Co-integration analysis between rice production and exchange reserves with rice consumption in Indonesia

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Abstract. Rice production is increasing every year but Indonesia still to import rice which is directly related to the use of foreign exchange reserves. Volume of rice import is caused by the small amount of rice production. If the volume of rice import is only a small amount means the amount of rice production is large. Large volume of imports will may have impact on foreign exchange reserves and constraints the ability to import raw materials and capital goods needed for development. The purpose of this study is to determine the co-integration between foreign exchange reserves and rice imports in Indonesia. The method used in this study is the Error Correction Model (ECM) analysis. The results of the study showed that there was co-integration of rice production and rice import while there was no co-integration of foreign exchange reserves and rice import that is the variables did not have a long-term relationship.

1. Introduction
The food problem faced by Indonesia is that it cannot meet the very high demand for rice. The reason for Indonesia being unable to meet the demand for rice is due to the increasing population and the increasingly narrow agricultural land area. As the population increases in Indonesia, rice consumption in Indonesia increases and so the narrower agricultural land, the less rice production is produced. Then the reality is the results of rice production are not able to meet the demand for rice in Indonesia, so it needs to be imported.

The amount of rice production can affect the fall or increase in the volume of rice imports. The large volume of rice imports is caused by the small amount of rice production and vice versa, if the volume of rice imports is only a small amount means the amount of rice produced is large. This shows that there is an opportunity that rice production in Indonesia has a long-term relationship to rice import activities. The Minister of Trade of the Republic of Indonesia issued regulation number 1 of 2018 concerning provisions on rice export and import. This regulation was made to help exporters and importers to know what things must be done in conducting international trade. International trade activities depend on the condition of a country’s foreign exchange reserves.

What is meant from foreign exchange reserves is an important source of financing used for national development. This foreign exchange reserve is held and accounted for by the Central Bank, Bank Indonesia [1]. Foreign exchange reserves in a country are used in various ways one of which is as a means of payment in import activities. Other uses of foreign exchange reserves are to pay off government foreign debt, maintain financial stability (monetary, especially exchange rates) and become state savings [2]. Limited foreign exchange reserves can cause unstable international trade activities. This influence has an impact on the difficulty of importers in importing goods that do not adequately meet demand in Indonesia.
Research on the relationship between rice production and foreign exchange reserves with import activities has been carried out by several researchers. Dwipayana and Kesumajaya [3] Examined the effect of prices, foreign exchange reserves and population on Indonesian rice imports using quantitative data. Almutmainnah [1] Examines the analysis of the effect of exports and imports on Indonesia’s foreign exchange reserves using a mixed approach that is quantitative and qualitative data. Zaeroni and Rustariyuni [4] also examined the effect of rice production, rice consumption and foreign exchange reserves on rice imports in Indonesia.

This study uses secondary data with a period of 29 years so that this research data is long term. Co-integration is a condition in which there is a long run equilibrium between two variables. Based on the explanation above, the writer wants to examine whether there has been a long-term equilibrium relationship or what is called cointegration in time series during the time period between rice production and foreign exchange reserves against rice imports in Indonesia.

2. Research methods

This study uses secondary data from the Indonesian Central Statistics Agency, Bank Indonesia, Comtrade and literature related to this problem. The data used in this research are time series data, namely data on foreign exchange reserves and the value of Indonesia's rice imports in 1990-2018. This study uses three variables, namely rice production, Indonesia's foreign exchange reserves and the value of Indonesia's rice imports. The production variable is calculated in tonnes while the foreign exchange reserve and rice import variables are valued in US dollars (US $). The three variables were analyzed using the method. The three variables were analyzed using a method developed [5] called the ECM (Error Correction Model).

