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POVERTY MACRO SYSTEM DYNAMICS MODELING BASED ON SIMULTANEOUS EQUATIONS MODELS

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ABSTRACT

Poverty factors are multidimensional and complex. Currently, to predict the number of people living below the poverty line using the concept of linear thinking. It is necessary to study the causal relationships among poverty factors in form of a system dynamics model. This study aims to predict the poverty rate people in "The Golden Indonesia" 2030 using poverty macro models. The data used are time series data from 2009 to 2018 at the national level (Indonesia), and data sources from the BPS Statistics-Indonesia, and the Ministry of Environment and Forestry of the Republic of Indonesia. The research method uses a system dynamics model, where the system of thinking is created based on the two-stage least square (2SLS) simultaneous equation model. The 2SLS simultaneous equation model testing results show that there are three significant simultaneous equations, including poverty, economic growth, and human development index. Furthermore, the three simultaneous equations show a causal loop diagram (CLD) in a system dynamics model. The mean absolute percentage error (MAPE) is 2.34%, meaning that the macro poverty model is valid. The scenario formats for prediction include "optimistic" for economic growth and the "moderate" for human development index (HDI), total population, unemployment, and environmental quality index variables (EQI). The predicted percentage number of poor people in 2030 is 4.12%, a positive deviation of 0.12% from the government's target of 4%. All parties need to work hard and together for the "optimistic" scenario to be implemented, which is to raise Indonesia's economic growth to 7.4%. This study assumes that there is no Covid-19 problem and only predicts 10 years due to limited data used in 2010-2018. The novelty of this study is the alignment of the prediction results between the system dynamics and the simultaneous equation models. In general, the system dynamics model is valid and could answer the complexity of a phenomenon to predict poverty.

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1. INTRODUCTION

The Republic of Indonesia Law No. 13 of 2011 [1] stated that poverty is the socio-economic condition of a person or group of people whose basic rights are not fulfilled to maintain and develop a dignified life. Basic needs that become the right of a person or group of people include the needs for food, health, education, employment, housing, clean water, land, natural resources, the environment, a sense of security from treatment or threats of violence, and the right to participate in the organization of social life and politics. In other words, there are multidimensional and complex factors in poverty alleviation, such as economic, social, environmental, and demographic dimensions [2]-[6].

Indonesia is committed to successfully implementing the Sustainable Development Goals by achieving the 2030 development agenda as the Golden Indonesia. McKinsey Global Institute stated: "*The government's target of 7 percent annual gross domestic product (GDP) growth* [7], *and the Republic of Indonesia Government Estimated Target of Poverty:* "Poverty rate in 2030 with intervention in the range of 4-4.5% [8]. It is clear that the achievement of such targets needs strong collaboration among stakeholders and commitments in both activities and financing, as the gaps still remain for achieving the ambitious 2030 agenda. Using projection method using the World Bank, growth assumption, growth per decile, inflation, and population, implies an estimated target of 2030 with intervention in the range of 4-4.5% [8]. In 2030, as a golden Indonesia, is the poverty rate of 4-4.5% appropriate or not?

There are a relationship between variables: unemployment and poverty ([9], [10]). There are a relationship between the economic dimension (annual gross domestic product growth, GDP) and poverty ([11]-[16]). There are a relationship between poverty and HDI ([17]-[20]). There are a relationship between poverty and EQI ([21]-[26]). There are a relationship between poverty and unemployment ([9], [10], [15], [27], [28]. The relationship between GDP and HDI be stated by [20], [29]-[31]. The relationship between GDP and EQI ([14], [21], [22], [32]-[40]). There are a relationship between GDP and unemployment ([41];[42]). The are a relationship between HDI and EQI ([43], [44]). There are a relationship between HDI and unemployment ([45], [46]. There are a relationship between EQI and unemployment ([47]-[49]). The causal relationship between economic dimensions, social dimensions (HDI), and environmental dimensions (EQI) be stated by [43], [50]-[52]. GDP and HDI together can reduce the number of poor people ([7]). The Causality GDP together with HDI will reduce the number of poor people ([18], [20]). While the elements of GDP and TPT together can reduce the number of poor people ([15], [27], [28];). Based on the explanation above, the factors associated with multidimensional poverty are annual GDP growth, HDI, EQI, employment, and population.

