a balanced path of income growth. (Mankiw, Romer, & Weil, 1992). Differences in human capital cause the rate of non-decreasing return to differ between regions. The rate of non-decreasing return in the poor regions is lower than in the rich ones. Small differences of human capital are a source of economic convergence between regions, otherwise, large differences of human capital lead to economic divergence. Human capital minimizes differences in standard of living between countries or the cross-country difference in income per capita between poor and rich countries that leads to faster convergence (Mankiw, Romer, & Weil, (1992) and Hayakawa & Venieris, (2018).

Socio-economic characteristics of a region have a close correlation with human capital in reducing the level of SEI. The quality of human capital is an important conditional factor in reducing the SEI (Rakauskiene & Strunz, 2016) through optimizing the use of natural resources with dimensions of allocation efficiency and government income in the provision of public goods through the efficiency in government spending, as well as minimizing the conflict level in society, both horizontally and vertically, and reducing the frequency of natural disasters (Hallegatte et. al., 2020) by strengthening the R and D (technological progress) accumulated from science. Therefore, the quality of human capital has positive consequences in reducing SEI through the socio-economic quality of a region (Rakauskiene & Strunz, 2016).

The distinguished studies of Corrado Gini's coefficient (1912), Williamson, (1965), and Theil (1989) with respect to the SEI do not involve the regional socio-economic characteristics in their formulae. In reality, those also determined the SEI of a region. Hence, an alternative approach, employed by this study, enlarges the type of variables included when calculating an inequality index. The variables are natural resources and natural disasters (as intrinsic characteristics of a region), and social conditions (conflict aspect), as well as government income which is conditional on the human capital, particularly their education and health levels. In the first part of this study, our approach focused on the sources of the SEI, which consist of socio-economic components of a region to measure the region's economic strengths and weaknesses, economic capability (capital formation of the region), environmental input efficiency or the weighted SEI of a region, and the conditional weighted SEI of the human capital of labor. The results of the measurements are indices that explain the variations in the level of inequality in the regions. The next step was to analyze the determinant factors of the SEI for the regions, which involved the interaction between the SEI and spatial local interaction, which also includes the economic growth and human capital of each region. We examined whether spatial local conditions, economic growth, and human capital reduce the SEI of the regions.

Given the empirical evidence of the SEI, this study specifically contributes to the literature on the SEI's methods that combine the relationship between economic aspects, social factors, and intrinsic characteristics of the regions. It presents a considerable contribution to the literature and future understanding of the linkages among economic, social, and intrinsic indicators, i.e., regional natural resources, government income, conflict, and natural disasters that are conditional on the human capital, particularly their education and health levels. This research strongly supports the SDGs 2030 which is included in the 17 main SDGs goals, namely no poverty (goal 1), zero hunger (goal 2), good health and well-being (goal 3), quality education (goal 4), decent work and economic growth (goal 8), industry, innovation, and infrastructure (goal 9), reduced inequalities (goal 10), sustainable cities and communities (goal 11), responsible production and consumption (goal 12), climate action (goal 13), peace, justice, and strong institutions (goal 16). Besides, those have focused on the relationship between economic factors and other social factors, like ethnic disparities (Berdiev et al., 2020; Binelli et al., 2015), environmental damage (Mader, 2018; McCarthy, 2007), natural disasters (Brown et al., 2018; (McCarthy, 2007), political conflicts (McCarthy, 2007), corruption (Berdiev et al., 2020), the low quality of communities in relation to their human capital, education, and health levels (Werfhorst, 2018; Binelli et al., 2015, Melamed & Samman, 2015, Hazari & Mohan, 2015), and urban and rural areas (Guo et al., 2018). This new alternative approach is expected to be employed to reduce the SEI problems of regions. In general, this current study attempts to fill this gap in the literature.

This study focuses on the need to distinguish two critical points between the sources and determinant factors of the SEI in the regions. First, we start to provide alternative approaches in calculating the SEI, based on the economic-societal and intrinsic characteristics of the regions. They are different from the well-known Gini's, Williamson's, and Theil's formulas. The approaches consider the four unique characteristics – natural resources, government income, conflict levels, and the frequency and types of natural disasters – that are conditional on the human capital, particularly the educational and health levels for the years 2010 to 2018. The approaches attempt to highlight some important characteristics of the regions relating to their economic strengths and weaknesses, economic capability (capital formation of the region), their environmental input efficiency or the weighted SEI of the regions, and the conditional weighted SEI of the human capital of labor. Second, it involves the key role of the spatial local conditions of the regions, besides their economic growth and human capital levels in affecting the SEI of the regions by using a dynamic spatial panel (GMM) model. Hopefully, these two approaches enable us to describe the different dimensions of the SEI of the regions in supporting the labor market as a whole, reducing inequality, increasing productivity, and strengthening the resilient regional economies (Rakauskiene & Strunz, 2016; Burns & Devillé, 2017; Clark & Bailey, 2018; Berdiev et al., 2020; Hallegatte et. al., 2020). These are the novelty of this study.

The structure of the rest of this study is that Section 1 reviews previous studies with regard to SEI and Section 2 presents a methodological approach that explains modeling of the

SEI with alternative approaches. Section 3 explains the application of alternative indices in the areas that meet the four regional socio-economic characteristics which consist of the sample of this study and data as well as descriptive statistics. Section 3 also accounts for the results of the implementation of the modeling of the SEI. Section 4 provides discussions and finally the conclusions of the study and present some policy recommendations.

1. Literature review

Several studies have examined the problem of regional, interregional and international SEI by using the well-known formulae found in Corrado Gini's coefficient (1912)[1] such as those by Nazim Tamkoc and Torul (2020); Mader, (2018); Werfhorst, (2018); Mikucka, Sarracino, & Dubrow, (2017); Frick and Goebel, (2008); Williamson, (1965)[2]; Theil, (1989)[3]; Binelli, Loveless, & Whitefield, (2015); and Das and Barua, (1996). These formulae have had a significant impact on works studying inequality in the past and they are still up-to-date (Mikucka et al., 2017). Gini employed his coefficient for analyzing per-capita-income's inequality. Milanovic (1997) showed that his coefficient consists of the product of three essential components: (1) The variation of the coefficient of income; (2) The linear correlation coefficients between income and the ranks of the poor and the rich (1 to N, respectively); and (3) A constant equal to 1/√3. Overall, the Gini coefficient must be equal to 1/3 for all the distributions, if Pen's parade is linear. Then, if Pen's parade is concave (convex); Gini's coefficient must be smaller (greater) than 1/3. Williamson (1965) used his measure to study regional inequality, but only at the aggregate level. For a deeper analysis of the North-South problem, a popular term used in Williamson's empirical research, it is necessary to disaggregate and to identify the causes of spatial inequality. Theil (1989) solely used regional per-capita income to capture regional inequality, particularly the between- and within-country inequalities. All these previous studies excluded the regional socio-economic characteristics of the regions being studied, such as the human capital, government income, and conflict levels. They also excluded the frequency and type of natural disasters, as well as any natural resources of the regions. In general, they do not deem those to be important characteristics of the regions.

An alternative approach, employed by this study, enlarges the type of variables included when calculating an inequality index. The variables are natural resources and natural

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[1] Pyatt (1976) shows the relationship of the coefficient to interpersonal comparisons by $G = \frac{\left(\frac{1}{n^2}\right)\sum_{i=1}^{n}\sum_{j=1}^{n}\max(0, y_i - y_j)}{\left(\frac{1}{n}\right)\sum_{i=1}^{n} y_i}$, the ratio of the mean absolute difference between all pairs (y_i,y_j) to twice the mean level of the variable y and *max* $(0,y_i\text{-}y_j)$ signifies the higher level of the two things within the bracket, Pyatt (1976).

[2] Williamson (1965) calculates three types of regional inequality indices: (1) A weighted coefficient of the variation of regional inequality (V_w) or $V_w = \frac{\sqrt{\sum_i (y_i - \bar{y})^2 \frac{f_i}{n}}}{\bar{y}}$,where f_i and n refer to the population of region *i* and n is the national population and y_i and $\bar{y}$ refer to "income per capita" in region *i* and average national income per capita, respectively. (2) An unweighted coefficient of the variation of regional inequality (V_{uw}) or $V_{uw} = \frac{\sqrt{\frac{\sum_i y_i - \bar{y})^2}{N}}}{\bar{y}}$, where N stands for the number of regions. (3) An absolute of weighted coefficient of the variation of regional inequality (M_w) or $M_w = \frac{\sum_i |y_i - \bar{y}| \frac{f_i}{n}}{\bar{y}} x100$

[3] Theil (1989) measures the income inequality by using the natural logarithm of the ratio of the arithmetic mean income to geometric mean income $J = \sum_{i=1}^{n} p_i \log(p_i / y_i)$, where pi is the population share of country i and yi is its income share of i in the world's population and in total world income. The previous equation is extended as inequality among regions $J_R = \sum_{g=1}^{G} P_g \log(P_g / Y_g)$. To measure the inequality among the countries of region R_g is represented by $J = J_R + \bar{J}$, where $\bar{J} = \sum_{g=1}^{G} P_g J_g$.

disasters (as intrinsic characteristics of a region) and the social conditions (conflict aspect), as well as government income which is conditional on the human capital, particularly their education and health levels. The literature provides strong evidence that all those variables have a significant role in reducing the level of the SEI takes place (Mankiw, Romer, & Weil, (1992) and Hayakawa & Venieris, (2018)). Mankiw et al., (1992) and Hayakawa & Venieris, (2018) show that human capital is an essential factor in explaining cross-country differences. It minimizes differences in standards of living between countries, or the difference of cross-country income per capita between poor and rich countries, which leads to faster convergence. In particular, a higher level of human capital fosters the accumulation of physical capital with sustained-reproducible production factors that have nondecreasing returns. In addition, it considers several other factors such as taxation policies, education, and health policies, as well as political stability to explain the differences among countries in per capita income or economic well-being (Rakauskiene & Strunz, 2016).

2. Methodological approach

Modeling SEI with alternative approach

As indicated above, the quantitative analysis considered a number of sources for determining the SEI of the regions. For each of these variables, an inequality was calculated which afterward were summarized into one total inequality index on a regional level. The inequality comparison was based on the latter. This approach deviated from the methods employed by Gini (1912) in Pyatt (1976), Williamson (1965), and Theil (1989). Their formulae do not consider the natural uniqueness of a region, neither do they consider several economic-societal or intrinsic characteristics. The results of using these new methods means we are able to identify more realisticly the extent of the economic and societal inequalities among the regions. Four variables were included in determining the regional inequalities within Aceh. These were natural resources, as represented by real investment (I_{it}), government income (G_{it}), natural disasters (D_{it}), and conflict (C_{it}). The indices i and t refer to region i and year t. The real investment in region i in year t (I_{it}) contributed to the capital stock of that region and thereby to its economic potential. G_{it} is government income by region, which represents the special autonomy funds obtained from the federal government. The conflicts in a region i (C_{it}) were classified into three groups: (a) Very vulnerable conflicts which are characterized by the kind of delinquency that requires the involvement of the security forces or police, the highest frequency of mutual armed engagements, the discharging of firearms, setting off explosives as well as throwing grenades, murder, and abduction. (b) Vulnerable conflicts such as the actions of mobs sweeping, plundering gun, the assertion of dropping the national flag, and criminal combustion. (c) Less vulnerable conflicts which include separatist meetings or lectures, terror or intimidation, narcotics, blackmail or robbery, and incineration. Aceh suffers from natural disasters which affect its individual regions (D_{it}) differently, not only large-scale earthquakes and tsunamis but also natural disasters such as landslides, fires, floods, tornadoes, tidal waves, and droughts. Finally, its human capital (HC), as represented by the health (H_{it}) and education (Ed_{it}) indices of region i in the year *t*. H_{it} and Ed_{it} stand for the life expectancy and expected years of schooling, respectively, in region i.