To test the analysis model StataSE-64 software is used. Before entering the ECM testing stage, there are several steps that need to be done. The first stage is the stationarity test which aims to find out whether the data used is stationary or not. The second stage of co-integration test is to find out whether the tested variables are co-integrated or not. The third stage is causality test to determine the direction of the causal relationship between the variables tested. The final stage is the ECM test to correct errors that occur in short-term relationships that are adjusted to long-term relationships. The stages of the analysis model in this study are as follows:

2.1. Data stationary test

Stationary test conducted in this study uses the Augmented Dickey-Fuller Unit Root Test and the Phillip-Perron Test.

\[
\Delta x_t = \alpha_0 + \gamma x_{t-1} + \sum_{\ell = 1}^{p} \alpha_\ell \Delta x_{t-\ell} + \epsilon_t
\]

Explanation:

- \(x_t\) = Period of time
- \(\alpha_0, \alpha_\ell, \gamma, \beta_t\) = Coefficient
- \(\epsilon\) = Equation error

The statistical hypotheses tested:

- \(H_0 : \gamma = 0\)
- \(H_1 : \gamma \neq 0\)

If \(\gamma = 0\) means the time series data is not stationary and vice versa if \(\gamma \neq 0\) then the time series data is stationary. The output produced in the form of statistical values and critical values of 1%, 5% and 10%. The formula used to find statistical values is :

\[
t = \frac{\gamma - \gamma H_0}{SE \gamma^*}
\]

Source: [6]
To get conclusions done by looking at and comparing the critical value with the existing statistical value (critical value and statistical value in absolute / absolute value). If the statistical value is smaller than the critical value, the null hypothesis cannot be rejected, which means the data is not stationary. If the statistical value is greater than the critical value, the null hypothesis is rejected, which means the data is stationary. Data that is not statistically carried out the process of differentiation (differentiation) level 1, if the data is still not stationary continued differentiation of level 2 and so on to get stationary data.

2.2. Cointegration test
Cointegration test in this study uses method by Johansen [7]. The conclusions obtained in the Johansen cointegration test can be used by means of the trace statistic value compared to the critical value. If the trace statistic value is greater than the critical value, there will be cointegration of the tested variables.

\[
\Lambda_{\text{trace}} = -T \sum_{k=1}^{\infty} \ln (1 - \lambda_i) \quad (3)
\]

Explanation:
- \(k = 0, 1, \ldots, n-1\)
- \(T = \) Number of observations used
- \(\lambda_i = \) Estimated value of the 1st order eigenvalue from matrix II

source : [7]

2.3. Causality test
According to Engle [8] if the two variables are proven to be integrated with the previous cointegration test, it is necessary to know the relationship between these variables with the causality test.

1. The relationship between rice production (B) and rice import (M)

\[
\Delta B_t = a_0 + \sum_{i=1}^{n} \beta_B \Delta B_{t-1} + \sum_{i=1}^{n} \beta_M \Delta M_{t-1} + \pi_1 \text{ect}_{t-1} + \epsilon_t \ldots \ldots \quad (4)
\]

\[
\Delta M_t = a_0 + \sum_{i=1}^{n} \beta_M \Delta M_{t-1} + \sum_{i=1}^{n} \beta_B \Delta B_{t-1} + \pi_1 \text{ect}_{t-1} + \epsilon_t \ldots \ldots \quad (5)
\]

Explanation:
- B_t = Total Production in Indonesia in the t-period (Ton)
- B_{t-1} = Total Production in Indonesia in the previous period (Ton)
- D_t = The value of Indonesia's foreign exchange reserves in the t-period (US$)
- D_{t-1} = The value of Indonesia's foreign exchange reserves in the previous period (US$)
- M_t = The value of Indonesia's rice imports in the t-period (US$)
- M_{t-1} = The value of Indonesia's rice imports in the previous period (US$)
- a_0, \beta_B, \beta_M = \) Coefficient
- ect = Error Correction Term

source : [9]

2.4. ECM (error correction model) test
Error Correction Model is applied in econometrics analysis for time series data because the ability of ECM to cover many variables to analyze long-term economic phenomena and study consistent empirical models with econometrics theory, as well as in the search for solutions to non-stationary time problems and spurious regression in econometric analysis.