Currently, to predict the number of people living below the poverty line using the concept of linear thinking. This type of thinking is often associated with a structural and systematic way of approaching tasks, where solutions are derived through a linear sequence of actions. It contrasts with more non-linear or holistic thinking, where connections between ideas may be more complex and interconnected. It is necessary to study the causal relationships among poverty factors in the form of a system dynamics model. Although many people have researched poverty using system dynamics model, there have been no articles on poverty macro system dynamics models based on simultaneous equation models. In other words, intervention scenarios are needed to obtain information on what policies the government should make so that the government's targets related to poverty are achieved.

So far, the application of the system dynamics model has been through a needs analysis procedure in the form of a focus group discussion to determine policy-determining variables in the form of controlled input (in a black box diagram, Figure 2). In other words, determining controlled inputs in system dynamics models rarely uses simultaneous equation models. This article can predict the amount of poverty according to the government target set at around 4-4.5% in 2030 using a system dynamics model by determining what policy information must be taken to achieve this target based on a simultaneous model.

2. RESEARCH METHODS

2.1 Materials and Data

There have been many government programs to alleviate poverty, including social safety networks, rice programs for poor families, direct cash subsidies, conditional cash programs, and others. The Indonesian government's program aimed at helping the poor is commendable. **Figure 1** implies that from year to year, the percentage of the number of poor people in Indonesia declines slowly.

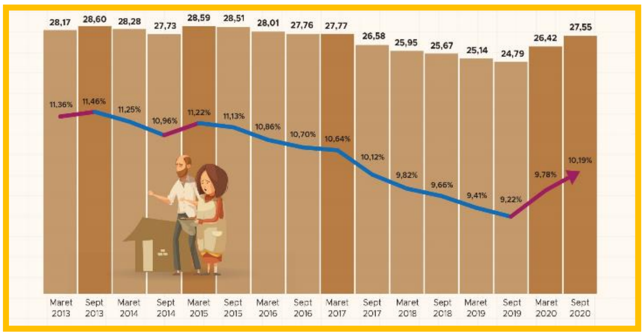

Figure 1. Number (million people) and Population Poverty Rate in Indonesia 2013-2020
***Source**: Statistic Indonesia (BPS)*

Poverty factors are multidimensional and complex. Currently, to predict the number of people living below the poverty line using the concept of linear thinking. It is necessary to study the causal relationships among poverty factors in the form of a system dynamics model. This study aims to predict the population poverty rate in "The Golden Indonesia" 2030 using poverty macro models.

The data used are time series data from 2009 to 2018 at the national level (Indonesia), and data sources from the BPS Statistics-Indonesia, and the Ministry of Environment and Forestry of the Republic of Indonesia. The variables used in this research are population, unemployment, gross domestic product, poverty, human development index, and environmental quality index.

2.2 Simultaneous Equation Model

The simultaneous equation model is a model that has more than one regression equation [53], where the equations are interdependent. In the simultaneous equation model, parameter estimation cannot be done without considering information about other equations [54]. Simultaneous models can explain a two-way (two-way) relationship between variables, so this model can be very complex. They are investigating the simultaneous relationship with the equation structural through the simultaneity test with the Hausman test. The first step is to get the residuals and estimate the endogenous variables through the reduced form equation. The second step, replacing the endogenous variables with the estimation results and residuals obtained, then performs regression in the form of a structural equation model. If there is more than one endogenous variable in the equation, what is shown is the Prob F-statistic[54]. If the F-test result is real, it indicates a simultaneity problem - in other words, the Ordinary Least Square (OLS) estimates are inconsistent.

