Triple reproduction analysis of economy, social, and environment in Indonesia: a simultaneous panel data analysis using EC2SLS

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Abstract. In the last few years, Indonesia’s economic growth has been slowing down. In 2011, Indonesia’s economic growth was 6,16%, but in 2014 it decreased to 5,2%. However, Indonesia’s economic growth is still positive compared to other countries. A region with high economic growth should have good environmental and social conditions. Good social conditions can be reflected through the Human Development Index (HDI) as reflection of actual well-being of the population. However, some regions in Indonesia have an unbalance system on economic growth and their social and environmental conditions. For example, during 2011-2014, DKI Jakarta has economic growth and HDI which tends to be high but has the lowest Environmental Quality Index (EQI), compared to other regions. It becomes a problem because high economic conditions should be supported by social and environmental conditions in order to achieve a sustainable economic system. To build a sustainable economic system, it is necessary to balance among the economic, social, and environment factors. The balance system among these factors can be explained by Triple Reproduction Theory which consists of three subsystems, namely reproduction of the economy, humans, and natural environment. Therefore, this study aims to see relationship among these three factors in 33 provinces in Indonesia, from 2011 to 2014. Using simultaneous panel data analysis using EC2SLS method, the results are: 1) There is a simultaneous relationship between economic growth and EQI in Indonesia, 2) There is simultaneous relationship between HDI and EQI in Indonesia, 3) There is no significantly relationship between economic growth and HDI in Indonesia, 4) Population density proved to have an effect on EQI in Indonesia.

1. Introduction

Economic growth is a key indicator of a country's development in current era of globalization. However, the condition of the world’s economy is slumped, the pace of the world economy is slowing down in the last few years. According to World Bank, since 2011 the world economic growth continuously decelerated until 2014. In 2011 world economic growth reached 3,16%, but in the following year experienced a slowdown to 2,83%. The slowdown in the world economy is closely correlated with economic growth in a country, including Indonesia. In 2011 to 2014, Indonesia's economic growth decreased from 6,16% to 5,2%.

To improve the economic condition of a region not only depends on a single factor, but also a continuous and interconnected system. The system of interconnection between economic, social, and environmental factors as a concept called triple reproduction system [10]. Triple reproduction system consists of three subsystems that support economic conditions in a region that are reproduction of
economy, reproduction of humans, and reproduction of natural environment. Reproduction of economy supporting the economic condition of a region through the production of its goods, while reproduction of humans supporting the economic system through the provision of production inputs as labor. On the other hand, reproduction of natural environment supporting the economic system through the provision of natural resources and the absorption of waste of production process. It is as presented on Figure.1.

Economy reproduction is a production system sustained by three categories of input, i.e., production goods, labor provided by human reproduction, and goods and services provided by the natural environment, consisting of natural resources and waste absorption services (hereafter called “environmental resources”). The natural environment is the reproduction system sustained by the productive capacity of nature itself, but partly supported by maintenance services from the economy and human society [11].

Inability to reproduce subsystems of triple reproduction will cause problems for the economic condition of a region. When the reproduction of economy is experiencing problems such as inhibition of production processes, this reduces production. Similarly, when the reproduction of human has problems so that it can’t provide the qualified labor required by the production process, it can also reduce production output. Another problem that arises is when most of the natural environment is public goods and not subject to rent, while its utilization exceeds its reproductive capacity and its depression is not addressed properly, it will cause environmental problems.

