Cointegration Test and Projection of Total Rubber and Tin Production and Their Effect on The Environment in Province of Bangka Belitung Island

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Abstract. The cointegration test in this study aims to see the long-term balance relationship between the amount of rubber and tin production produced in the Province of Bangka Belitung Islands. This time series test uses historical data from 2002-2015. In addition to seeing the cointegration relationship, it will also be seen how the projection results are produced until 2025. This cointegration test results that the amount of rubber and tin production produced in the Province of Bangka Belitung Islands does not have a significant relationship between the two variables as evidenced by a probability value of 0.1366. The probability value that is greater than 5% of the alpha level means that these two variables are independent of each other and the projection results show that tin and rubber production has an upward trend from 2016-2025. The projected value of tin production is not as high as the projection value of rubber plantations with a percentage difference of 11.67%. It is also time for the community to develop the plantation sector and move away from the mining sector which has been undertaken in line with the increasing environmental damage that has been generated.

1. Introduction

In a simple linear regression equation, the dependent and independent variables in the regression equation that are not stationary in the means and variance will cause the resulting error to also be an error. In this situation, a spurious regression case occurs when the dependent variable and the independent variable have a regression coefficient value equal to zero. On the other hand, the resulting error can be stationary even though the dependent and independent variables are not stationary. This condition indicates the existence of cointegration between the dependent and independent variables [1]. Engle dan Granger [2] define the cointegration concept as a long-term balance on time series variables, for example the application of the case of forecasting electricity sales on a monthly basis with the application of seasonal cointegration in an error correction framework [3].

A lot of research on forecasting has also been carried out with several selected forecasting methods and by the process of fitting model on the first step, for example poverty projections in the Province of the Bangka Belitung Islands using the Holt's Exponential Smoothing model which gives the result that the poverty rate in this province has increased significantly in year 2019 [4]. Not only economic factors that can be done through this projection process, the projections about the level of electricity consumption in that province have also been carried out using the same model [5]. The Granger causality test has also been carried out to see the causal relationship between export variables, economic growth, and employment opportunities in the Province of the Bangka Belitung Islands with the result that there is no causal relationship between the three variables [6].
Cointegration testing in this study is a test of the analysis model regarding the spurious regression problem [7]. Tin and rubber which are the leading commodities in the Province of the Bangka Belitung Islands with two different sides are interesting to study from the cointegration relationship between the both. Tin as a non-renewable natural resource and has always been the main source of income for the people of the Bangka Belitung Islands Province, it is the time to move on to other sectors, such as rubber from the plantation sector. Based on the amount of production produced, rubber production in 2020 is higher than the amount of pepper production. This can also be a preventive measure to not rely on one tin mining sector which has certainly not environment and also as one of the non renewable natural resources. The people must diversify the income sector, one of them from the rubber plantation sector. It is hoped that in the future, the negative impact caused by the mining sector on environmental sustainability can be minimized immediately.

2. Experimental Procedure

Time series is an important class of temporal data objects and it can be easily obtained from scientific and financial applications [8]. In economic scope, most economic variables that are used for policy analysis and forecasting are characterized by high persistence and possibly non stationary behavior [9]. This study examines the causal relationship and will determine the projected value between the variables of the amount of rubber and tin production in the Province of the Bangka Belitung Islands. The data used in this study were sourced from the Central Statistics Agency (BPS) of the Bangka Belitung Islands Province as listed in Table 1 below:

| Years | Total Tin Production (Ton) | Total Rubber Production (Ton) |
|-------|---------------------------|------------------------------|
| 2003  | 32610                     | 630                          |
| 2004  | 27566                     | 39485                        |
| 2005  | 22140                     | 23324                        |
| 2006  | 20781                     | 14317                        |
| 2007  | 11654                     | 3916                         |
| 2008  | 16424                     | 20271                        |
| 2009  | 15671                     | 28298                        |
| 2010  | 15601                     | 41436                        |
| 2011  | 18472                     | 59451                        |
| 2012  | 28242                     | 60981                        |
| 2013  | 34379                     | 47564                        |
| 2014  | 33596                     | 49916                        |
| 2015  | 33828                     | 56920                        |