The next step is to determine the pattern of the causality of each loop between the elements in the CLD using the Two Stage Least Square (2SLS) simultaneous equation model. Generally, the structural equation form of the simultaneous equation model is as follows (**Equation (1)**) **[54];[55]**:

$$
\begin{aligned}
Y_{1t} &= \beta_{12}Y_{2t} + \beta_{13}Y_{3t} + \cdots + \beta_{1M}Y_{Mt} + \gamma_{11}X_{1t} + \gamma_{12}X_{2t} + \cdots + \gamma_{1K}X_{Kt} + \varepsilon_{1t} \\
Y_{2t} &= \beta_{21}Y_{1t} + \beta_{23}Y_{3t} + \cdots + \beta_{2M}Y_{Mt} + \gamma_{21}X_{1t} + \gamma_{22}X_{2t} + \cdots + \gamma_{2K}X_{Kt} + \varepsilon_{2t} \\
Y_{3t} &= \beta_{31}Y_{1t} + \beta_{32}Y_{2t} + \cdots + \beta_{3M}Y_{Mt} + \gamma_{31}X_{1t} + \gamma_{32}X_{2t} + \cdots + \gamma_{3K}X_{Kt} + \varepsilon_{3t} \\
&\;\;\vdots \\
Y_{Mt} &= \beta_{M1}Y_{1t} + \beta_{M2}Y_{2t} + \cdots + \beta_{M,M-1}Y_{M-1,t} + \gamma_{M1}X_{1t} + \gamma_{M2}X_{2t} + \cdots + \gamma_{MK}X_{Kt} + \varepsilon_{Mt}
\end{aligned}
\tag{1}
$$

Information:
$Y_1, Y_2, \ldots, Y_M$: Endogenous variables
$X_1, X_2, \ldots, X_K$: Exogenous variables
$\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_K$: Error terms
t : Observation
β : Endogenous parameter coefficient
γ : Exogenous parameter coefficient

2.3 Simultaneous Equation Model Identification Rules

In identifying simultaneous equation models, the following conditions are applied:

a. Order Condition Identification

A necessary (but not sufficient) identification condition known as an order condition can be expressed under the following conditions:

$$K - k \geq m - 1$$

If $K - k = m - 1$, the equation qualifies as Just Identified. If $K - k > m - 1$, the equation qualifies as Overidentified.

b. Identify Rank Conditions

According to the rank condition, a simultaneous equation model can be said to be identified if it can form a nonzero determinant from the coefficients of variables that are not contained in the equation but are contained in other equations in the simultaneous equation model.

2.4 Hausman Test

Investigating the simultaneous relationship with the equation structural through the simultaneity test with the Hausman test. The steps are as follows:

a. The first step is to get the errors and estimate the endogenous variables through the reduced-form equation.

b. The second step, replacing the endogenous variables with the estimation results and errors obtained, then performs regression in the form of a structural equation model. If there is more than one endogenous variable in the equation, what is shown is the Prob F-statistic [54]. If the F-test result is real, it indicates a simultaneity problem - in other words, the Ordinary Least Square (OLS) estimates are inconsistent.

Here are the hypotheses for the Hausman Test:

H_0 : Random Effect
H_1 : Fixed Effect

The Hausman Test statistics:
$m = \hat{q}Var(\hat{q})^{-1}\hat{q}$

Information:
$\hat{q} = \hat{\beta} - \hat{\beta}_{GLS}$
$Var(\hat{q}) = Var(\hat{\beta}) - Var(\hat{\beta}_{GLS})$

Decision rules:
Rejected H_0 if $m \geq X^2_{(a,p)}$

2.5 Two Stage Least Square (2SLS)

The next step is to determine the pattern of the causality of each loop between the elements in the CLD using the Two Stage Least Square (2SLS) simultaneous equation model. The 2SLS is employed to replace the OLS method, which cannot be applied to estimate an equation in a system of simultaneous equations, primarily due to the interdependence between the error terms and endogenous explanatory variables. The two-stage least squares or 2SLS is used to estimate simultaneous equation models or system of equations. The following are the steps to solve 2SLS:

a. Using the OLS method on the reduced form equation:

$$Y_1 = \pi_{11}X_1 + \pi_{12}X_2 + \cdots + \pi_{1K}X_K + \varepsilon_1$$

$$Y_2 = \pi_{21}X_1 + \pi_{22}X_2 + \cdots + \pi_{2K}X_K + \varepsilon_1$$

$$\vdots$$

$$Y_i = \pi_{i1}X_1 + \pi_{i2}X_2 + \cdots + \pi_{iK}X_K + \varepsilon_i \quad (2)$$