These variables enter the calculations as proportions which are the regional values divided by the corresponding sum over all the regions. This was done for every single year. Using proportions makes any comparisons easier. This is especially interesting where equations (1) and (4) are concerned. Disasters and conflicts were originally reported as occurrences. To transform them into economic values, the respective frequencies were multiplied by the total gross regional domestic product (GRDP) of the region[4] at the current prices (Y_{it}). This was used as an approximation of the economic damage caused by these occurrences. After this, they were turned into proportions as described above. Another variable, the income gap between the nonpoor and poor, was taken into account for assessing inequality between the regions in Aceh. This factor was considered to be an approximation of the social characteristics. The income gap is the change in the GRDP as the total income of society at current prices, which is subtracted by the poor household's expenditure based on the poverty line of the i^{th} region. Subscripts i and t refer to the district and year. These economic and societal characteristics of a region can be used to calculate two different SEI indices. The first of these two is shown in Equation (1).

$$SEI1_{ia} = \frac{1}{M}\sum_{t=1}^{M}[R_{it} - W_{it}] = \frac{1}{M}\sum_{t=1}^{M}E_{it} \text{, with } E_{it} = R_{it} - W_{it} \tag{1}$$

where R_{it}, shown in Equation (2), constitutes the sum of the real investment in region i relative to the total investment in Aceh per capita plus the ratio of government expenditure in region i to that of all the regions in Aceh; each taken per capita. Subscript t refers to a specific year and M to the total of all the years considered in the analysis. The multiplication of 1/M over $\sum_{t=1}^{M}E_{it}$ results in the SEI index among regions and, without 1/M in the formula, it indicates the SEI within each region i. W_{it}, given in Equation (3), is calculated in a similar way. It represents the sum of the economic losses from disasters and conflicts; the ratio of the disaster per capita (D_{it}) to the total disaster per capita (D^T_t) of the i^{th} region in the year t and the ratio of the conflict per capita (C_{it}) to the total conflict per capita (C^T_t) of the i^{th} region in the year t. Pop_{it} and Pop^T_t refer to the population of the i^{th} region and total population of Aceh in year t, respectively. Y_{it} and Y^T_t both refer to the GRDP, the former to that of region i and the latter to the total of all the regions in year t. Aceh is administratively divided into 23 regions and cities. This total number is represented by N and the total GRDP of the i^{th} region in the year t. The term of E_{it} or $R_{it} - W_{it}$ stands for the economic characteristics of region i which is specified as follows:

$$R_{it} = \left(\frac{\frac{I_{it}}{Pop_{it}}}{\frac{I^T_t}{Pop^T_t}} + \frac{\frac{G_{it}}{Pop_{it}}}{\frac{G^T_t}{Pop^T_t}} \right) = \left(\frac{i_{it}}{i^T_i} + \frac{g_{it}}{g^T_t} \right) \tag{2}$$

with $i_{it} = \frac{I_{it}}{Pop_{it}}, i^T_t = \frac{I^T_t}{Pop^T_t}, g_{it} = \frac{G_{it}}{Pop_{it}}, g^T_t = \frac{G^T_t}{Pop^T_t}$ *for all i= 1, ...,N*

and

$$W_{it} = \left(\frac{\frac{(D_{it}/D^T_t)*Y_{it}}{Pop_{it}}}{\frac{(D_{it}/D^T_t)^T_t * Y^T_i}{Pop^T_t}} + \frac{\frac{(C_{it}/C^T_t)*Y_{it}}{Pop_{it}}}{\frac{(C_{it}/C^T_t)^T_t * Y^T_t}{Pop^T_t}} \right) = \left(\frac{d_{it}}{d^T_t} + \frac{c_{it}}{c^T_t} \right) \tag{3}$$

with $d_{it} = \frac{(D_{it}/D^T_t)*Y_{it}}{Pop_{it}}, d^T_t = \frac{(D_{it}/D^T_t)^T_t * Y^T_t}{Pop^T_t}, c_{it} = \frac{(C_{it}/C^T_t)*Y_{it}}{Pop_{it}}, c^T_t = \frac{(C_{it}/C^T_t)^T_t * Y^T_t}{Pop^T_t}$ *for all i=1,...,N*

[4] In this study, we used the total GRDP at current prices of district i as a multiplier to obtain the estimated economic damage values (economic loss) because the natural topography of Aceh consists of mountains, plains, and coastal areas. Hence, we assumed that the impact of the economic loss due to natural disasters and conflicts is only experienced by the area concerned. However, if the natural topography of the area of plains is much wider, it is recommended to use the total GRDP of all districts per capita. The facts show that the index value with the total GRDP of all the districts per capita has a smaller coefficient of variation than the total GRDP of district i (Martin, 1999).

Another SEI index, $SEI2_{ia}$ is offered in Equation (4). Its main difference to $SEI1_{ia}$ is that the economic characteristics of district i, E_{it}, are taken relative to the social characteristics, S_{it}. The latter is approximated by the difference in per capita income between nonpoor and poor people in district i, relative to the average per capita income difference in Aceh. $SEI2_{ia}$ is called the economic capability index of district *i*. It focuses on the regional ability to generate the capital necessary for each district, relative to the average of Aceh as a whole.

$$SEI2_{ia} = \frac{1}{M}\sum_{t=1}^{M}[(R_{it} - W_{it})/S_{it}] = \frac{1}{M}\sum_{t=1}^{M}\left[\frac{E_{it}}{S_{it}}\right] \quad (4)$$

$$S_{it} = \left(\frac{\dfrac{Y_{npit} - Y_{pit}}{Pop_{it}}}{\dfrac{Y_{npt}^{T} - Y_{pt}^{T}}{Pop_{t}^{T}}}\right) = \left(\frac{\Delta y_{it}}{\Delta y_{t}^{T}}\right) \quad (5)$$

with $\Delta y_{it} = \frac{Y_{npit} - Y_{pit}}{Pop_{it}}, \Delta y_{t}^{T} = \frac{Y_{npt}^{T} * Y_{pt}^{T}}{Pop_{t}^{T}}$ *for all i=1,…,N*

Specifically, Equation (1) presents a composite index of regional (R_{it}) and the natural resource and conflict characteristics (W_{it}) in the region. It focuses more on *the regional economic strength and the weakness index of a region*, which is denoted by the change in the regional characteristics and the natural and conflict characteristics. The larger positive value of $R_{it} - W_{it}$ ($SEI1_{ia} > 0$) is better than the negative value of $R_{it} - W_{it}$ ($SEI1_{ia} < 0$) because the values of i_{it} and g_{it} per capita have to be larger than the values of d_{it} and c_{it} per capita ($i_{it} + g_{it} > d_{it} + c_{it}$). This is seen as being "*sustainable development*" for the i^{th} region.

Equation (4) represents another side of the SEI for the regions, related to *a regional economic capability index of the region* or a composite ratio index of the economic values per capita ($E_{it} = R_{it} - W_{it}$) and societal values per capita, for each region (S_{it}). The detailed features of Equation (4) can be explained since: (i) The larger positive values of $SEI2_{ia}$ ($SEI2_{ia} > 0$) are affected by the larger positive value of the economic characteristics (E_{it}) and the smaller social characteristics of the regions, or the smaller income gap per capita (S_{it}). (ii) The negative economic values per capita, with respect to the income gap per capita, result in the negative values of the SEI of the regions; this condition becomes riskier if the region has a negative economic value.

Moreover, equations (1) and (4) are maintained by *the input efficiency index*, which is represented by Equation (6). It provides the SEI related to the real comparative socio-economic issues because of all variables of this study in the economic values per capita measurement (SEI_{ia}). To obtain the realistic findings, it merely uses the amount of real investment (I_{it}), total government income (G_{it}), and the incomes of the poor (P_{pit}) and the nonpoor (P_{npit}), for calculating the environmental input efficiency index or weighted SEI index of i^{th} region. This is explicitly explained by the ratio of the capital per capita of the district i ($f_{wit} = i_{wit} + g_{wit}$) with two factors. These are income per capita measured by the GRDP at the current prices (y_{it}) of district i minus the economic damage per capita of disasters and conflicts ($n_{wit} = d_{wit} + c_{wit}$) that occurred in the same district ($y_{it} - n_{wit}$). This ratio is divided by another ratio of the capital per capita ($f_{wit} = i_{wit} + g_{wit}$) of the i^{th} region to the income gap per capita of the i^{th} region ($\Delta y_{it} = y_{npit} - y_{pit}$). It is also called the "*weighted socio-economic inequality index*," and a larger positive value is better. The simplified Equation (6) is as follows:

$$SEI3_{ia} = \frac{1}{M}\sum_{t=1}^{M}\left[\left\{E_{wit} / S_{wit}\right\} - 1\right] \tag{6}$$

The term of E_{wit} and S_{wit} stand for the weighted economic and social characteristics of the region in per capita values, which are specified as follows:

$$E_{wit} = \left\{ \frac{\frac{I_{it}}{Pop_{it}} + \frac{G_{it}}{Pop_{it}}}{\frac{Y_{it}}{Pop_{it}} - \frac{\left(\frac{D_{it}}{D_t^T} xY_{it}\right)}{Pop_{it}} + \frac{\left(\frac{C_{it}}{C_t^T} xY_{it}\right)}{Pop_{it}}} \right\} = \left\{ \frac{i_{wit} + g_{wit}}{y_{it} - (d_{wit} + c_{wit})} \right\} = \left\{ \frac{f_{wit}}{y_{it} - n_{wit}} \right\} \tag{7}$$

with $i_{wit} = \frac{I_{it}}{Pop_{it}}, g_{wit} = \frac{G_{it}}{Pop_{it}}, y_{it} = \frac{Y_{it}}{Pop_{it}}, d_{wit} = \frac{\left(\frac{D_{it}}{D_t^T} xY_{it}\right)}{Pop_{it}}, c_{wit} = \frac{\left(\frac{C_{it}}{C_t^T} xY_{it}\right)}{Pop_{it}},$

$f_{wit} = i_{wit} + g_{wit}, n_{wit} = d_{wit} + c_{wit}$, *for all i=1,…,N*

$$S_{wit} = \left\{ \frac{\frac{I_{it}}{Pop_{it}} + \frac{G_{it}}{Pop_{it}}}{\frac{Y_{npit}}{Pop_{it}} - \frac{Y_{pit}}{Pop_{it}}} \right\} = \left\{ \frac{i_{wit} + g_{wit}}{y_{npit} - y_{pit}} \right\} = \left\{ \frac{f_{wit}}{\Delta y_{it}} \right\} \tag{8}$$

with $y_{npit} = \frac{Y_{npit}}{Pop_{it}}, y_{pit} = \frac{Y_{pit}}{Pop_{it}}, \Delta y_{it} = y_{npit} - y_{pit}$, *for all i=1,…,N*