2. Research Problem and Objective
The Ministry of Environment and Forestry has developed The Environmental Quality Index (EQI) for 33 provinces in Indonesia. DKI Jakarta has highest GDRP but lowest EQI during 2011-2014. This indicates that systems in the economy not synchronized well. According to the theory of triple reproduction, sustainable economic system only occurred when economic system, labor and environment are aligned. In line with [2], he states that the economic conditions of a region are influenced by economic, social, and environmental factors. All three factors sustain one another to form a sustainable development. Improving the economy of a country isn’t enough by increasing its GDP but also must be supported by improving the quality of social and environmental factors. Therefore, research on the influence of social, economic, and environmental factors on economic growth is important to do. This study aims to examine the relationship between economic, social, and environmental factors in 33 provinces in Indonesia.
3. Methodology
The data used in this study comes from the Central Bureau of Statistics (BPS) and the Ministry of Environment and Forestry (KLHK) within the period 2011-2014. This study uses simultaneous data analysis method of panel data. Several researches use the simultaneous equation system method in explaining the relationship between economic growth and environmental conditions [1]. Panel data has advantage that can control the heterogeneity of individuals that can’t be captured by cross-section data. In addition, panel data provide more informative, more varied data, with low collinearity among variables [5]. One of the advantage of using panel data is researchers have greater flexibility in modeling the differences between individuals [7].

A system of simultaneous equations is used to explain the potential endogenousness of a number of explanatory variables. The endogeneity of the explanatory variable is a serious problem as it may cause inconsistent and biased estimation when using OLS methods. In the simultaneous equation, there are two types of variables, endogenous variable and pre-determined variable [12]. Pre-determined variables consist of exogenous variables and endogenous lag variables. The endogenous variable that becomes explanatory variable will be stochastic so it is usually correlated with the error term in the equation where the variable becomes explanatory variable, so OLS can’t be used. When a simultaneity problem occurs and OLS can’t be used, then another estimation method needed is two-stage least squares (2SLS) [8]. The 2SLS method replaces the endogenous variable with its estimated value. We used Hausman test to simultaneity test.

Hausman's simultaneous test steps are as follows:
1. Establish a reduced form equation to obtain an estimate of the value of the endogenous variable and its residual.
2. Regress the structural equation by replacing the value of the endogenous variable with the estimated value obtained in the previous step along with the other independent variables.
3. If the residual endogenous variable is significant, it means there is a problem of simultaneity between these variables.

In order to estimate, the structural equations in the equation model must be identified (just identified or over identified). The model identification can be determined by "order condition" as a necessary and a "rank condition" as a condition of sufficiency. In the order condition, a model with M simultaneous equations will be identified if the number of exogenous variables not present in the equation is at least equal to the number of endogenous variables in the equation minus one [12].

\[ K - k = m - 1 \] (1)

with:
- \( K \) : the number of exogenous variables in the system
- \( k \) : the number of exogenous variables in the equation
- \( m \) : number of endogenous variables in the equation

A simultaneous model of panel data called simultaneous equation with error components was developed by Baltagi [3-4]. Baltagi proved that simultaneous equation with error component have efficiency gains in terms of the mean squared error when performing error component two-stage least squares (EC2SLS) and error component three-stage least squares (EC3SLS) over the standard simultaneous equation counterparts, 2SLS and 3SLS, respectively [1].

This study uses economic growth variables, HDI, and EQI as endogenous variables, whereas for the pre-determined variable it uses inflation variable, share of manufacturing industry to total GDRP, population density, and Gross Fixed Capital Formation (GFCF). The structural equation proposed in this study is as follows:

\[ \text{LnGDRP}_{it} = \beta_0 + \beta_1 \text{HDI}_{it} + \beta_2 \text{EQI}_{it} + \beta_3 \text{Ind}_{it} + \beta_4 \text{Inf}_{it} + \varepsilon_{it} \] (2)

\[ \text{HDI}_{it} = \beta_0 + \beta_1 \text{LnGDRP}_{it} + \beta_2 \text{EQI}_{it} + \beta_3 \text{Ind}_{it} + \beta_4 \text{GFCF}_{it} + \varepsilon_{it} \] (3)

\[ \text{EQI}_{it} = \beta_0 + \beta_1 \text{HDI}_{it} + \beta_2 \text{LnGDRP}_{it} + \beta_3 \text{Density}_{it} + \varepsilon_{it} \] (4)
with $\ln GDRP$ is economic growth, $HDI$ is human development index, $EQI$ is environment quality index, $Ind$ is share of manufacturing industry to total GDRP, $Inf$ is an inflation rate, $GFCF$ is gross fixed capital formation, $Density$ is population density, and $\epsilon$ is an error term.