We obtained

$$\hat{Y}_1 = \pi_{11}X_1 + \pi_{12}X_2 + \cdots + \pi_{1k}X_k$$

$$\hat{Y}_2 = \pi_{21}X_1 + \pi_{22}X_2 + \cdots + \pi_{2k}X_k$$

$$\vdots$$

$$\hat{Y}_i = \pi_{i1}X_1 + \pi_{i2}X_2 + \cdots + \pi_{ik}X_k \quad (3)$$

So, the simultaneous equation is:

$$Y_1 = \hat{Y}_1 + \varepsilon_1$$

$$Y_2 = \hat{Y}_2 + \varepsilon_2$$

$$\vdots$$

$$Y_i = \hat{Y}_i + \varepsilon_i \quad (4)$$

b. The endogenous variables that appear on the left-hand side of the structural equation are replaced with equations $Y_i = \hat{Y}_i + \varepsilon_i$ and we obtained:

$$Y_i = \alpha_{i1}(\hat{Y}_1 + \varepsilon_1) + \alpha_{i2}(\hat{Y}_2 + \varepsilon_2) + \cdots + \alpha_{im}(\hat{Y}_i + \varepsilon_i) + \beta_{i1}X_1 + \cdots + \beta_{ik}X_k + \varepsilon_i$$

$$Y_i = \alpha_{i1}\hat{Y}_1 + \alpha_{i2}\hat{Y}_2 + \cdots + \alpha_{im}\hat{Y}_i + \beta_{i1}X_1 + \cdots + \beta_{ik}X_k + \varepsilon^* i \quad (5)$$

Where: $\varepsilon^* i = \varepsilon_i + \alpha_{i1}\varepsilon_1 + \alpha_{i2}\varepsilon_2 + \alpha_{im}\varepsilon_i$

The following are the results of the model specifications obtained **Equation (2)**:

$$Pov_t = \beta_{10} + \beta_{11}GDP_t + \beta_{12}HDI_t + \beta_{13}EQI_t + \beta_{14}UE_t + \beta_{15}Pop_t + e_{1t} \quad (6)$$
$$GDP_t = \beta_{20} + \beta_{21}Pov_t + \beta_{22}HDI_t + \beta_{23}EQI_t + \beta_{24}UE_t + \beta_{25}Pop_t + e_{2t} \quad (7)$$
$$HDI_t = \beta_{30} + \beta_{31}GDP_t + \beta_{32}Pov_t + \beta_{33}EQI_t + \beta_{34}UE_t + \beta_{35}Pop_t + e_{3t} \quad (8)$$
$$EQI_t = \beta_{40} + \beta_{41}GDP_t + \beta_{42}HDI_t + \beta_{43}EQI_t + \beta_{44}UE_t + \beta_{45}Pop_t + e_{4t} \quad (9)$$
$$UE_t = \beta_{50} + \beta_{51}GDP_t + \beta_{52}HDI_t + \beta_{53}EQI_t + \beta_{54}UE_t + \beta_{55}Pop_t + e_{5t} \quad (10)$$

Information:
Pov_t : Percentage of the poor population in the t-year;
GDP_t : Percentage of the GDP in the t-year;
HDI_t : The Human Development Index in the t-year;
EQI_t : The Environmental Quality Index in the t-year;
UE_t : The Unemployment in the t-year;
Pop_t : Total population in the t-year;
β_{kl} : Estimation result parameters l in the structural equation k;
u_{1t} : error term structural equation 1; t-year;
u_{2t} : error term structural equation 2; t-year;
u_{3t} : error term structural equation 3; t-year;
u_{4t} : error term structural equation 4; t-year;
u_{5t} : error term structural equation 5; t-year.

Based on the simultaneity problem, the equations that have been formed have been identified. The results of significant testing for each equation were three significant simultaneous equations. So that the results of the identification of the model are as follows:

Table 1. Identification Results for Order Conditions and Rank Conditions

Equations	(K-k)> (M-m)	Rank Condition	Order Condition
Pov	5 > 2	Over identified	Over identified
GDP	5 > 2	Over identified	Over identified
HDI	5 > 2	Over identified	Over identified
EQI	5 > 2	Over identified	Over identified
UE	5 > 2	Over identified	Over identified

Then, to determine between fixed effect and random effect, Hausman test was performed. Furthermore, the classical assumption test includes normality and multicollinearity tests [55]. Whereas the homogeneity and non-autocorrelation tests were only carried out for structural equations (Pov equation), because the 2SLS random effect model has accommodated these two classical assumptions.