The result of Equation 6 can also be obtained using Equation 9, where the result is the product of the simple mathematical multiplication of Equation 6. This study, however, keeps using Equation 6 for calculating the SEI of a region, to obtain a consistent understanding and specific depiction of the "*weighted socio-economic inequality index*," particularly for the capital per capita of a region, with respect to its economic losses (disaster and conflict) and the income gap between nonpoor and poor people.

$$SEI3_{ia} = \frac{1}{M}\sum_{t=1}^{M}\left[\left\{\frac{f_{wit}}{y_{it} - n_{wit}} / \frac{f_{wit}}{\Delta y_{it}}\right\} - 1\right] = \frac{1}{M}\sum_{t=1}^{M}\left[\left\{\frac{\Delta y_{it}}{y_{it} - n_{wit}}\right\} - 1\right] \tag{9}$$

The fourth index attempts to include the role of human capital in the formula (Equation 6) as represented by the health (H_{it}) and education (Ed_{it}) indices of region i in year *t*. H_{it} and Ed_{it} stand for the life expectancy and expected years of schooling, respectively, in region i. This is also called "the *conditional weighted-socio-economic inequality index on the human capital of labor.*" This index explains the role of human capital as a "labor-augmenting" technological progress (Romer, 2009) to create socio-economic efficiency in the economy, to enhance the socio-economic level of the regions. This index is a ratio of the capital per capita of district i ($f_{HCwit} = i_{HCwit} + g_{HCwit}$) over the income per capita measured by GRDP at the current prices (y_{HCwit}) of district i minus the economic damages per capita of disasters and conflicts ($n_{HCwit} = d_{HCwit} + c_{HCwit}$) occurring in the same district ($y_{HCwit} - n_{HCwit}$), in which the human capital of labor is a conditional variable. Then, this ratio is divided by another ratio of the capital per capita ($f_{HCwit} = i_{HCwit} + g_{HCwit}$) of the i^{th} region to the income gap per capita of the i^{th} region ($\Delta y_{HCwit} = y_{HCwnpit} - y_{HCwpit}$) with the human capital of labor as a constraining factor. A larger value for $SEI4_{ia}$ is better. The formulation is presented as follows:

$$SEI4_{ia} = \frac{1}{M}\sum_{t=1}^{M}\left[\left\{E_{HCwit} / S_{HCwit}\right\} - 1\right] \tag{10}$$

The terms E_{HCwit} and S_{HCwit} stand for the conditional weighted-social and economic characteristics of a region in per capita values which are specified as follows:

$$E_{HCwit} = \left\{ \frac{\left\{\frac{I_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\} + \left\{\frac{G_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}}{\left[\left\{\frac{Y_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}\right] - \left[\left\{\frac{\left(\frac{D_{it}}{D_t^T} xY_{it}\right)}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\} + \left\{\frac{\left(\frac{C_{it}}{C_t^T} xY_{it}\right)}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}\right]} \right\} \tag{11}$$

Or

$$E_{HCwit} = \left\{\frac{i_{HCwit} + g_{HCwit}}{y_{HCwit} - (d_{HCwit} + c_{HCwit})}\right\} = \left\{\frac{f_{HCwit}}{y_{HCwit} - n_{HCwit}}\right\} \tag{12}$$

with $i_{HCwit} = \frac{I_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}$, $g_{HCwit} = \frac{G_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}$, $y_{HCwit} = \frac{Y_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}$,

$d_{HCwit} = \frac{\left(\frac{D_{it}}{D_t^T} xY_{it}\right)}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}$, $c_{HCwit} = \frac{\left(\frac{C_{it}}{C_t^T} xY_{it}\right)}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}$, $f_{HCwit} = i_{HCit} + g_{HCwit}$, $n_{HCwit} = d_{HCwit} + c_{HCwit}$,

for all i=1,…,N

$$S_{HCwit} = \left\{ \frac{\left\{\frac{I_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\} + \left\{\frac{G_{it}}{L_{it}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}}{\left\{\frac{Y_{npit}}{L_{npit}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\} - \left\{\frac{Y_{pit}}{L_{pit}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}} \right\} \tag{13}$$

Or

$$S_{HCwit} = \left\{\frac{i_{HCwit} + g_{HCwit}}{y_{HCwnpit} - y_{HCwpit}}\right\} = \left\{\frac{f_{HCwit}}{\Delta y_{HCwit}}\right\} \tag{14}$$

with $y_{HCwnpit} = \left\{\frac{Y_{npit}}{L_{npit}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}$, $y_{HCwpit} = \left\{\frac{Y_{pit}}{L_{pit}\left[\sqrt[2]{(H_{it} * Ed_{it})}\right]}\right\}$, $\Delta y_{HCwit} = y_{HCwnpit} - y_{HCwpit}$, *for all i=1,…,N*

The second critical point of this study was to analyze the determinant factors for the SEI of the regions by using a dynamic spatial panel GMM model. The model enabled us to depict a better dynamic relationship between the economic variables due to the parameter estimates being more consistent and unbiased (Baltagi, Fingleton, & Pirotte, 2019; Baltagi, 2005; Pesaran, 2015). The validity of the model was justified by the J-Stat value, which was smaller than the chi-square (χ^2), and strengthened by the probability (J-Stat) value being smaller than $\alpha = 0.05$ (Baltagi, 2005; Pesaran, 2015). The analysis strongly emphasized the critical role of the spatial local conditions of each region, as represented by the spatial distance of the regions, with the economic growth and human capital levels affecting the SEI of the regions. The initial form was based on Arellano & Bond, (1991) and Arellano & Bover, (1995) as follows:

$$Y_{i,t} = \alpha_{it} + X_{it}\beta + \mu_{i,t} \quad , for\ all\ i=1,...,N \tag{15}$$

Equation (15) can be reformulated as follows:

$$SEIJ_{i,t} = \alpha_{it} + X_{it}\beta + \mu_{i,t} \quad \text{, with J= 1,4,6, and 10} \tag{16}$$

where SEIJs stands for a variety of the SEIs of the i[th] region at time t and X_{it} refers to the explanatory variables consisting of the economic growth rate (g) and human capital index (IPM), β is the estimated coefficients of the the observed variables, α stands for the constant and μ is the error terms. If βs have significantly larger negative coefficients, the human capital and economic growth play an important role in reducing the SEI of the regions. Equation (16) is expanded by involving the spatial dependence, in terms of the distance between the regions and the neighboring regions. The general case for this spatiotemporal model in this study is based on the previous literature, as proposed by Anselin, Gallo, & Jayet, (2008) and Lee & Yu, (2010). Generally, it can be modified as a general form of the used function for further analysis in this study.

$$SEIJ_{i,t} = \alpha_{it} + \gamma SEIJ_{i,t-1} + \rho WSEIJ_{i,t} + \lambda WSEIJ_{i,t-1} + X_{it}\beta + \mu_{i,t} \quad with \quad J = 1,4,6,10 \tag{17}$$

where W denotes the vectors of the spatial weights of a region across regions, which account for the neighborhood effect. This spatial weight *(W_{ij})* is represented by the spatial distance of regions as a geographic proximity with three regions at a zero spatial distance in kilometers (km) from the other regions (see Figure 1). SEIJs are a variation of the SEI indices based on equations (1), (4), (6) and (10). Next, to test the individual behavior of the panel data and the behavioral stability of all the observed variables , the unit root test (the values of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)) and the cointegration test based on the Kao Residual Cointegration Test (ADF statistics) are used.

3. The application of alternative indices in the areas that meet the four regional socio-economic characteristics

3.1. The sample

To simplify the implemented ideas of this study, Aceh with 23 regencies/cities is one of the appropriate regions as it has the primary needs for this study (Graph 1). Aceh, one of 34 provinces in Indonesia, is located in the most western part of Indonesia and is one of the regions in the world that has unique regional characteristics and community conditions; it is a prosperous region due to its natural resources, but most of the population live below the poverty line (McCarthy, 2007). A prolonged armed conflict occurred in Aceh for more than 30 years (Bass, Poudyal, Tol, et al., 2012; Gunaryadi, 2006); a separatist conflict that received international attention (Zeccola, 2011; McCarthy, 2007, Gunaryadi, 2006). The effects of this armed conflict included human rights violations (Zeccola, 2011; Drexler, 2006), poor mental health (Bass, Poudyal, Tol, et al., 2012; Agustini, E.N., I . Asniar, 2011), and severe poverty (Zeccola, 2011; Drexler, 2006). In addition to the armed conflict, Aceh experienced an unusually devastating natural disaster, the Indian Ocean tsunami in 2004 (Kennedy, Ashmore, Babister, & Kelman, 2008; McCarthy, 2007), from which it suffered the worst damage in the world (Matsumaru, Nagami, & Takeya, 2012; Kennedy et al., 2008). Tsunamis cause regional damage and changes, increase a region's vulnerability to disasters (Marchand, Buurman, Pribadi, & Kurniawan, 2009; Kennedy et al., 2008), and increase poverty due to income loss (Tewfik & Andrew, 2008). After the tsunami struck Aceh, the Government of Aceh made peace with the separatist movement (Zeccola, 2011); (Ahtisaari, 2008) by signing a peace

MoU in Helsinki in 2005 (Ahtisaari, 2008). One requirement of the MoU was the issuance of the Special Autonomy Law (UUPA No 11 in 2006) that regulates the oil and gas revenue-sharing system between Aceh and the central government. The application of this law in Aceh will have increased the regional government's revenue by a very significant amount over the 20 years period of the autonomy law, which runs from 2008 to 2027 and this should reduce the poverty and the SEI in Aceh. After the conflict and natural disaster, Aceh conducted public administration reforms related to peace and development (Hillman, 2013; Rice, 2009). For the sake of reconciliation between the government and the separatist movement in Aceh, and for reconstruction after the tsunami, Aceh required a very large budget (Bass, Poudyal, Tol, et al., 2012; Matsumaru et al., 2012; Zeccola, 2011; Kennedy et al., 2008; Rice, 2009; Gunaryadi, 2006) and the involvement of many parties from various groups, both local, national and international (McCarthy, 2007; Gunaryadi, 2006) over a long time (Leary, 2004) and at a high cost (Matsumaru et al., 2012; Marchand et al., 2009).

Graph 1. Geographical Outlook of Aceh by Regions
Source: *topographical Map of Indonesia, Government Geospatial Information Agency (BIG) and Ministry of Domestic Affairs regulations (Permendagri), No. 56/2015*
Note: *Banda Aceh City (BA), Aceh Barat Regency (AB), and Lhokseumawe City (L) are the chosen regions as a zero spatial distance in kilometers (KM) from the other regions (spatial weight (W_{ij})) in a dynamic spatial panel (GMM) model.*

3.2. Data and descriptive statistics

Data used in this study were obtained from various sources, of which the most important ones were the statistical yearbooks of Aceh Province and of Indonesia by the government's Central Bureau of Statistics (CBS) in 2019. The CBS database is generally supported by the Village Potential Statistics (PODES) which covers 6,508 villages. The data cover all the villages and neighborhoods in Aceh and provides detailed village information with regard to the villages' administration, finance, demography, employment, environment, anticipation, the incidence of natural disasters, education, health, social culture, social infrastructure, economy, security, autonomy, and community empowerment programs. Data on any conflicts are obtained from the Regional Police of Aceh. Then, data on the investment and government income in Aceh are provided by the Investment and One-Stop Services Agency and the Regional Revenue and Finance Service of Aceh Province and Indonesia Agency, respectively. The descriptive statistics of the main selected variables for modeling the SEI of ith region are represented in *Table 1*.