4. Result
4.1. Descriptive Analysis
In general, the condition of Indonesian economy during the period 2011-2014 has grown. This can be seen from the growth of Indonesia’s Gross Domestic Product (GDP) constant price 2010 which increased by 1,315,918.80 billion rupiahs or 18.06% from 2011 to 2014. GDP is the total output of all production sectors in a region. Increasing of GDP shows that the performance of the production sector in Indonesia is getting better. On the other hand, increasing of GDP or output in the production sector, does not mean that the rate of economic growth in Indonesia has also increased. Indonesia's economic growth rate during 2011-2014 has declined from 6.16% in 2011 to 5.2% in 2014. It can be seen on Figure.2.

![Figure.2. Indonesia’s Economic Growth](image1)

![Figure.3. Indonesia’s Human Development Index](image2)

In the contrary, Indonesia's human quality conditions reflected by Human Development Index (HDI) indicators have generally improved over the period 2011-2014 (see Figure.3). DKI Jakarta has the highest HDI, while Papua has the lowest HDI within that period. In line with the condition of Indonesia's economic growth which decreased during the period of 2011-2014, environmental conditions reflected by the value of the Indonesian Environment Quality Index (EQI) also generally experienced a downward trend. However, in 2014, the value of EQI has increased slightly from the previous year (see Figure.4). Contrast to its HDI, DKI Jakarta has the lowest EQI among other provinces in Indonesia.

![Figure.4. Indonesia’s Environment Quality Index](image3)
4.2. Simultaneous Panel Analysis

The first step is examining whether there is a simultaneous relationship between the economic, social, and environmental factors in 33 provinces in Indonesia using the Hausman test. Summary of the results of this test can be seen in Table 1.

| Eq. | Hausman Test | Simultaneous Relationship |
|-----|--------------|---------------------------|
|     | Wald $\chi^2$ | Prob. |                   |
| 1   | 795.470      | 0.000 | Yes                |
| 2   | 621.830      | 0.000 | Yes                |
| 3   | 66.430       | 0.000 | Yes                |

Based on Table 1, it can be seen that the three structural equations proposed have a simultaneous relationship. Next step is identifying structural equation by using order condition which can be seen in Table 2.

| Eq. | Identification |
|-----|----------------|
| 1   | Just Identified |
| 2   | Just Identified |
| 3   | Over Identified |

The result in Table 2 shows that the three equations meet the order condition. To handle the over-identified equation, 2SLS method is used. However, this 2SLS method can also be used for just-identified equations. Referring to [4], this study uses the EC2SLS method which is considered more efficient in explaining a system of simultaneous equations. Summary of the best simultaneous equations model that has been obtained in this study is presented in Table 3. These three simultaneous equations have also fulfilled the assumption of residual normality and no multicollinearity among the independent variables.

| Eq. | Endg. Variable | Pre-det Variable | Coef. | Statistical Result |
|-----|----------------|-----------------|-------|--------------------|
| 1   | LnGDRP         | HDI -0.036      | $R^2$ | 0.432              |
|     |                | EQI -0.078 *    | Wald $\chi^2$ | 28.333 |
|     |                | Inf 0.010       | Prob $\chi^2$ | 0.000  |
|     |                | Ind 0.007       |       |                    |
|     |                | C 19.041 *      |       |                    |
| 2   | HDI            | LnGDRP 0.116    | $R^2$ | 0.291              |
|     |                | EQI -0.791 *    | Wald $\chi^2$ | 61.300 |
|     |                | GFCF -0.000     | Prob $\chi^2$ | 0.000  |
|     |                | Ind -0.112      |       |                    |
|     |                | C 120.700 *     |       |                    |
| 3   | EQI            | LnGDRP -3.366 * | $R^2$ | 0.579              |
|     |                | HDI -0.924 *    | Wald $\chi^2$ | 145.071 |
|     |                | Density -0.001 *| Prob $\chi^2$ | 0.000  |
|     |                | C 166.800 *     |       |                    |