2.6 Model Parameter Testing

a. Simultaneous Test

Simultaneous testing is a test performed to test the parameters of the equation by knowing the simultaneous influence between the independent and the response variables. Simultaneous tests generally use the F-test to see whether the coefficient of determination (R^2) has a real effect on endogenous variables in each equation.

b. Partial Test

Partial tests are carried out using the t-test with the aim of testing each explanatory variable individually has a real or no effect on endogenous variables in each equation.

2.7 Classic Assumption Test

a. Normality Testing

The normality assumption test is a test that aims to determine whether errors are normally distributed or not. The normality test can be performed using the Jarque-Bera test as follows.

Hypotheses:

H_0 : Normally distributed errors
H_1 : Errors are not normally distributed

Test Statistics:

$$JB = n\left[\frac{S^2}{6} + \frac{(K-3)^2}{24}\right]$$

Information:

N : Number of observations

S^2 : Skewness value

K : Kurtosis value

b. Multicollinearity Testing

Multicollinearity was first discovered by Ragnar Frisch, which means the existence of a perfect linear relationship between some or all explanatory (independent) variables of a regression model. Furthermore, the term multicollinearity detection is used in a broader sense, namely, to examine the occurrence of high linear correlations among explanatory variables.

How to detect multicollinearity can be done by looking at the values of *Tolerance* (TOL) and *Variance Inflation Factor* (VIF) with the following formula.

$$VIF_j = \frac{1}{TOL_j} = \frac{1}{1 - R_j^2}$$

$\mathrm{TOL_j} < 0{,}1$; there is multicollinearity
$\mathrm{VIF_j} > 10$; there is multicollinearity

c. Heteroscedasticity Testing

The heteroscedasticity assumption test is one of the important assumptions in regression models, error variance must be identical and not form a specific pattern. The heteroscedasticity test uses Breusch-Pagan-Godfrey test (BPG), with steps as follows.

Hypotheses:

$\mathrm{H_0}$: No heteroscedasticity
$\mathrm{H_1}$: There is heteroscedasticity

Test Statistics:

$$LM = \left(\frac{NT}{2(T-1)}\right)\left[\left(\frac{\sum_{i=1}^{N} u_i^2}{\sum_{i=1}^{N}\sum_{i=1}^{T} u_{it}^2}\right) - 1\right]^2 \sim X_1^2$$

where, u_{it} is the error and u_i is the sum over the period t.

The significance level α is 5% with the rejection area Reject $\mathrm{H_0}$ if the Breusch-Pagan LM test value is > $\chi^2_{(\alpha,df)}$ or can be seen based on the Breusch-Pagan probability value with the following conditions,

1) Chi Square probability (p-value) > 0.05, so heteroscedasticity does not occur.
2) Chi Square probability (p-value) < 0.05, hence heteroscedasticity.

d. Autocorrelation Testing

The autocorrelation assumption test is a test to determine whether the errors of the regression model have met independent assumptions or not. The Durbin-Watson test and plot Autocorrelation Function are tests that can be used for autocorrelation tests. The Durbin-Watson test is as follows.

$\mathrm{H_0}$: There is no positive or negative correlation
$\mathrm{H_1}$: There is a positive or negative correlation

Rejection Area: $d < \mathrm{d_L}$: reject $\mathrm{H_o}$. or $d > 4 - \mathrm{d_L}$: reject $\mathrm{H_0}$.
Test Statistics:

$$d = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2}$$

Information:

d : Durbin Watson value

d_L : Lower limit

d_U : Upper limit

e_i : error term

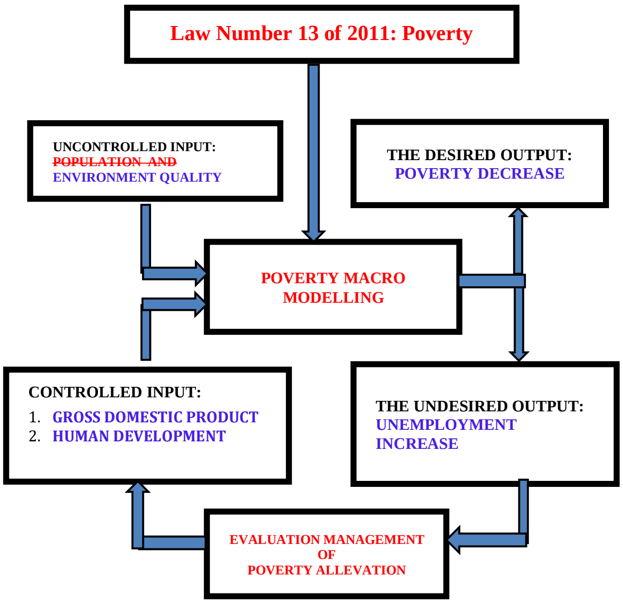

Figure 2. Black-Box Diagram of Poverty Macro Modeling

Based on the statistical test using the simultaneous equation model above, it is used as a reference basis to form a black-box diagram and policies must be implemented to anticipate/change system behavior according to the desired output [57], this study aims to predict the poverty rate people in 2030, so as the desired output is the poor population, while the uncontrolled input is the population. The factors that have a significant relationship to the number of poor people are GDP and HDI, so they are used as controlled inputs. Considering that the unemployment variable also has a relationship with the variable of the poor, it is used as an unwanted output. all the explanations above are presented in the form of a black-box diagram (Figure 3).

After this, we made the causal loop diagram (CLD) as follow in Figure 3:

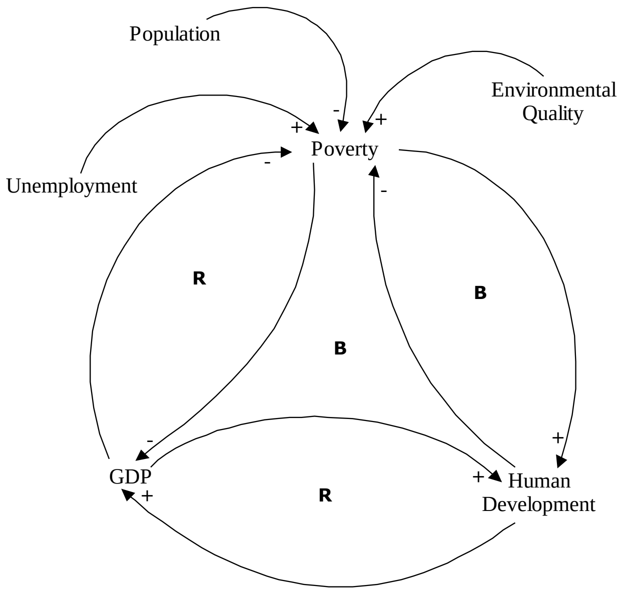

Figure 3. Causal Loop Diagram (CLD)

In CLD (Figure 3), one can see the loop between Pov-GDP-HDI.

3. RESULTS AND DISCUSSION

3.1 Results

This macro poverty model can be used to predict the number of poor people, because the model meets the assumption of normality, no multicollinearity, and no autocorrelation. The research method uses a system dynamic, where the system of thinking is built based on the two-stage least square (2SLS) simultaneous equation model. The 2SLS simultaneous equation model testing results show that there are three significant simultaneous equations, including poverty, economic growth, and human development index. For three variables Poverty, GDP, and HDI, significant testing are as follows:

$$POV = -367450516.462 - 6.229E^{-099}(GDP) + 11824601.788(HDI) + 10185.266(EQI) + 0.581(UE) - 1.469(Pop)$$

$$GDP = -5.660E^{16} - 1.082E^{8}(Pov) + 1.681E^{15}(HDI) + 1.046E^{13}(EQI) + 2.999E^{7}(UE) - 1.923E^{8}(Pop)$$

$$HDI = 31.108 + 4.877E^{-016}(GDP) + 5.960E^{-008}(Pov) - 0.004(EQI) - 1.338E^{-008}(UE) + 1.281E^{-007}(Pop)$$

with each Adjusted R-Squared value for the Pov, GDP, and HDI estimation equation is 98.9%. It is just that a positive sign in the relationship between HDI and Pov does not mean that the higher the HDI, the higher the Pov. This is shown in the inductive argument that human development has not been very effective in reducing poverty, or that there is a disorientation in the goals of human development toward poverty alleviation. Likewise, the negative meaning of the relationship between the number of people and the number of poor people does not mean that an increase in population will reduce the number of poor people. But it can be interpreted more in the inductive argument, namely that there is an imbalance in the composition of the number of poor people, which decreases slowly with population growth that increases rapidly (inverse relationship in terms of growth rates).

The dynamic system associates one element (variable) with other elements [56], including the results of the statistical test of the simultaneous equation above - whether the variable (element) is significant or insignificant (ns). This is because between elements (variables) is a complete unit in the system, and each variable has its own contribution (including variables based on the results of statistical tests are not significant. In other words, the system will automatically run iterations, where the tendency of the elements (variables) that are not significant will automatically contribute. Before that, we made the stock flow diagram as follows:

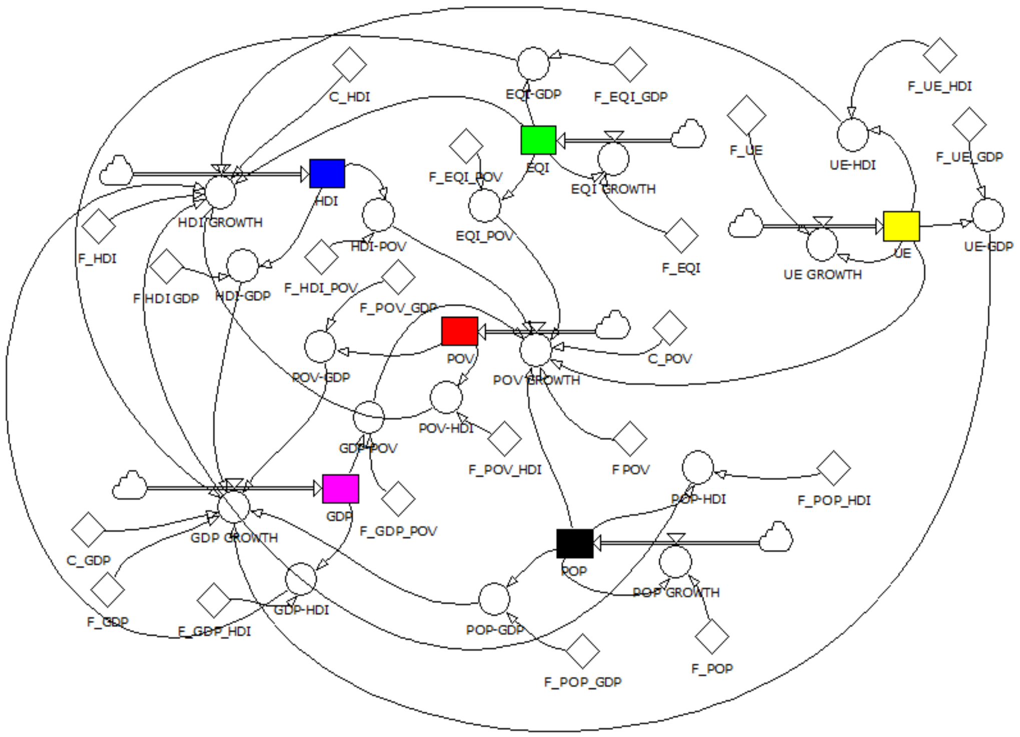

Figure 4. Stock Flow Diagram

The simulation process uses Powersim studio 10 software, and previously built a stock flow diagram (SFD) based on CLD (**Figure 4**). SFD are graphical representations used in system dynamics modeling to describe the dynamic behavior of factors that influence poverty, such as the human development index, environmental quality index, unemployment, population size, and gross domestic products (GDP) in a system over time (**Figure 5**). Data processing using powersim studio 10 software can be processed based on the SFD form. Furthermore, the three simultaneous equations show a causal loop diagram (CLD) in a system dynamics model. The mean absolute percentage error (MAPE) for each Poverty, GDP, and HDI is 2.34%; 0.64%; and 0.03%, meaning that the macro poverty model is valid.