Table 1. Descriptive Statistics of Selected Variables for Modeling the SEI Indices, 2010-2018

Description of Indicators	Abbr[a]	Unit[b]	Mean	Med	Max	Min	Std. Dev	Covar	Skewness	Kurtosis
Health indicator	H	Index	67.594	68.290	71.270	62.590	2.308	0.034	-0.555	2.306
Education indicator	E	Index	13.709	13.620	17.260	11.540	1.003	0.073	0.771	4.595
District disaster over total disasters	D	Share	16.203	8.500	146.000	0.000	21.343	1.317	2.782	13.305
Economic loss per disaster (per capita)	D*Yit/P	Million	1.087	0.680	8.860	0.000	1.209	1.112	2.515	12.179
District conflict over total conflicts	C	Share	2.130	2.000	3.000	1.000	0.852	0.400	-0.252	1.430
Economic loss per conflict (per capita)	C*Yit/P	Million	1.124	0.780	4.040	0.090	0.959	0.854	0.986	3.312
Investment	I	Million	102,457	3,740	2,183,521	0.000	279,558	2.729	4.149	23.244
Investment per capita	I/P	Million	0.559	0.020	14.620	0.000	1.665	2.976	4.807	31.607
Government income	G	Million	820,461	718,033	2,414,901	55,515	446,597	0.544	1.207	4.314
Government income per capita	G/P	Million	4.835	4.030	19.020	0.130	3.042	0.629	1.988	8.211
Gross regional domestic product (GRDP)	Y	Million	5,522,747	4,304,405	20,080,868	745,859	4,371,145	0.791	1.417	4.755
GRDP of the poor per capita	Yp	Million	12,684	10,133	39,181	2,548	8,702	0.686	1.216	3.739
GRDP of the nonpoor per capita	Ynp	Million	5,510,063	4,291,669	20,049,166	743,211	4,364,892	0.792	1.418	4.757
Per capita gap of GRDP between nonpoor and poor	Ygap/P	Million	25.065	21.910	66.570	11.620	10.396	0.415	1.648	5.843
Investment per worker	I/L	Million	0.028	0.001	0.734	0.000	0.082	2.977	4.912	33.155
Government income per worker	G/L	Million	0.250	0.204	0.957	0.006	0.160	0.642	1.866	7.180
GRDP per worker	Y/L	Million	1.263	1.144	2.600	0.683	0.415	0.328	1.254	4.244
Economic loss per disaster (per worker)	D/L	Million	0.054	0.035	0.349	0.000	0.055	1.024	2.010	8.169
Economic loss per conflict (per worker)	C/L	Million	0.056	0.040	0.198	0.005	0.047	0.828	0.878	3.018
GRDP of the nonpoor per worker	Ynp/L	Million	1.532	1.398	3.016	0.859	0.468	0.306	1.006	3.364
GRDP of the poor per worker	Yp/L	Million	0.017	0.017	0.027	0.011	0.003	0.168	0.387	3.274
Per worker gap of GRDP between nonpoor and poor	Ygap/L	Million	1.515	1.382	3.003	0.842	0.468	0.309	1.012	3.383
Economic growth	eg	Pecent	3.600	4.230	13.150	-20.340	2.928	0.813	-3.965	28.884
Human capital indicator	HC	Index	68.016	67.37	84.37	58.97	4.968	0.073	0.942	4.2263

Source: *calculations based on CBS data, 2019*

Note: *a) Abbreviation of indicator as used in text and formulas, b) Unit of measurement, and total observations: 207. H and E stand for health and education indices of the i^{th} region; D refers to the ratio of district disasters over the total disasters multiplied by Y_{it} or D*Yit of the i^{th} region; d or $D*Y_{it}/P$ is the disaster per capita in economic value; C denotes the ratio of the conflict rate over the total conflict rate by using three classifications (very vulnerable, vulnerable, and less vulnerable) multiplied by Y_{it} or C*Yit of the i^{th} region; c or $C*Y_{it}/P$ is the conflict per capita in economic value; I and I/P = i are real investment and investment per capita of the i^{th} region; G and G/P = g are the total government income and the government income per capita of the i^{th} region, respectively; Y stands for GRDP at current prices as the total income of the i^{th} region; Y_p and Y_{np} are the total poor income and the total nonpoor income, respectively; y_{gap} or $(Y_{np}- Y_p)/P$ is income gap per capita between the nonpoor income and the poor income with respect to the total population of the i^{th} region; I/L, G/L and Y/L refer to investment, government income, and GRDP per workers, respectively; D/L/ and C/L are economic loss per disaster and per conflict per worker; Ynp/L and Yp/L are GRDP of the nonpoor per worker and GRDP of the poor per worker; Ygap/L refers to per worker gap of GRDP between nonpoor and poor; eg stands for economic growth with oil and gas at the constant price; and HC refers to human capital indicator*

Table 1 shows that there were regions never experienced natural disasters during the period from 2010 to 2018, as indicated by the minimum value (0.000), particularly three regions (see *Table 3*). In general, 20 regions (86.96%) in Aceh experienced natural disasters during the period from 2010 to 2018. *Table 3* represents this condition in detail. This represents that many regions in Aceh are very vulnerable to natural disasters. In addition, there is also a critical point regarding the investment in the regions, in which had a minimum value (0.000) during the years from 2010 to 2018. This study highlights that 78.26% of the regions in Aceh were not able to encourage their existing investors to invest more, as a form of alternative development capital, in the regions (the detailed table is not presented in this paper). This condition created a dependency on the central government's capital spending. In general, *Table 1* represents the real socio-economic conditions of the 23 regions that have to be proved scientifically through further analysis, by considering a specific model of the uniqueness of the socio-economic characteristics of the regions.

3.3. The results

The results were obtained by employing the different versions depicted in equations (1), (4), (6), and (10). Inequality indices showed the important aspects related to the SEI of the 23 regions. Disasters and conflicts were crucial determinants of the differences in the indices between the districts. *Table 2* provides the results for the average of all nine years for each of the 23 districts, but not on a year-by-year calculation basis. The results showed that the vulnerable condition of the economic characteristics of natural disasters and conflicts would create more problems for the regions. Moreover, this will get worse if the characteristics of the community related to the income gap in a region were also weak. This was indicated by a large number of poor people in one region. Generally, based on *Table 2*, the socio-economic values of 10 regions were positive and 13 regions had negative values. The magnitude of the positive values of the socio-economic indices varied among the regions. That is an interesting point to be analyzed from Equation (1). The negative value ($SEI1_{ia} < 0$) denotes the worst socio-economic inequality, or a region that has weak regional economic strength compared to those with a positive value ($SEI1_{ia} > 0$). A negative value of $SEI1_{ia} < 0$ showed the economic condition of the region was in an insecure state. The reason was that the total economic value of the disasters and conflicts that occurred was larger than the total economic value from real investment and total government income, or ($i+g < d+c$). In other words, some regions have negative economic values, or they are highly vulnerable to natural disasters and conflict issues. The evidence of this study shows that some regions are insecure, as represented by *Table 2*.

Further investigation by this study, in connection with Equation (1) ($SEI1_{ia}$), looked into the role of the social index of the regions involved in the equation, especially Equation (4) ($SEI2_{ia}$). The result of Equation (4) gave us the other points regarding the economic and social inequality of the regions, and it is also called a regional economic capability index, or a composite ratio index of the economic values per capita ($E_{ia} = R_{ia} - W_{ia}$) and societal values per capita of each region (S_{ia}). *Table 2* denotes the SEI of the regions. The critical points are: (i) The regions with a positive value of $SEI2_{ia}$ have the highest regional economic strength (the positive of $E_{ia} = R_{ia} - W_{ia}$) and the smallest social weakness, which is represented by the income gap per capita in the regions or the income gap per capita between the income per capita of the poor and the nonpoor in the regions ($SEI2_{ia} > 0$). It means that there is a great opportunity for the region to encourage capital growth as the main source of economic development. (ii) A region with a negative value of $SEI2_{ia}$ means it has a significant weakness in its regional economic capability so that the region has a negative result of $SEI2_{ia}$ due to less capital growth in the region to enhance the region's economic development. The regional economic weakness of these regions is highly affected by the negative economic value of the regions, $E_{ia} = R_{ia} - W_{ia}$ or $R_{ia} < W_{it}$. (iii) There is another strong finding of this study, in which some regions have a small weakness in their regional economic capability or a small positive economic value, $E_{ia} = R_{ia} - W_{ia}$ or $R_{it} < W_{it}$ so that they have a small economic capability or a slightly positive $SEI1_{ia}$ ($SEI1_{ia} < 0$). However, these regions are capable of better economic development with a slight capital growth. These regions are Aceh Tenggara/Southeast Aceh (R4), Nagan Raya/Southwest Aceh (R15), and Langsa city/East Aceh (R21).

These findings are correlated with the results of Equation (6) by using real comparative socio-economic values per capita as the main measurement. It shows the ratio of regional capital per capita of i^{th} region, with respect to the economic value of disasters and conflicts per capita and the income gap per capita of i^{th} region. This result gives a more proportional and realistic SEI for the regions and this is the so-called environmental input efficiency index or weighted SEI index of i^th^ region. There is a strong indication from the result of $SEI3_{ia}$ (Equation (6)) in which the values of $SEI3_{ia}$ are influenced by the economic value of the disasters and conflicts per capita and the income gap per capita of i^{th} region. If the economic value of the disasters and conflicts per capita increases, while everything else is unchanged, the value of $SEI3_{ia}$ becomes smaller, and if the economic value of the income gap per capita of the region increases, still holding everything else constant, the value of $SEI3_{ia}$ becomes larger. However, if the economic value per capita (i+g) increases, while holding everything else unchanged, the value of $SEI3_{ia}$ is a constant. The important conclusion is that the smallest $SEI3_{ia}$ value results in the smallest economic values for disaster and conflict per capita, as well as the income gap per capita of i^{th} region, so that the region has a significant input efficiency. *Table 2* shows a detailed environmental input efficiency index or weighted SEI index of i^{th} region for 23 regions in Aceh during the years from 2010 to 2018.

Moreover, *Table 2* also shows the statistical indicators of the environmental input efficiency index or weighted SEI index of i^{th} region. Some regions have the smallest positive values of $SEI3_{ia}$ on average. According to these results, Aceh Selatan/South Aceh (R3) in *Table 2* is the regency/city with the best SEI, based on the environmental input efficiency index or weighted SEI index (Equation 6 or SE3ia in line 3 of *Table 2*) with the highest value, 0.201. Furthermore, the result from Equation (10) depicts relatively the same structure for the SEI, in which most regions with either the largest or moderate values for the environmental input efficiency index have better conditional weighted socio-economic inequality. But, some regions have extreme values above the average of $SEI4_{ia}$ (0.326). Overall, the regional economic strength and weakness index (SEI1) and economic capability index (SEI2) of the regions also determine the regional environmental input efficiency index or weighted index (SEI3) and conditional weighted index (SEI4). *Table 2* also shows a variety of socio-economic inequalities with specific characteristics for the SEIs' results.