*) Significance with alpha 10%
Based on these estimation results, it can be seen that the intercept value of the three structural equations significant at the level of significance of 10%. In structural equation 1, the intercept value of 19.041 indicates that when the variables in the model for all provinces are zero, the average economic growth of 33 provinces in Indonesia is 19.04%. In addition, the structural equation 1 shows that the quality of the environment proved to affect economic growth in Indonesia. EQI coefficient value of -0.078 indicates that in the ceteris paribus condition, when the value of EQI decreased by one point, the economic growth of 33 provinces in Indonesia will increase by 7.8%. This is in accordance with a study conducted by [6] which states that the value of GDRP has negative relation with environmental quality in Indonesia. Based on the theory of triple reproduction, environmental conditions (natural environment) support the production system through the provision of natural resources and the ability of residual absorption. When environmental quality decreases, the supply of resources used for the production process will also decrease so that eventually the production output will also decrease. Other than that, [9] stated that poor environmental quality can increase operational costs used by the economy to produce goods and services.

Result obtained on the estimation of structural equation 2 is the indicator of environmental quality proved to affect the human development index in 33 provinces in Indonesia. The regression coefficient value of -0.791 indicates that when the independent variables in the model are in ceteris paribus, an increase of one point of environmental quality index can decrease the human development index by 0.791 points. According to the theory of triple reproduction, environmental conditions support the reproduction of humans through the provision of living environment.

From result by structural equation 3, it is known that the variable of economic growth, HDI, and population density proved to have an effect on the condition of environmental quality in 33 provinces in Indonesia. The value of regression coefficient of -3.366 indicates that in the ceteris paribus, when economic growth of 33 provinces in Indonesia increased by 1%, then the environmental quality index will decrease by 0.0366%. Meanwhile, the regression coefficient of -0.924 and -0.001 for the HDI and population density variables show that when the HDI increases by one point, the EQI will decrease by 0.924 points and when the population density increases by one person/km2, EQI will decrease by 0.001 points with the assumption ceteris paribus. Population density is the ratio of population to the total area. Therefore, as population density increases, it indicates that there is an increase in social and economic activity in the region. These activities will surely leave waste or residue that will pollute the environment. Therefore, as population density in a region increases, it will be inversely proportional to the condition of environmental quality in the region.

According to the theory of triple reproduction, production systems support the natural environment through maintenance service, while social indicators (HDI) support natural environment through daily maintenance. One of the ways to increase production output is to increase input from the production sector itself. However, these inputs must be obtained from natural environments, which will affect the condition of the quality of environmental resources. In addition, the lack of feedback from the economic sector in maintaining environmental conditions may also lead to a deterioration in the quality of the environment.

5. Conclusion
To build a sustainable economic system, it is necessary to balance between the economic, social, and environment factors. The balance system between these factors can be explained by Triple Reproduction Theory which consists of three subsystems, namely reproduction of the economy, humans, and natural environment. Using simultaneous panel data (33 provinces, 2011 to 2014) with EC2SLS method, it is statistically proved that:
1) There is simultaneous relationship between economic growth and EQI in Indonesia,
2) There is simultaneous relationship between HDI and EQI in Indonesia,
3) There is no significantly relationship between economic growth and the HDI in Indonesia,
4) Population density proved to have an effect on EQI in Indonesia.

Clearly, greater focus on maintaining sustainability between economic growth and EQI, also HDI and EQI is needed, because they have simultaneous relationship. It proves that Triple Reproduction
Theory applies in Indonesia, although HDI has not shown any influence for economic growth yet. In other words, the quality of human development as a labor proxy has not been able to meet the needs of industry/production yet. However, more research should be done for further analysis of reproduction of human subsystem.

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