1. The relationship between rice production (B) and rice import (M)

\[
\Delta B_t = \alpha_B \beta_B B_{t-1} + \sum_{i=1}^{p-1} \xi_B \Delta B_{t-1} + \nu_B + \epsilon_t \ldots \ldots \quad (7)
\]

\[
\Delta M_t = \alpha_M \beta_M M_{t-1} + \sum_{i=1}^{p-1} \xi_M \Delta M_{t-1} + \nu_M + \epsilon_t \ldots \ldots \quad (8)
\]
2. The relationship between foreign exchange (D) and rice import (M)

\[ \Delta D_t = \alpha_D \beta_D D_{t-1} + \sum_{i=1}^{P-1} \gamma_D \Delta D_{t-1} + v_D + \varepsilon_t \ldots \ldots \] (9)

\[ \Delta M_t = \alpha_M \beta_M M_{t-1} + \sum_{i=1}^{P-1} \gamma_M \Delta M_{t-1} + v_M + \varepsilon_t \ldots \ldots \] (10)

Where:

- \( B_t \) = Total Production in Indonesia in the t-period (Ton)
- \( B_{t-1} \) = Total Production in Indonesia in the previous period (Ton)
- \( D_t \) = The value of Indonesia's foreign exchange reserves in the t-period (US$)
- \( D_{t-1} \) = The value of Indonesia's foreign exchange reserves in the previous period (US$)
- \( M_t \) = The value of Indonesia's rice imports in the t-period (US$)
- \( M_{t-1} \) = The value of Indonesia's rice imports in the previous period (US$)
- \( \alpha, \beta, \gamma, \nu \) = Coefficients
- \( \varepsilon \) = Equation error
- \( t \) = Time trend

Source: [7]

3. Result and discussion

This study uses several variables, namely the rice production variable (B), the foreign exchange reserve variable (D) and the rice import variable (M) with the time series data type. The data used are from 1990-2018. The rice production variable is the data on the amount of rice produced annually by Indonesian farmers which is calculated in tonnes per year sourced from the Indonesian Central Statistics Agency. The variable of foreign exchange reserves is savings or state assets held by the central bank which are calculated in units of US$ per year and obtained from Bank Indonesia. The rice import variable is the total value in the form of money spent to import rice from other countries which is calculated in units of US$ per year and obtained from Comtrade. Data on the amount of rice production, foreign exchange reserves and the value of rice imports is shown in figure 1 below:

![Figure 1](image_url)  
*Figure 1. Number of rice production, Foreign reserves and value of rice import. LnB: amount of rice production (ton/year). LnD: amount of foreign exchange (US$/year). LnM: Amount of rice import (US$/year).*
The chart above shows the different patterns/trends on the three variables. On the graph can be seen that the amount of rice production has not fluctuated. The amount of production increased slowly starting from 1990 as many as 28,923,436 tons until in 2018 it had reached 53,136,600 tons. The increase in rice production that occurs is the result of the consistency of the rice production increase program, through the help of seeds, accompaniment, agricultural machinery, reservoirs and price guarantees for farmers. The majority of rice production in Indonesia is produced by small farmers, while that produced by large private and non-private companies is only a small part of the total national rice production.

Similarly, foreign exchange reserves have increased continuously every year. The increase in foreign exchange reserves can be seen from the value in 1990 of US $ 8,656,793,062 and increased until 2018 to reach US $ 120,654,000,000. In 2017 an increase in foreign exchange reserves caused by several factors, namely the withdrawal of government foreign borrowing, foreign exchange earnings derived from tax and foreign exchange earnings from the government's share of oil and gas exports, and the results of the auction of Bank Indonesia Securities (SBBI) foreign exchange. The position of foreign exchange reserves that continues to increase is inseparable from the good macroeconomic conditions of Indonesia. Bank Indonesia assesses that increasing foreign exchange reserves will be able to support the resilience of the external sector and maintain macroeconomic and financial system stability.

The trend of foreign exchange reserves is seen to continue to increase, but there have been a number of times decreased as in 2013 amounted to US $ 13,410,800,219 from 2012. Likewise in 2015 also decreased by US $ 5,933,758,059 from 2014. The decline in foreign exchange reserves was caused by The two main things, namely the expenditure for the payment of government foreign debt and the use of foreign exchange in stabilizing the rupiah exchange rate in accordance with its fundamentals due to the strengthening value of the US dollar, by stabilizing the exchange rate will aim to support the preservation of macroeconomic and financial system stability.