Table 2. Socio-Economic Inequality Indices among the Regions on Average and Descriptive Statistics, 2010-2018

Districts/Cities*	Interegional Socio-Economic Inequality (SEI) Indices			
	SEI1ia	SEI2ia	SEI3ia	SEI4ia
R1-Simeulue (Southwest Island of Aceh)	0.042	1.376	0.035	0.296
R2-Aceh Singkil (South of Aceh)	0.051	2.071	0.037	0.278
R3-Aceh Selatan (South of Aceh)	-0.031	-1.069	0.201	0.382
R4-Aceh Tenggara (Southeast of Aceh)	0.017	0.568	0.055	0.231
R5-Aceh Timur (East of Aceh)	-0.049	-1.301	0.125	0.331
R6-Aceh Tengah (Middle of Aceh)	-0.025	-0.557	0.109	0.337
R7-Aceh Barat (West of Aceh)	0.078	1.558	0.179	0.503
R8-Aceh Besar (North of Aceh)	-0.095	-2.184	0.162	0.378
R9-Pidie (Northeast of Aceh)	-0.061	-2.011	0.181	0.488
R10-Bireuen (Northeast of Aceh)	-0.105	-2.774	0.178	0.410
R11-Aceh Utara (Northeast of Aceh)	-0.127	-2.144	0.133	0.420
R12-Aceh Barat Daya (Southwest of Aceh)	-0.003	-0.094	0.060	0.289
R13-Gayo Lues (Southeast of Aceh)	0.062	1.599	0.033	0.319
R14-Aceh Tamiang (Southeast of Aceh)	-0.005	-0.136	0.059	0.239
R15-Nagan Raya (Southwest of Aceh)	0.020	0.368	0.115	0.406
R16-Aceh Jaya (Northwest of Aceh)	0.106	2.830	0.077	0.285
R17-Bener Meriah (Middle of Aceh)	-0.004	-0.083	0.051	0.355
R18-Pidie Jaya (Northeast of Aceh)	-0.031	-1.113	0.114	0.425
R19-Banda Aceh City (Cap. City-North of Aceh)	-0.009	-0.046	0.063	0.147
R20-Sabang City (North Island of Aceh)	0.123	2.354	0.017	0.238
R21-Langsa City (East of Aceh)	0.013	0.322	0.057	0.196
R22-Lhokseumawe City (Northeast of Aceh)	-0.052	-0.364	0.104	0.257

R23-Subulussalam City (South of Aceh)	0.085	3.070	0.019	0.280
Regional Descriptive Statistics				
Mean	3.35E-19	0.097	0.094	0.326
Median	-0.005	-0.135	0.081	0.314
Maximum	0.580	15.302	0.591	0.971
Minimum	-0.277	-8.732	0.001	0.083
Std. Dev.	0.122	2.807	0.077	0.112
Covar	3.64E+17	28.848	0.819	0.344
Skewness	1.566	1.884	2.193	1.303
Kurtosis	8.702	11.409	11.801	7.747
Jarque-Bera	365.062	732.384	834.047	252.896
Probability	0.000	0.000	0.000	0.000
Sum	3.47E-17	20.140	19.454	67.398
Sum Sq. Dev.	3.066	1622.898	1.221	2.587
Observations	207	207	207	207

Source: *own compilation*
Note: *$SEI1_{ia}$ is socio-economic inequality which depicts a composite index of regional and natural and conflict characteristics, or a regional economic strength and weakness index of a region; $SEI2_{ia}$ stands for a regional economic capability index of a region; $SEI3_{ia}$ refers to environmental input efficiency index or weighted SEI index; and $SEI4_{ia}$ is a conditional weighted SEI index. *Name of districts/cities are adjusted to the topography of a region in the map (Graph.1)*

Specifically, this realistic index points out that the variations in the SEI depends on the smallest economic values of disaster and conflict per capita, as well as the income gap per capita of the i^{th} region, and the largest positive economic values per capita (i+g) of the region itself. *Table* 2 highlights that the SEI still matters in all the 23 regions of Aceh. The main points that could be noted are that natural disasters and conflicts play an important position in stabilizing and maintaining the economic conditions of the regions for their long-term development. In addition, the income gap between the poor and nonpoor people should be reduced significantly to obtain a suitable income distribution for the regions. These things are also supported by efficient and effective real investment and the total government income/spending of the regions (Digdowiseiso, Sugiyanto, & Setiawan, 2020). *Table 3* shows a detailed description of the regions that are most vulnerable to natural disasters and conflicts, as indicated by the negative values of $SEI1_{ia}$ and $SEI2_{ia}$ by regions and years, for all the observed years from 2010 to 2018.

Table 3. Frequency of Natural Disasters By Districts and Years and SEI Indices (SEI1ia and SEI2ia), 2010-2018

<table>
<tr><th>Natural Disaster in Districts</th><th>Frequency of Years</th><th>Frequency of Districts in Natural Disaster</th><th>Total Fre-quency</th><th>Natural Disaster in Years</th><th>Natural Disaster in Years and Districts</th><th>Frequency of Occurance per year over all Districts</th><th>Frequency of Years in Natural Disaster</th><th>Total Fre-quency</th></tr>
<tr><td>R13, R20, R23</td><td>0</td><td>3 (13.04%)</td><td>0</td><td rowspan="2">2010, 2013</td><td>2010 (R3, R4, R6, R7, R8, R10, R11, R12, R14, R15, R17, R18, R22)</td><td rowspan="2">13</td><td rowspan="2">2</td><td rowspan="2">26 (24.07%)</td></tr>
<tr><td>R1, R2, R16</td><td>1</td><td>3 (13.04%)</td><td>3 (2.78%)</td><td>2013 (R3, R5, R6, R8, R9, R10, R11, R12,</td></tr>
</table>

					R14, R18, R19, R21, R22)			
R4	2	1 (4.35%)	2 (1.85%)		2011 (R5, R6, R7, R8, R9, R10, R11, R12, R14,R15, R18, R22)			
R7	3	1 (4.35%)	3 (2.78%)	2011, 2017, 2018	2017 (R3, R4, R5, R6, R7, R8, R10, R11, R15, R17, R18, R19)	12	3	36 (33.33%)
R21	4	1 (4.35%)	4 (3.70)		2018 (R3, R5, R6, R8, R9, R10, R11, R12, R17, R18, R21, R22)			
R17, R19	5	2 (8.70%)	10 (9.26%)	2012	2012 (R1, R3, R5, R6, R8, R9, R10, R11, R14, R15, R18, R19, R21, R22)	14	1	14 (12.96%)
R3, R6, R9, R12, R15, R22	6	6 (26.09%)	36 (33.33%)	2014	2014 (R3, R5, R8, R9, R10, R11, R14, R18, R21, R22)	10	1	10 (9.26%)
R5, R14	7	2 (8.70%)	14 (12.96%)	2015, 2016	2015 (R2, R8, R9, R10, R11, R12, R14, R15, R17, R18, R19)	11	2	22 (20.37%)
	8	0	0		2016 (R5, R8, R10, R11, R12, R14, R15, R16, R17, R18, R19)			
R8, R10, R11, R18	9	4 (17.39%)	36 (33.33%)	2010 - 2018	2010-2018 (R13, R20, R23)	0	9	0
Total		23	108			60	18	108

Source: *author's analysis based on the initial calculations of the natural disasters by districts and years, 2010-2018*

Based on *Table 2*, this study further investigated the determinants of the SEI of the regions by considering the dynamic relationship of the economic variables using a dynamic spatial panel GMM model represented by Equation (17). Equation (17) emphasizes the analysis involving the critical role of the spatial local conditions in each region, as represented by the spatial distance of the regions together with the economic growth and human capital levels, and how they affect the SEI of the regions. The previous stage of this session started with a discussion regarding the characteristics of the relationship of the observed variables, such as each type of SEI, economic growth, human capital, and the spatial distance of the regions in a short-run and long-run correlation. To reach the functional relationship among the observed variables of balanced panel data, this study employed the unit root test for analyzing the individual behavior of the panel data used, to see whether the panel data was in a stationary condition or not, at the different levels, based on the values of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP).

In short, the decision on the stationary state of the observed variables depended on whether the p-value of the empirical test of each selected variable was smaller than the value at significant level (α), which was equal to 0.05 (5%). The results in *Table 3* show that all the variables in this study have stationary conditions at different levels. This means that all the variables have a short-run and long-run relationship, or these variables tend to meet at the equilibrium point. This is strengthened by the p-value of the empirical test of each selected variable being smaller than the value at significant level (α), which was equal to 0.05 (5%) by using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests..

Table 4. Unit Root Test of the Observed Variables with Augmented Dickey-Fuller (ADF) and Phillips Perron (PP)

Variables	Statistic Indicators	Level		First Difference	
		ADF	PP	ADF	PP
Y1	Statistic	72.972	176.193	70.064	204.001
	Prob.**	0.007	0.000	0.013	0.000
Y2	Statistic	75.577	182.406	71.288	205.755
	Prob.**	0.004	0.000	0.010	0.000
Y3	Statistic	48.856	113.976	60.324	190.571
	Prob.**	0.359	0.000	0.076	0.000
Y4	Statistic	40.393	95.911	60.270	204.067
	Prob.**	0.705	0.000	0.077	0.000
Y1*BA	Statistic	72.665	169.577	69.200	194.416
	Prob.**	0.004	0.000	0.009	0.000
Y1*AB	Statistic	69.665	171.771	69.797	199.315
	Prob.**	0.008	0.000	0.008	0.000
Y1L	Statistic	70.155	176.107	69.784	203.968
	Prob.**	0.007	0.000	0.008	0.000
Y2*BA	Statistic	75.247	174.237	70.430	195.560
	Prob.**	0.002	0.000	0.007	0.000
Y2*AB	Statistic	72.000	179.290	71.020	200.467
	Prob.**	0.005	0.000	0.006	0.000
Y2L	Statistic	71.921	182.380	70.750	205.745
	Prob.**	0.005	0.000	0.006	0.000
Y3*BA	Statistic	42.814	113.493	57.327	185.266
	Prob.**	0.522	0.000	0.086	0.000
Y3*AB	Statistic	47.274	112.684	60.224	187.933
	Prob.**	0.340	0.000	0.052	0.000
Y3L	Statistic	48.015	111.782	58.679	190.067
	Prob.**	0.313	0.000	0.068	0.000
Y4*BA	Statistic	34.467	95.278	57.402	198.946
	Prob.**	0.848	0.000	0.085	0.000
Y4*AB	Statistic	38.531	94.081	60.070	197.874
	Prob.**	0.704	0.000	0.054	0.000
Y4L	Statistic	39.644	94.450	58.935	203.671
	Prob.**	0.659	0.000	0.066	0.000
eg	Statistic	57.593	169.569	71.050	227.224
	Prob.**	0.117	0.000	0.010	0.000
IPM	Statistic	65.111	57.402	55.351	81.710
	Prob.**	0.033	0.121	0.163	0.001

Note: Y1 ($SEI1_{ia}$) is socio-economic inequality which depicts a composite index of regional and natural and conflict characteristics or a regional economic strength and weakness index of a region; Y2 ($SEI2_{ia}$) stands for a regional economic capability index of a region; Y3 ($SEI3_{ia}$) refers to an environmental input efficiency index or weighted SEI index; and Y4 ($SEI4_{ia}$) is a conditional weighted SEI index. Yn*BA, Yn*AB, and Yn*L are the interaction variables of the SEIs with a distance space with the neighboring region represented by Banda Aceh (BA= Banda Aceh City/the capital city of Aceh (R19), Aceh Barat (AB= Aceh Barat/West Aceh (R7)), and Lhokseumawe City (L= Northeast Aceh (R22) as a zero spatial distance in kilometers (km) from the other regions. eg and IPM stand for the economic growth and human capital index, respectively.