The time series data used in this study will then be tested for stationarity of the data through the Augmented Dicky Fuller test, then the optimum lag length will be determined, Granger causality test, cointegration test with the Johansen approach, and as the last step the projected values of the two variables used in this study will be determined. In this study using two research variables, the specification of the research model is called bivariate vector autoregression [10]. If the variables used in this study have a cointegration relationship, then this research can be continued by testing the Vector Error Correction Model (VECM) because the time series data used is not stationary at the level but it stationary at the same level of differentiation and there is a linear combination between the variables used [11]. On the other hand, if the research variables do not have a causal relationship, the test will continue using the Vector Auto Regressive (VAR) model which consists of the following two equations:

\[ Pk_t = \alpha_1 + \sum a_i Pk_{t-i} + \sum b_i Pt_{t-j} + \epsilon_t \]  \hspace{1cm} (1)

\[ Pt_t = \alpha_2 + \sum c_i Pk_{t-i} + \sum d_i Pt_{t-j} + \epsilon_t \]  \hspace{1cm} (2)

Where:
3. Results

3.1 Data Stationarity Test

The following is the graphic of the data used in this study:

![Data Pattern of Total Rubber and Tin Production](image-url)

Figure 1. Data Pattern of Total Rubber and Tin Production

Based on the graph above, it can be seen that the variable amount of rubber and tin production in the Province of the Bangka Belitung Islands contains trend on data, so the data is not stationary and it is necessary to test the data stationarity through the Augmented Dicky Fuller test with output after 1st difference because the data is not stationary at the level with the results that the data is stationary at the 1st difference probability value above 5%.

3.2 Optimum Lag Determination

To determine the optimum lag, this study uses several criteria consisting of the Akaike Information Criterion (AIC), Schwartz Information Criterion (SIC), and Hannan-Quinn (HQ) which are the smallest value among the various lags proposed from the entire time series data used. This is the results of the process of determining the optimum lag length that has been carried out:

| Lag | LogL   | LR     | FPE    | AIC      | SC       | HQ       |
|-----|--------|--------|--------|----------|----------|----------|
| 0   | -205.4016 | NA*  | 3.55e+15* | 41.48031* | 41.54083* | 41.41393 |
| 1   | -201.7013 | 5.180435 | 3.91e+15 | 41.54025 | 41.72180 | 41.34109* |
| 2   | -199.0555 | 2.645805 | 6.01e+15 | 41.81109 | 42.11368 | 41.47916 |
| 3   | -198.3239 | 0.438926 | 1.85e+16 | 42.46478 | 42.88840 | 42.00007 |

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error

From the test results above, it can be seen that the optimum lag value is in the first lag with the smallest AIC, SIC, and HQ values among other lag values.

pk_t = Total rubber production year–t
pk_{t-1} = Total rubber production in the previous year–t
pt_t = Total tin production year–t
pt_{t-1} = Total tin production in the previous year
a_i, b_i, c_i, d_i = Constant
\epsilon_{it} = White noise/distraction factor
3.3 Granger Causality Test

Based on the granger causality test, no causal relationship was found between the variables of the amount of tin and rubber production, but it has a one-way relationship, the amount of rubber production affects the amount of tin production as indicated by a probability value of 0.0187, this value is less than the level of $\alpha = 5\%$.

| Null Hypothesis                          | Obs | F-Statistic | Prob.  |
|------------------------------------------|-----|-------------|--------|
| TIN does not Granger Cause RUBBER        | 13  | 0.04852     | 0.8301 |
| RUBBER does not Granger Cause TIN        | 7.84816 | 0.0187     |

3.4 Cointegration Test

This test was conducted to determine the possibility of long-term stability (long run equilibrium) between the amount of tin and rubber production variable produced by the Province of the Bangka Belitung Islands. The cointegration test in this study uses the Johansen approach with the analysis result as a below:

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | Critical Value | Prob.**  |
|----------------------------|------------|-----------------|----------------|----------|
| Unrestricted Cointegration Rank Test (Trace) | None   | 0.569826 | 14.44317 | 15.49471 | 0.0716  |
| At most 1 *                | 0.374654  | 5.163946 | 3.841466 | 0.0231  |
| Unrestricted Cointegration Rank Test (Maximum Eigenvalue) | None   | 0.569826 | 9.279224 | 14.26460 | 0.2637  |
| At most 1 *                | 0.374654  | 5.163946 | 3.841466 | 0.0231  |

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Based on the results of this test, it can be seen that the data used in this study does not have a cointegration relationship. It can be seen by the value of the trace statistic and max eigen statistic, each of them is smaller than the critical value at the 5% level. So, this data do not have a cointegration relationship, then the next research process can be continued by using the Vector Auto Regression (VAR) differentiation form.