Unlike the case with rice imports, it is seen that every year the value of rice imports experiences fluctuations or unstable changes. Based on the graph, Indonesia imported the highest rice in 2011, which was US $ 1,513,163,507. During 2011, the amount of imported rice that entered Indonesia was 2.75 million tons with Vietnam as the largest rice exporter with 1.78 million tons. Apart from Vietnam, there are Thailand which is the second largest rice exporter country with 938.7 thousand tons exported to Indonesia and several other countries such as China and Pakistan which are the countries of origin of rice imports in Indonesia.

Data from the Ministry of Agriculture shows that the trade balance of rice always experienced a deficit during 1983-2016, except in 1993 which succeeded in recording a supply weighing 339 thousand tons. This is what caused Indonesia to import rice at least compared to other years which only cost US $ 7,196,264. Although Indonesia is a rice importer, Indonesia actually also exports small volumes of rice. Indonesia's rice exports reached their highest peak in 1993 with a total of 342 thousand tons being exported.

3.1. Data stationarity test

The data used in this research is time series data, which consists of 3 variables, namely rice production, foreign exchange reserves and the value of rice imports. The three variables must have a stationary nature so that the data can be used according to the needs of the analysis. The results of the data stationarity test from the results of this study are as shown in Table 1.

Based on Table 1, it can be seen that the rice import variable (IMM) is stationary at the level level (zero order) is shown on the statistical value on the ADF test that is -3.993 and on the Philip-Perron Testnamely -3.937, greater than the critical value of 1%, namely -3.770. Level level (zero order) is the designation or symbols that show a data that is not carried out differentiation process. As for the data the differentiation process carried out will be given a symbol of order n where n is the number of times the process the differentiant is carried out. But the other two variables, namely rice production (lnB) and foreign exchange reserves (lnD) are data which is not stationary at the level level (zero order) because the value of the two statistical tests is smaller than the value critical there is. This is indicated by the statistical value of lnB in the ADF Test that is 0.954 and in Philip-PerronThe test is 1,710 and the statistical value of lnD in the ADF
Test shows the number -1,154 and in the Philipron Test is -1,236. After differentiation the results are obtained that the variable lnB and Stationary IND in the first order (first differences) in both the ADF Test and the Philip-Perron Test. This matterindicated by the lnB statistical value in the ADF Test which is -5.506 and in the Philip-Perron Test which is -5.583 also the lnD statistical value in the ADF Test shows a score of -5.971 and in the Philip-Perron Test of -6.219.

Table 1. Data stationarity test results.

| Variable | Level | Difference | Explanation       |
|----------|-------|------------|-------------------|
|          | ADF test | Philips-Perron test | ADF test | Philips-Perron test |
| lnB      | 0.954  | 1.710      | -5.506***    | -5.583***    | Stationary in Order I | Stationary in Order I |
| LnD      | -1,154 | -1,236     | -5.971***    | -6.219***    | Stationary in Order I | Stationary in Order I |
| lnM      | -3.993*** | -3.937*** | -    | -    | Stationary in Order 0 | Stationary in Order 0 |
| Critical value | 1% | 5% | 10% |
|          | -3.770  | -2.992      | -2.628        |

Source: data processed, 2018

If the average and variant values of the time series data used do not change constantly it is called stationary data. Based on the results of the stationarity test conducted, it was found that the three variables, namely rice production, foreign exchange reserves and the value of rice imports, have stationary time series data. If the data is stationary then it can be continued to the analysis that you want to do next.

3.2. Johansen method cointegration test

Based on the research results, it shows that there has been a cointegration between domestic rice production and rice imports in Indonesia. This is in accordance with the results of the Johansen Method Cointegration Test as shown in table 2 below.

Table 2. Results of the Johansen method cointegration test on rice production (lnB) and rice import value (lnM).

| Rank | Eigenvalue | Trace statistic | 5% Critical value |
|------|------------|----------------|------------------|
| r = 0 | 0.45041    | 17.5957        | 15.41            |
| r = 1 | 0.05172    | 1.4339*        | 3.76             |

Source: Data processed, 2018

Note: * shows rank position

Based on table 2 it can be explained that the results of Johansen's co-integration test on lnB and lnM indicates that Ho is rejected and Ha accepted, which means that co-integration occurs at the 95% confidence level which is indicated by the value of trace statistics, i.e. 17.5957 is greater than the critical value of 15.41. This is also evidenced from at least one equation co-integration is also shown in rank (r = 1) between rice production (lnB) and rice import value (lnM).