Table 4 depicts the unit root test of the observed variables based on Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)

After testing the unit root of the variables, this study employed the cointegration test. This test looks into the behavioral stability of all the observed variables in the long-run equilibrium. To test the cointegration of all the variables, it employs the Kao Residual Cointegration Test based on ADF (Augmented Dickey-Fuller) statistics. To determine whether all the variables had a long-run equilibrium condition or not, it depends if the t-statistic value of ADF was larger than the t-table value, or the p-value of the empirical test of all the selected variables was smaller than the value at significant level (α), which was equal to 0.05 (5%). The empirical results of the cointegration test from all the selected variables of the SEIs (the determinant models in this study, based on the types of values obtained for the socio-economic inequality indices, which were a dependent variable) showed that they had the long-run equilibrium state due to their value at significant level (α) which was equal to 0.05 (5%), and was larger than the p-value of the empirical test. This happened with all the models employed in this study. Generally, this means that the models used in this study were good, and could be employed to estimate the short-run-and long-run functional relationship of the observed variables. *Table 5* shows the results of the cointegration test, undertaken with the Kao Residual Cointegration Test, based on the ADF (Augmented Dickey-Fuller) statistics.

Table 5. Cointegration Test of the Observed Variables with Augmented Dickey-Fuller (ADF) and Phillips Perron (PP)

Kao Residual Cointegration Test	Statistic Indicators	Model 1	Model 2	Model 3	Model 4
ADF (Augmented Dickey-Fuller)	t-Statistic	-8.794162	-8.934293	-6.299852	-7.331305
	Probability	0.0000	0.0000	0.0000	0.0000
	Residual variance	0.001437	0.908477	0.000522	0.000832
	HAC variance	0.000977	0.524062	0.000253	0.000455
ADF Test Equation with D(RESID) as Dependent Variable					
RESID(-1)	Coefficient	-1.179817	-1.260416	-1.121882	-1.163252
	Std. Error	0.115293	0.119567	0.125212	0.121336
	t-Statistic	-10.23321	-10.54153	-8.959882	-9.587046
	Probability	0.0000	0.0000	0.0000	0.0000
D(RESID(-1))	Coefficient	0.143888	0.178876	0.116761	0.044512
	Std. Error	0.0756	0.080331	0.094324	0.086076
	t-Statistic	1.903272	2.22672	1.23787	0.517125
	Probability	0.0591	0.0276	0.2179	0.6059
	R-squared	0.523249	0.55093	0.515763	0.58087
	Adjusted R-squared	0.519744	0.547628	0.512203	0.577788
	Durbin-Watson stat	2.012879	1.954952	2.256634	2.124135

Notes: *model 1 stands for Y1 ($SEI1_{ia}$) as a dependent variable (socio-economic inequality) which depicts a composite index of regional and natural and conflict characteristics or a regional economic strength and weakness index of a region; model 2 refers to Y2 ($SEI2_{ia}$) as a dependent variable (a regional economic capability index of a region); model 3 stands for Y3 ($SEI3_{ia}$) as a dependent variable (an environmental input efficiency index or weighted SEI index); and model 4 refers to Y4 ($SEI4_{ia}$) as a dependent variable (a conditional weighted SEI index); Yn*BA, Yn*AB, and Yn*L are the interaction variables of SEI_{ias} with a distance space with the neighboring region represented by Banda Aceh (BA= Banda Aceh City/the capital city of Aceh (R19), Aceh Barat (AB= Aceh Barat/West Aceh (R7)), and Lhokseumawe City (L= Northeast Aceh (R22) as a zero spatial distance in kilometers (km) from the other regions. eg and IPM stand for the economic growth and human capital index, respectively.*

Based on the unit root and cointegration tests, *Table 6* describes the further investigation into the SEI of the regions with the detailed estimation coefficients of the observed variables by using a dynamic spatial panel GMM model. The p-values of the J-statistic, which were larger than the value at significant level (α), which was equal to 0.05 (5%) for all the models, and found by employing the dynamic spatial panel GMM model. It meant that all the models used were valid for estimating if they used the dynamic spatial panel GMM model. *Table 6* shows that the previous SEI (DY) significantly influenced the SEI of the regions with the estimation coefficients of each variable DY from all the models being around 0.4095, 0.4253, 0.827, and 0.9291, respectively (*Table 6* in line 1). However, the magnitude of the effect was quite different for each one, and model 4 had the largest estimation coefficient of DY compared to the others. It denotes that the previous SEI (DY) of the regions significantly affects the SEI of the regions.

Table 6. The Estimation Coefficients of SEI of the Regions Based on Dynamic Spatial Panel GMM models, 2010-2018.

Variables	Statistics Indicators	Model 1	Model 2	Model 3	Model 4
DY	Coefficient	0.409466	0.425311	0.8027	0.92914
(Yt-1)	Standard Error	0.071432	0.069026	0.056923	0.021711
	t-Statistic	5.732219	6.161633	14.10142	42.79603
	Probability	0.0000	0.0000	0.0000	0.0000
Y*BA	Coefficient	0.000054	-0.00096	-0.000674	-0.000953
(Yt*BA)	Standard Error	0.000205	0.000255	0.000317	0.00027
	t-Statistic	0.266273	-3.769279	-2.12523	-3.532039
	Probability	0.7903	0.0002	0.035	0.0005
Y*AB	Coefficient	0.000975	0.001444	0.002831	0.002976
(Yt*AB)	Standard Error	0.000178	0.000226	0.000215	0.000182
	t-Statistic	5.484141	6.386446	13.18226	16.38602
	Probability	0.0000	0.0000	0.0000	0.0000
YL	Coefficient	0.002032	0.002283	0.001572	0.001556
(Yt*L)	Standard Error	0.000149	0.000173	0.000254	0.000209
	t-Statistic	13.67495	13.16701	6.182298	7.455776
	Probability	0.0000	0.0000	0.0000	0.0000
DY*BA	Coefficient	0.000352	0.000767	0.00053	0.000938
(Yt-1*BA)	Standard Error	0.00019	0.000207	0.000362	0.000268
	t-Statistic	1.853376	3.701394	1.462429	3.492903
	Probability	0.0655	0.0003	0.1454	0.0006
DY*AB	Coefficient	-0.000381	-0.000705	-0.002559	-0.002923
(Yt-1*AB)	Standard Error	0.000231	0.000237	0.000271	0.000179
	t-Statistic	-1.64599	-2.97745	-9.432013	-16.35884
	Probability	0.1016	0.0033	0.0000	0.0000
DY*L	Coefficient	-0.001135	-0.001231	-0.001027	-0.001558
(Yt-1*L)	Standard Error	0.000263	0.000221	0.000301	0.000201
	t-Statistic	-4.317911	-5.57061	-3.41177	-7.768469
	Probability	0.0000	0.0000	0.0008	0.0000
eg	Coefficient	0.000261	0.055505	-0.006068	0.000584
	Standard Error	0.005549	0.11099	0.004857	0.004223
	t-Statistic	0.046945	0.500092	-1.249259	0.138387
	Probability	0.9626	0.6176	0.2132	0.8901
IPM	Coefficient	0.000053	0.006736	0.000182	-0.000696
	Standard Error	0.000595	0.014897	0.000482	0.000878
	t-Statistic	0.0724	0.452159	0.377863	-0.793172
	Probability	0.9424	0.6517	0.706	0.4288
C	Coefficient	-0.012233	-0.835945	0.011129	0.06468
	Standard Error	0.046573	1.120932	0.037856	0.063509
	t-Statistic	-0.262672	-0.745758	0.29397	1.018439
	Probability	0.7931	0.4568	0.7691	0.3099
R-squared		0.899268	0.892955	0.879652	0.936583
Adjusted R-squared		0.894058	0.887419	0.873428	0.933303
Durbin-Watson stat		1.999597	2.077964	2.043521	2.849158

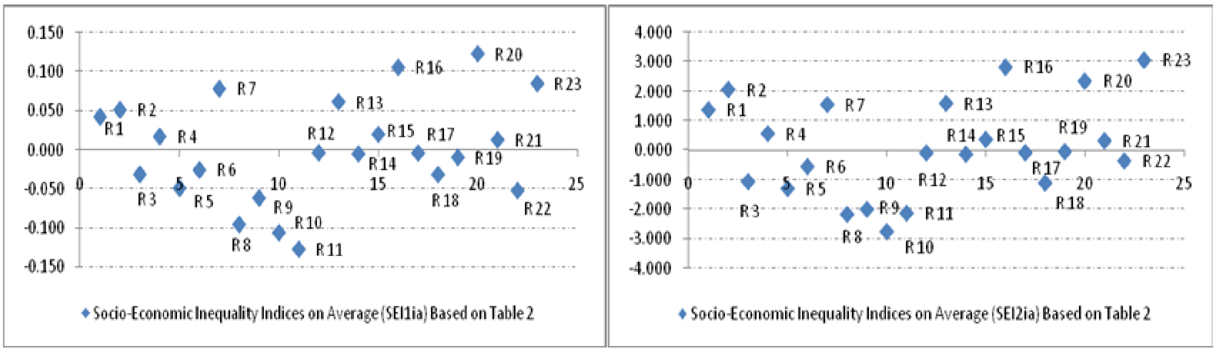
J-statistic	0.901321	3.648389	0.346547	0.068034
Probability (J-statistic)	0.342428	0.056123	0.556074	0.794222
Instrument Variables	DY, Y*BA, Y*AB, Y*L, DY*BA, DY*AB, DY*L, H, E	DY, Y*BA, Y*AB, Y*L, DY*BA, DY*AB, DY*L, H, E	DY, Y*BA, Y*AB, Y*L, DY*BA, DY*AB, DY*L, H, E	DY, Y*BA, Y*AB, Y*L, DY*BA, DY*AB, DY*L, H, eE

Note: *model 1 stands for Y_1 ($SEI1_{ia}$) as a dependent variable which depicts a composite index of regional and natural disaster and conflict characteristics or a regional economic strength and weakness index of a region; model 2 refers to Y2 ($SEI2_{ia}$) as a regional economic capability index of a region; model 3 stands for Y3 ($SEI3_{ia}$) as an environmental input efficiency index or weighted SEI index; and model 4 refers to Y4 ($SEI4_{ia}$) as a conditional weighted SEI index. Yn*BA, Yn*AB, and Yn*L are the interaction variables of SEIs with a distant space with the neighboring region represented by Banda Aceh (BA= Banda Aceh City/the capital city of Aceh (R19), Aceh Barat (AB= Aceh Barat/West Aceh (R7)), and Lhokseumawe City (L= Northeast Aceh (R22) as a zero spatial distance in kilometers (km) from the other regions. eg and IPM stand for the economic growth and human capital index, respectively. The instrumental variables of these models are DY (SEIs), Y*BA, Y*AB, Y*L, DY*BA, DY*AB, DY*L, H (health index), and E (education index)*

Furthermore, all the interaction variables which were involved in the role of the spatial distance of the SEI with a distance space to the neighboring regions had a significant effect on the SEI of the regions. This condition highlighted that the spatial distances (spatial effect) of the regions still played important roles in reducing the SEI among the regions. In contrast, based on the dynamic spatial panel GMM model, the economic growth and human capital of the regions were not the prominent factors for reducing the SEI among the regions due to the p-value of the empirical test being smaller than the value at a significant level (α) which equalled 0.05 (5%), (see *Table 6*). It denoted that the inequality of the socio-economic conditions among the regions matters. The government should consider the important share of the spatial distance variable in determining a lower SEI among the regions. This is seriously connected to the government's public policy for government income and spending. *Table 6* directly elaborates on the estimated coefficients of the functional relationship, in line with the dynamic spatial panel GMM models.