3.2 Discussion

The scenario analysis is divided into four scenarios: pessimistic, existing, moderate, and optimistic. We can refine the scenarios based on the specific economic theory or model we are using and incorporate feedback from experts in poverty investigations. Scenario analysis is a valuable tool for decision-makers to access potential risks and opportunities in different future situations. The existing scenario is based on the current economic conditions and trends. It assumes that existing policies and economic factors will continue without major disruptions. The optimistic scenario assumes positive economic developments, often driven by favorable policy changes, technological breakthroughs, or global cooperation. The pessimistic scenario considers adverse economic events such as recessions, financial crises, or geopolitical tensions leading to negative impacts on the economy. The moderate scenario lies between the optimistic and pessimistic scenarios, reflecting a balanced and realistic view of potential economic development.

The assumption is that government programs for poverty alleviation can be effective in 2020 (existing). Then, a hypothesis is made that the percentage of the number of poor people in 2030 will be around 4-4.5%. The scenario formats for prediction include “optimistic” for economic growth and “moderate” for human development index, total population, unemployment, and environmental quality index variables. The predicted percentage number of poor people in 2030 is 4.12%, a positive deviation of 0.12% from the government’s target of 4%. All parties need to work hard and together for the “optimistic” scenario to be implemented, which is to raise Indonesia’s economic growth to 7.4% (all explanations are based on **Figure 4**).

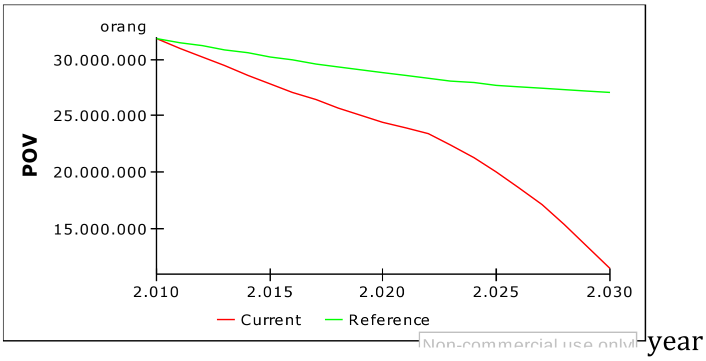

Figure 5. Current (green line) and Scenario (red line) Conditions

Figure 5, using a system dynamics model based on simultaneous equation models, shows that if the government runs the program as it is now (business as usual BAU), the decline in the poverty rate people will slow down (green line). However, if the government intervenes in program activities according to the results of the scenario, the poverty rate people in 2030 will be 4.12% (the red line in **Figure 5** shows as if it cuts the x-axis-but it does not and it is impossible for poverty to be negative). This condition will be achieved if, in 2030, the economic growth is 7.4%, the environmental quality 72.67, the rate of unemployment growth decreased by 1.93%, and the average growth rate of the population is 0.75% each year.

What is interesting in this article is the goodness-of-fit macro model of poverty because the prediction results are very precise. **Table 2** presents the differences in the prediction results of this model with the predictions or targets of the government and the McKinsey Global Institute, which are as follows.

Table 2. Differences in Poverty and Economic Growth Predictions between Models and Targets in 2030

Data	Target	Model	Difference
Government Target Poverty	4-4.5	4.12	0.12 – 0.38
McKinsey (Economic Growth)	7	7.4	0.4
Poverty in 2020 by BPS Statistics Indonesia	9.78	9.36	0.42

Table 2 states that the macro model of poverty is valid and very precisely in line with the government's target of poverty and predictions of economic growth by the McKinsey Global Institute. The difference between the model and the hypothesis ranges from 0-0.42%, and the results are relatively the same.

4. CONCLUSIONS

The poverty macro model is very valid for making predictions because the mean absolute percentage error value is below 10%. The prediction of the percentage of the number of poor in 2030 is 4.12%. This condition will be achieved if, in 2030, the economic growth is 7.4%, environmental quality 72.67, the rate of unemployment growth decreased by 1.93%, and the average growth rate of the population is 0.75% each year.

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