The co-integration between rice production and rice imports in Indonesia is caused by a large number demand for rice in Indonesia. Rice demand in Indonesia consists of household consumption and outside household consumption. Demand for consumption in a household is interpreted as a lot demand for rice by individual or household. While consumer demand outside the home. A ladder is defined as a demand for rice by a company such as a restaurant, hospital, hotel and rice stock for Bulog. Therefore, the continuing increase in population in Indonesia will be causing rice demand to increase.
Co-integration of rice production and imports can occur due to the limited amount of local production which is the government's stock, so that the rice stock has not been able to meet total consumption. Based on the Central Statistics Agency, in meeting people's consumption needs, the amount of domestic rice production is categorized as surplus or excess. However there is a public company that is called Bulog, which has the responsibility of improving the stabilization and management of the supply of staple foods and food. If the amount of domestic rice production is also used for procurement of rice stocks at Bulog, the amount of domestic rice production will experience limited quantities and will not be able to meet the total consumption needs. If rice is limited, the price in the market cannot be controlled, so that the policies carried out by the government are in handling it the problem of shortage of rice in a relatively fast time is to import rice.

The variable of foreign exchange reserves with rice imports does not occur cointegration, this is in accordance with the results of the Johansen Method cointegration test as shown in table 3 below.

Table 3. Results of the Johansen cointegration test on the value of foreign exchange reserves (InD) and the value of rice imports (lnM).

| Rank | Eigenvalue | Trace statistic | 5% Critical value |
|------|------------|-----------------|-------------------|
| r = 0 | 13,5373* | 15,41 | |
| r = 1 | 0,38156 | 0,5623 | 3,76 |
| r = 2 | 0,02061 | | |

Source: data processed, 2018
Note: * shows rank position

Based on table 3 it can be explained that the results of the Johansen cointegration test on lnD and lnM indicated that there was no cointegration as indicated by the total rank (r = 0) between foreign exchange reserves (lnD) and the value of rice imports (lnM). This conclusion is also supported by the results of statistical tests which show that at the 95% confidence level, a trace statistic value of 13.5373 is obtained, this figure is smaller than the critical value of 15.41. There was no cointegration between foreign exchange reserves and rice imports due to the lack of use foreign exchange reserves for rice imports. Rice import is an import activity whose scope is still very high-small compared to other import activities. So that the use of foreign exchange reserves Rice imports are very small compared to the total foreign exchange reserves. This is the one causing foreign exchange and import of rice does not have a stable relationship / balance in long-term.

3.3. Causality test results

The causality test meant in this study is a test of whether there is a causal and reciprocal relationship between 2 variables, in this case, between rice production and the value of rice imports. To find out whether there is a causal relationship between the two variables, it can be seen in the results of the causality test as shown in table 4 below.

Table 4. Granger method causality test results.

| Parameter | Rice production (lnB) | Value of rice imports (lnM) | Causality results |
|-----------|-----------------------|-----------------------------|-------------------|
| Relation (β) |                        |                             | Two-way Relationship |
| LnB t-1   | 0,000***              | 0,002**                     | (lnB ↔ lnM)       |
| LnM t-1   | 0,062*                | 0,066*                      |                   |

Source: Data processed, 2018
Note: * significant at α = 10%; ** significant at α = 5%; *** significant at α = 1%
Based on table 4, the lnB variable shows that the value of $\beta$ at $B_t - 1$ is 0.000 significant at $\alpha = 1\%$, and the value of $\beta$ at $M_t - 1$ is 0.062 significant at $\alpha = 10\%$. This means that the amount of rice production can affect the value of rice imports. Next to the lnM variable shows that the $\beta$ value at $B_t - 1$ is 0.002 significant at $\alpha = 5\%$ and the $\beta$ value at $M_t - 1$ is 0.066 is significant at $\alpha = 10\%$. This also means that the variable value of rice imports can affect the amount of rice production. So that the cointegration equation variable ln B and lnM shows a two-way relationship, which means the amount of rice production (lnB) affects the amount of rice production (lnB).