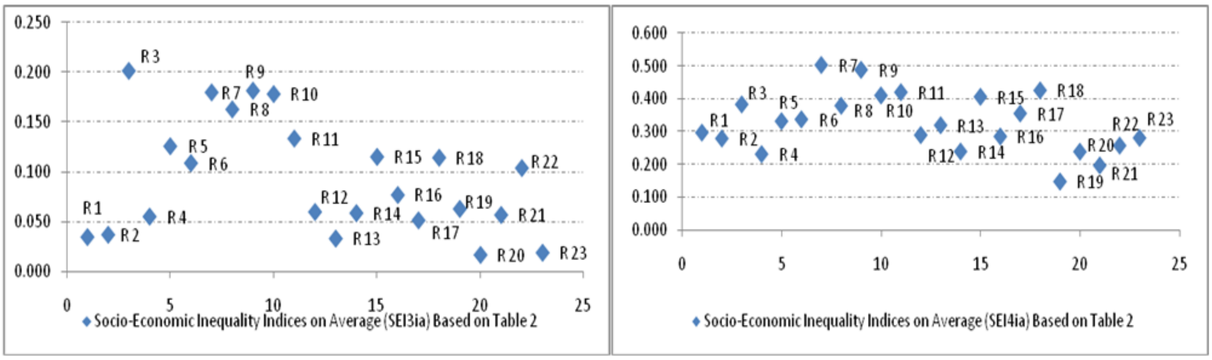
4. Discussions

The concluding stage of this study highlighted the pattern of the SEI indices of the regions by each model, based on $SEI1_{ia}$, $SEI2_{ia}$, $SEI3_{ia}$, and $SEI4_{ia}$, using scatter plot diagrams. Some relevant statements can be drawn from these diagrams, namely: (1) $SEI1_{ia}$, on average, was around positive and negative values (zero = 0). The largest and smallest regional values were 12.3% (0.123) and -12.7% (-0.127) on average, respectively. (2) $SEI2_{ia}$ showed that the average value was 0.097. The largest and smallest values were about 3.070 and -2.774 on average, respectively. (3) The largest and smallest values of $SEI3_{ia}$ were 1.81% (0.181) and 1.7% (0.017), and the average $SEI3_{ia}$ value was 0.094, and the largest and smallest values for $SEI4_{ia}$ were 0.503 and 0.147 and the average $SEI4_{ia}$ value was 0.326. In general, the SEI of the regions became flatter and better when human capital was involved in the calculation of the index ($SEI4_{ia}$). It means that human capital still played an important role in reducing the SEI of the regions. The distribution patterns of $SEI1_{ia}$ (a), $SEI2_{ia}$ (b), $SEI3_{ia}$ (c), and $SEI4_{ia}$ (d) are represented in Graphs 2 (SEI_{ia} on average based on *Table 2*, 2010-20018) and 3 (SEI within 23 regions, 2010-20018. However, the table that denotes the SEI within in each region is not provided in this paper because it is very large in size) as follows:



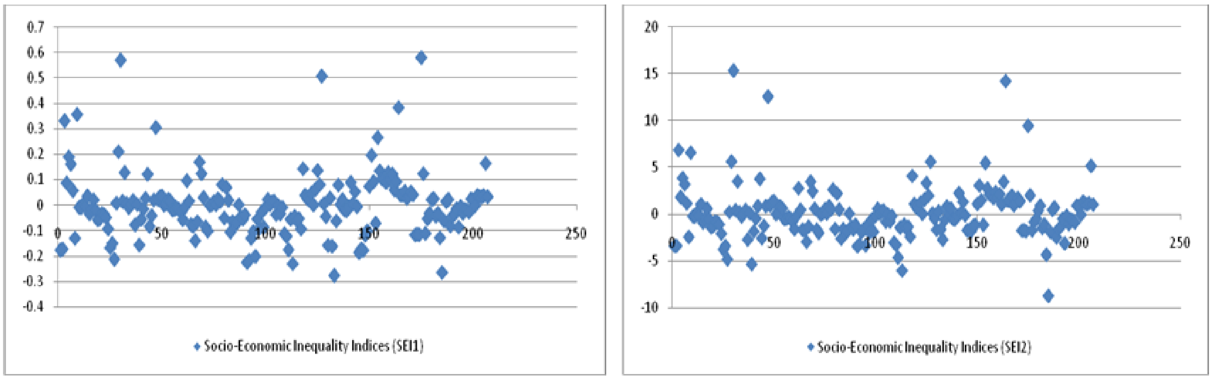
(a) $SEI1_{ia}$ (b) $SEI2_{ia}$

Graphs 2 (a) and (b). The average of economic inequality indices of regions or the regional economic strength and weakness inequality indices (SEI1ia) and the economic capability inequality indices or the regional capital formation inequality indices (SEI2ia), 2010-20018



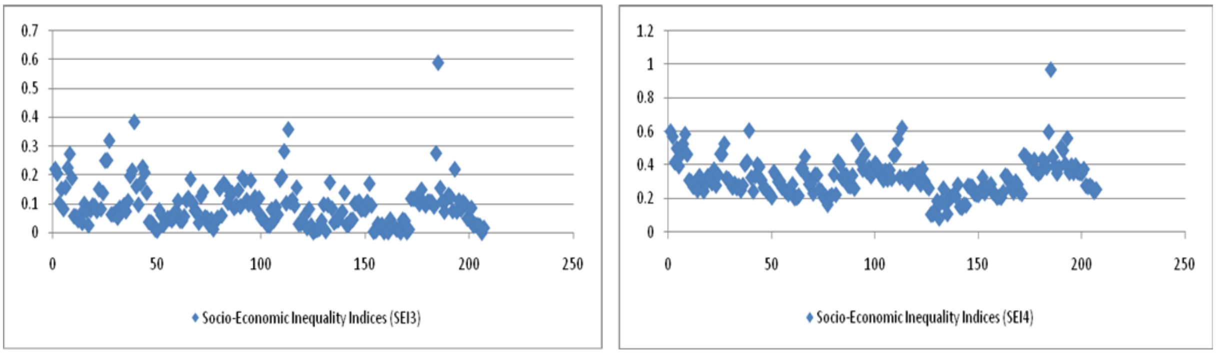
(c) $SEI3_{ia}$ (d) $SEI4_{ia}$

Graphs 2 (c) and (d). The average of environmental input efficiency inequality indices of regions or the weighted SEI indices of regions ($SEI3_{ia}$) and the conditional weighted SEI indices ($SEI4_{ia}$), 2010-2018



(a) $SEI1_{ia}$ (b) $SEI2_{ia}$

Graphs 3 (a) and 3(b). The economic inequality indices within 23 regions or the regional economic strength and weakness inequality indices ($SEI1_{ia}$) and the economic capability inequality indices within 23 regions or the regional capital formation inequality indices ($SEI2_{ia}$), 2010-20018



(c) SEI3$_{ia}$ (d) SEI4$_{ia}$

Graphs 3(c) and 3(d). The environmental input efficiency inequality indices or the weighted socio-economic inequality indices within 23 regions (SEI3$_{ia}$) and the conditional weighted socio-economic inequality indices within 23 regions (SEI4$_{ia}$), 2010-20018

Furthermore, based on the forecast and residual patterns from employing dynamic spatial panel GMM models during the period from 2010 to 2018, the variations in the SEI of the regions analyzed became smaller, as represented by SEI4 or model 4, compared to the others (models 1, 2, and 3). The Theil inequality coefficient of model 1 (SEI1) was 0.1629, which was higher than the Theil inequality coefficient of model 2 (SEI2), 0.1676. Moreover, the Theil inequality coefficient of model 3 (SEI3) was 0.1112 and the Theil inequality coefficient of model 4 (SEI4) was 0.0412. This denotes that the SEI of the regions, established by using models 1, 2, and 3 was higher than that found by model 4, due to their Theil indices being far from zero (Theil, 1989).

Conclusion

This study investigates the conditional SEI of the regions on human capital in Indonesia, particularly for the two aspects that are the sources and determinant factors of the SEI of the regions. The critical socio-economic and intrinsic characteristics of a region are highlighted in this study, such as natural resources, government income, conflict, and natural disasters, and these are the most crucial ones for determining a region's socio-economic inequality. This study also examines the role of the spatial distance of regions, economic growth, and human capital on the SEI of regions. To obtain the first main purpose of this study, we used an alternative approach that was conditional on the human capital of a region, particularly the education and health levels. This approach attempted to account for the sources of the SEI through analyzing the economic strength and weakness, the economic capability, environmental input efficiency, and conditional weighted SEI of the human capital of each regency/city. The second purpose of this study involves the critical role of spatial local conditions, together with economic growth and human capital levels, and their effect on the SEI of regions. To accomplish this purpose, the study used a dynamic spatial panel (GMM) model. In general, these two approaches are directed to enrich a different dimension of this analysis, which is related to regional SEI supporting the labor market as a whole, increasing productivity, and strengthening resilient regional economies.

The empirical results show that the formulated equations (1), (4), (6), and (10) calculate the SEI of the regions and are able to describe detailed information with regard to the SEI of the regions. The role of the socio-economic and intrinsic characteristics of a region, and across regions, can be explained by the simplified formulas. Natural disasters and conflicts have to be considered in maintaining "sustainable development environmentally." This denotes that the effect of those matter. In addition, the critical role of human capital in strengthening development as a whole is highly recommended. There is strong evidence for including the human capital of labor in the calculation of the SEI of the regions, particularly SEI4ia. It enables it to reduce the SEI to a lower index. It means that the human capital of labor plays an important role in enhancing and sustaining the development quality of the regions. In general, the human capital index, consisting of the health and education levels of the regions as a conditional interaction, has an indispensable responsibility to reduce the inequality level of the socio-economic conditions among the regions. In short, this indicates that these variables strongly encourage the sustained self capability of a region for development. Therefore, to create a better quality of SEI in the regions, two critical points should be considered, namely natural disasters which prevent environmental development and minimize the conflicts in society, as well as strengthening the quality of the human capital of labor by improving the health and education of the labor force.

In addition, the estimation coefficients from using the dynamic spatial panel GMM model in this study show a different story; that the effect of a distant space with neighboring regions or the spatial distance of the regions determines the SEI of the regions. In this case, spatial distance is represented by Banda Aceh (BA= Banda Aceh City/the capital city of Aceh (R19), Aceh Barat (AB= Aceh Barat/West Aceh (R7), and Lhokseumawe City (L= Northeast Aceh (R22) as a zero spatial distance in kilometers (km) from the other regions. This point highlights that the government still has to consider spatial distance as an important variable in reducing the SEI of the regions. This is seriously related to the government's strategic policies for government spending on appropriate "public goods," to support the quality of the sustained development of the regions (Digdowiseiso et al., 2020).