3.5 VAR Estimation

The estimation model using the VAR model assumes that all economic variables are interdependent with each other. The estimation results of the VAR as Table 5.

Based on the results of the VAR test above, a regression equation can be made as follows:

$RUBBER = -0.0600942 \times RUBBER_{t-1} - 0.310023 \times TIN_{t-1} + 1478.419$

$TIN = 0.006199 \times RUBBER_{t-1} + 0.267447 \times TIN_{t-1} + 263.9415$

3.6 Projection

The last step in this research is to determine the projection value of the amount of rubber and tin production in the Province of the Bangka Belitung Islands so that the public can compare and determine the type of income sector chosen and depend on one sector, especially the mining sector which is not very environmentally friendly, so income sector of the community is not diversification process. The results of the projections in this study as Figure 2.
Table 5. Vector Autoregression Estimates

|                  | D(RUBBER) | D(TIN) |
|------------------|-----------|--------|
| D(RUBBER(-1))   | -0.060942| 0.006199 |
|                  | (0.24361)| (0.10289) |
|                  | [-0.25017] | [0.06025] |
| D(TIN(-1))      | -0.310023| 0.267447 |
|                  | (0.73278)| (0.30952) |
|                  | [-0.42308] | [0.86408] |
| C                | 1478.419 | 263.9415 |
|                  | (3863.19) | (1631.75) |
|                  | [0.38269] | [0.16175] |
| R-squared        | 0.027386 | 0.077665 |
| Adj. R-squared   | -0.188750| -0.127298 |
| Sum sq. resid    | 1.47E+09 | 2.62E+08 |
| S.E. Equation    | 12785.23 | 5400.266 |
| F-statistic      | 0.126709 | 0.378923 |
| Log likelihood   | -128.7737| -118.4316 |
| Akaike AIC       | 21.96229 | 20.23860 |
| Schwarz SC       | 22.08351 | 20.35983 |
| Mean dependent   | 1161.083 | 320.1667 |
| S.D. dependent   | 11726.36 | 5086.228 |
| Determinant resid covariance (dof adj.) | 3.79E+15 |
| Determinant resid covariance | 2.13E+15 |
| Log likelihood   | -245.8297|
| Akaike information criterion | 41.97162 |
| Schwarz criterion| 42.21407 |

Figure 2. The Result Projection of Tin and Rubber Production

It can be seen that the projection results from the amount of rubber production significantly increased when compared to the projection results of tin which also increased but in total the amount produced was not as much as the amount of rubber production produced by the Province of the Bangka Belitung Islands. Certainly, the results of this projection are in line with the local government's goals it’s not to rely on the mining sector as the community's income sector. This is also reinforced by the mining sector
as one of the non-renewable natural resources which cannot always be used as the main source of income for the local community and of course will harm the environment from mining activities carried out.

4. Conclusion

Based on the all of testing process that has been carried out on the amount of tin and rubber production in the Province of the Bangka Belitung Islands as well as the projection process carried out, it can be concluded that there is no causal relationship between the variables of the amount of tin and rubber production, but has a relationship in one direction, namely the amount of rubber production affects the amount of tin production which is indicated by a probability value of 0.0187, this value is less than the level of $\alpha = 5\%$.

The cointegration test produced also gives the result that there is no cointegration relationship between the two variables used in this study, so it can be continued with testing using the Vector Auto Regression (VAR) differentiation form.

The result of projection value as the last step in this study has the result that the amount of rubber production has significantly increased than the amount of tin production which also increased but in total produced is not as much as the amount of rubber production. There is a difference of 11.67% from the ratio of the amount of rubber and tin produced. These results can be used as a reference for the local government to take action to diversify the community's income sector so that it does not only source from one sector of income, especially the mining sector which is not very environmentally friendly and also as one of the non renewable natural resources. Through the results of this research, the community immediately goes to the plantation sector for example, rubber plantations so that the negative impacts caused by the mining sector can be immediately minimized.

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