The results of the causality test also state that rice production and the value of rice imports have a two-way relationship which means the amount of rice production causes how much the value of rice imports and the value of rice imports also causes the amount of rice production. Rice imports can influence the level of rice production interpreted as a lack of dependence on imports if domestic rice production is getting higher. If the import value is small at a time it means the amount of rice production at that time had a higher yield. Therefore, a way is needed so that rice production continues to increase through increasing the productivity of rice farming and expanding the planting area. Increased rice production produced by Indonesian farmers will provide a good impact with the fulfillment of sufficient food needs for the community both quantity and quality thereby reducing the likelihood of a food security crisis.

3.4. Error correction model test results
The long-term and short-term balance relationship between the 2 variables can be assessed through the ECM (Error Correction Model) test. The results of the ECM test between rice production and rice import value in Indonesia are as shown in table 5 below.

Table 5. Estimation of VECM rice production and value of rice import.

| Estimation parameter | Rice production (lnB) | Value of rice import (lnM) |
|----------------------|-----------------------|---------------------------|
| Long-term balance relationship ($\beta$) | -4.421*** | 1 |
| Adjustment speed ($\alpha$) | -0.008*** | -0.771*** |
| Short-term Relationship ($r$) | | |
| LnB | | |
| t-1 | -0.062*** | -22.255*** |
| LnM | | |
| t-1 | 0.015** | 0.096* |

Source: data processed, 2018
Note: * significant at $\alpha = 10\%$; ** significant at $\alpha = 5\%$; *** significant at $\alpha = 1\%$

Based on table 5, it indicates that the cointegration equation model is good. Equation Good cointegration is expressed as an indication of the long-term equilibrium between productionrice and the value of rice imports in Indonesia. Table 5 also explains that when predicted from the equation the integration is positive, the value of rice imports is above the equilibrium line because the coefficient of lnM is positive while the estimation of the adjustment speed ($\alpha$) at lnB is -0.008. It means when value rice imports are above equilibrium, so the amount of rice production in Indonesia will adjust to equilibrium with an adjustment speed of -0.008. In table 5 also explains that between production and the value of rice imports has a short-term relationship.

ECM test results, it was found that between rice production and rice imports in Indonesia there is long term and short term relationships. Short-term relationship obtained is interpreted as Rice production and rice imports will adjust to each other to achieve balance in the long run long. In adjusting the long-term balance can be known speed adjustment. The speed at which rice production is adjusted towards long-term equilibrium is as large as its coefficient which is -0.008. This is interpreted as the speed of adjustment of rice production towards the import balance of -0.008.

This research shows that there is a cointegration between rice production and rice import because the amount of rice produced by farmers makes it one of the contributing factors Indonesia needs to import rice.
This is in accordance with research conducted by Azhar and Chalil [10] which states that between rice production and rice imports with a time lag of 2 seasons planting there is a real relationship and inversely proportional. Factors that cause these relationships is feared that in the long run, rice production has not been able to meet the needs North Sumatra residents. Then the steps taken by the North Sumatra Bureau of Logistics North Sumatra isrice imports from other countries to strengthen stock. Rice imports are not only for secure needs but also for the benefit of national rice. With rice stocks maintained will reduce inflation which will occur where the price of rice will be a trigger for inflation in North Sumatra.

Based on previous research that examines the effects of prices, foreign exchange reserves, and quantities population of Indonesian rice imports using the technique Multiple linear analysis shows that the foreign exchange reserve variable partially influences and significant impact on Indonesia's rice imports in the period 1997-2012 [3]. However, this study shows the results. The difference is that there are no long-term relationships or short-term relationships analyzed using the Johnsen's cointegration test. This is caused by the method used [3] unable to capture the relationship between the two variables significantly.

4. Conclusion
Based on the results of the discussion shows that there is a cointegration equation between numbers rice production and import. This equation has a two-way relationship, which means the amount of production rice affects the value of rice imports and so does the value of rice imports also affects the amount of rice production and this equation also have a short-term and long-term relationship. While there is no cointegration between foreign exchange reserves and rice imports in Indonesia, which means no there is a long-term relationship so that the causality test and the ECM test are not followed.

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