Finally, this study undertook to formulate these alternative methods with the expectation that they could be applied in other regions with the same issues, based on the regional socio-economic and intrinsic characteristics. They are natural resources, government income, natural disasters, and societal conflicts that are conditional on the human capital, particularly their educational and health levels, especially in developing countries. These help the government enhance the quality of the sustained development by using an alternative-comprehensive method for better analysis of this issue. Moreover, it also does not neglect the critical role of regional spatial distance in determining the SEI of the regions. Moreover, the best possibility for future studies is to formulate the combination of all of these variables in one formula, with the absolute values of the SEI of the regions. This was a strong recommendation by Williamson (1965), which this study followed. This is still of interest in the future. In general, Martin (1999) argued that, based on economic mechanisms, regional policies are very complex and have undesirable consequences, which have impacts not only locally but also nationally.

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References

Agustini, E.N., Asniar, I., & H. M. (2011). The prevalence of long-term post-traumatic stress symptoms among adolescents after the tsunami in Aceh. *Journal of Psychiatric and Mental Health Nursing*, *18*, 543–549. https://doi.org/10.1111/j.1365-2850.2011.01702.x

Ahtisaari, M. (2008). Lessons of Aceh peace talks. *Asia Europe Journal*, *6*(1), 9–14. https://doi.org/10.1007/s10308-007-0163-x

Anselin, L., Gallo, J. Le, & Jayet, H. (2008). Spatial Panel Econometrics. In *Advanced Studies in Theoretical and Applied Econometrics*, *46*, 625–660. https://doi.org/10.1007/978-3-540-75892-1_19

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Carlo Application to Data : Evidence and an Employment Equations. *The Review of Economic Studies*, *58*(2), 277–297. Retrieved from http://www.jstor.org/stable/2297968

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*(August, 1990), 29–51.

Baltagi, B.H. (2005). *Econometric Analysis of Panel Data*.

Baltagi, B.H., Fingleton, B., & Pirotte, A. (2019). A time-space dynamic panel data model with spatial moving average errors. *Regional Science and Urban Economics*, *76*, 13–31. https://doi.org/10.1016/j.regsciurbeco.2018.04.013

Bass, J., Poudyal, B., Tol, W., Murray, L., Nadison, M., & Bolton, P. (2012). A controlled trial of problem-solving counseling for war-affected adults in Aceh, Indonesia. *Social Psychiatry and Psychiatric Epidemiology*, *47*(2), 279–291. https://doi.org/10.1007/s00127-011-0339-y

Berdiev, Aziz N., Rajeev K. Goel., & James W. Saunoris. (2020). The path from ethnic inequality to development: The intermediary role of institutional quality. *World Development*, 130 (104925). https://doi.org/10.1016/j.worlddev.2020.104925

Binelli, C., Loveless, M., & Whitefield, S. (2015). What Is Social Inequality and Why Does it Matter ? Evidence from Central and Eastern Europe. *World Development*, *70*(28920), 239–248. https://doi.org/10.1016/j.worlddev.2015.02.007

Brown, P., Daigneault, A.J., Tjernström, E., & Zou, W. (2018). Natural disasters, social protection, and risk perceptions. *World Development*, *104*, 310–325. https://doi.org/10.1016/j.worlddev.2017.12.002

Burns, T.R., & Devillé, P. (2017). Socio-economics: The approach of social systems theory in a forty year perspective. *Economics and Sociology*, *10*(2), 11–20. https://doi.org/10.14254/2071-789X.2017/10-2/1

CBS. (2019). Provinsi Aceh Dalam Angka (The Statistical Yearbooks of Aceh Province of Indonesia) - Government's Central Bureau of Statistics (CBS).

Clark, J., & Bailey, D. (2018). Labour, work and regional resilience. *Regional Studies*, *52*(6), 741–744. https://doi.org/10.1080/00343404.2018.1448621

Das, S. K., & Barua, A. (1996). Regional inequalities, economic growth and liberalisation: a study of the Indian economy. https://doi.org/10.1080/00220389608422420

Digdowiseiso, K., Sugiyanto, E., & Setiawan, H. D. (2020). Fiscal Decentralisation and Inequality in Indonesia. *Ekonomika regiona [Economy of region]*, *16*, 989–1002. https://doi.org/10.17059/ekon.reg.2020-3-24.

Drexler, E. (2006). History and liability in Aceh, Indonesia: Single bad guys and convergent narratives. *American Ethnologist*, *33*(3), 313–326. https://doi.org/10.1525/ae.2006.33.3.313

Frick, J. R., & Goebel, J. (2008). Regional income stratification in unified Germany using a gini decomposition approach. *Regional Studies*, *42*(4), 555–577. https://doi.org/10.1080/00343400701543181

Gini, C. (1912). Variability and Mutability ("Variabilità e Mutabilità"), (Bologna: P. Cuppini. 1912. p. 156.)

Gunaryadi. (2006). The EU in the peace process for Aceh. *Asia Europe Journal*, *4*(1), 87–100. https://doi.org/10.1007/s10308-006-0042-x

Guo, Y., Zhu, J., & Liu, X. (2018). Implication of rural urbanization with place-based entitlement for social inequality in China. *Cities*, (November 2017), 0–1. https://doi.org/10.1016/j.cities.2018.05.007

Hallegatte, S., Vogt-Schilb., A., Rozenberg., J., Bangalore., M., & Chloé Beaudet. (2020). From Poverty to Disaster and Back: a Review of the Literature. *Economics of Disasters and Climate Change*, 4:223–247. https://doi.org/10.1007/s41885-020-00060-5

Hayakawa, H., & Venieris, Y.P. (2018). Duality in human capital accumulation and inequality in income distribution. *Eurasian Economic Review*, *9*(3), 285–310. https://doi.org/10.1007/s40822-018-0110-8

Hazari, B., & Mohan, V. (2015). Social exclusion, capital accumulation and inequality. *International Review of Economics and Finance*, *39*, 371–375. https://doi.org/10.1016/j.iref.2015.07.004

Hillman, B. E. N. (2013). Public Administration Reform In Post-Conflict Societies: Lessons From Aceh, Indonesia. *Public Administration and Development*, *14*(November 2012), 1–14. https://doi.org/10.1002/pad

Kennedy, J., Ashmore, J., Babister, E., & Kelman, I. (2008). The Meaning of "Build Back Better": Evidence from Post- Tsunami Aceh and Sri Lanka. *Journal of Contingencies and Crisis Management*, *16*(1), 24–36.

Leary, K. (2004). Critical moments as relational moments: The centre for humanitarian dialogue and the conflict in Aceh, Indonesia. *Negotiation Journal*, *20*(2), 311–338. https://doi.org/10.1111/j.1571-9979.2004.00025.x

Lee, L. fei, & Yu, J. (2010). Some recent developments in spatial panel data models. *Regional Science and Urban Economics*, *40*(5), 255–271. https://doi.org/10.1016/j.regsciurbeco.2009.09.002

Mader, S. (2018). The nexus between social inequality and CO 2 emissions revisited : Challenging its empirical validity. *Environmental Science and Policy*, *89*(April), 322–329. https://doi.org/10.1016/j.envsci.2018.08.009

Mankiw, N.G., Romer, P.M., & Weil, D.N. (1992). A Contribution to the Empirics of Economic Growth Author. *The Quarterly Journal of Economics*, *107*(2), 407–437. https://doi.org/10.2307/2118477

Marchand, M., Buurman, J., Pribadi, A., & Kurniawan, A. (2009). Damage and casualties modelling as part of a vulnerability assessment for tsunami hazards: a case study from Aceh, Indonesia. *Journal of Flood Risk Management*, *2*, 120–131. https://doi.org/10.1111/j.1753-318X.2009.01027.x

Martin, P. (1999). Public policies, regional inequalities and growth. *Journal of Public Economics*, *73*, 85–105. https://doi.org/10.1016/S0047-2727(98)00110-8.

Matsumaru, R., Nagami, K., & Takeya, K. (2012). Reconstruction of the Aceh Region following the 2004 Indian Ocean tsunami disaster : A transportation perspective. *IATSSR*, *36*(1), 11–19. https://doi.org/10.1016/j.iatssr.2012.07.001

McCarthy, J.F. (2007). The demonstration effect: Natural resources, ethnonationalism and the Aceh conflict. *Singapore Journal of Tropical Geography*, *28*(3), 314–333. https://doi.org/10.1111/j.1467-9493.2007.00304.x

Melamed, C., & Samman, E. (2013). Equity, Inequality and Human Development in a Post-2015 Framework. *United Nations Development Programme Human Development Report Office Research Paper*, (February 2013).

Mikucka, M., Sarracino, F., & Dubrow, J. K. (2017). When Does Economic Growth Improve Life Satisfaction ? Multilevel Analysis of the Roles of Social Trust and Income Inequality in 46 Countries, 1981 – 2012. *World Development*, *93*, 447–459. https://doi.org/10.1016/j.worlddev.2017.01.002

Milanovic, B. (1997). A simple way to calculate the Gini coefficient, and some implications. *Economics Letters*, *56*, 45–49.

Nazim Tamkoc¸ M., & Torul, O. (2020). Cross-sectional facts for macroeconomists : wage, income and consumption inequality in Turkey. *The Journal of Economic Inequality*. https://doi.org/doi.org/10.1007/s10888-019-09436-4 Cross-Sectional

Pesaran, M.H. (2015). *Time Series and Panel Data Econometrics*. https://doi.org/10.1017/CBO9781107415324.004

Pyatt, G. (1976). On the Interpretation and Disaggregation of Gini Coefficients. *The Economic Journal*, *86*(June), 243–257.

Rakauskiene, O. G., & Strunz, H. (2016). Approach to reduction of socioeconomic inequality: Decrease of vulnerability and strengthening resilience. *Economics and Sociology*, *9*(4), 243–258. https://doi.org/10.14254/2071-789X.2016/9-4/15

Rice, R. (2009). Planinning for the End of the Construction Boom in Tsunami- Stricken ACEH and Transition to a Rapidly Growing Sustainable Economy. *Economic Papers, 26*(3), 261–275.

Romer, P. M. (2009). Increasing Returns and Long-Run Growth. *The Journal of Political Economy*, *94*(5), 1002–1037. Retrieved from http://www.jstor.org/stable/1833190

Tewfik, A., & Andrew, N.L. (2008). Reconciling poverty alleviation with reduction in fisheries capacity: boat aid in post-tsunami Aceh, Indonesia. *Fisheries Management and Ecology*, *15*, 147–158. https://doi.org/10.1111/j.1365-2400.2008.00597.x

Theil, H. (1989). Journal of Econometrics, *42*, 145-155. North-Holland. *Journal of Econometrics*, *42*, 145–155.

UUPA (2006), Undang-Undang Pemerintahan Aceh Number 11 (UUPA No 11) - Special Autonomy Law of Aceh.

Werfhorst, H.G. Van De. (2018). Research in Social Stratification and Mobility Early tracking and socioeconomic inequality in academic achievement: Studying reforms in nine countries ☆. *Research in Social Stratification and Mobility*, (August 2017), 1–11. https://doi.org/10.1016/j.rssm.2018.09.002

Williamson, J.G. (1965). Regional Inequality and the Process of National Development: A Description of the Patterns. *Economic Development and Cultural Change*, *13*(4, Part 2), 1–84. https://doi.org/10.1086/450136

Zeccola, P. (2011). Dividing disasters in Aceh, Indonesia: separatist conflict and tsunami, human rights and humanitarianism, *35*(December 2004), 308–328.