Analysis of factors influencing Thai rice trade based on Gravity model

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Abstract. The purpose of this study is to analyse what factors influencing Thai rice export including importers' GDP, exporters of GDP, distance of the countries, international rice prices, production and exchange rates by using the gravity model approach. The results show that the factors that influence rice exports in Thailand include the GDP of the importing country, the GDP of the exporting country, distance, international rice prices, production and the real exchange rate. Factors that have positive coefficients are importers' GDP and real exchange rates, while those with negative coefficients are exporters' GDP, rice prices, production and distance. Positive coefficients include importer's GDP and Real Exchange Rate. The GDP of the importing country has a positive coefficient of 0.73 and the real exchange rate or RER (Real Exchange Rate) has a positive coefficient of 0.73. In addition, the negative coefficient values include exporters' GDP, rice prices, production and distance. The exporting country's GDP has a negative coefficient of 0.98, prices have a negative coefficient of 1.37 and production has a negative coefficient of 0.23 and distance has a negative coefficient of 0.3.

1. Introduction
Rice is a staple food and the main source of calories for rural communities and a source of food security. Rice also has an important role in the commodity that generates wages for workers in the agricultural and non-agricultural sectors [1]. 9 of the 10 largest rice producing countries in the world are Asia. Thailand is the three largest exporters in the world for decades, most of the Thailand's population is empowering the agricultural sector, where 50% of agricultural land in Thailand is devoted to producing rice and 55% of the rice produced is used for domestic consumption and the remaining 45% is used for export to various countries. country, rice exports in Thailand accounted for 20% of the country's total revenue. The determination of exports made by Thailand considers various factors including population.
growth, world rice stocks, consumption levels, total production, and so on [2]. Thailand exports rice to various countries in the world, such as Asia Aggregation, China, Japan, Hong Kong, Singapore, Yemen, Indonesia, Philippines, Malaysia, Lao People's Democratic Republic, Israel and so on. The following is the development of rice exports in Thailand to various importing countries, which can be seen in table 1 [3].

Table 1. Development of rice exports in Thailand to importing countries in 2010-2020 (tons/year).

| Importers          | 2016      | 2017      | 2018      | 2019      | 2020      |
|--------------------|-----------|-----------|-----------|-----------|-----------|
| World              | 9,883,289 | 11,628,303| 11,075,346| 7,580,431 | 5,688,868 |
| Asia Aggregation   | 3,559,540 | 4,169,295 | 4,621,878 | 2,265,910 | 1,645,962 |
| China              | 1,033,503 | 1,199,737 | 1,001,812 | 471,339   | 381,363   |
| Hongkong, China    | 325,436   | 347,466   | 222,511   | 266,601   | 258,677   |
| Singapore          | 207,362   | 223,200   | 188,563   | 169,848   | 175,540   |
| Yemen              | 127,593   | 123,203   | 104,233   | 96,724    | 127,296   |
| Indonesia          | 58,726    | 149,440   | 178,064   | 185,503   | 121,298   |
| Philippines        | 400,010   | 129,158   | 809,017   | 61,140    | 89,406    |
| Malaysia           | 308,726   | 291,723   | 1,027,964 | 327,722   | 79,608    |

Source: [3]

Table 1 shows that Thailand's rice exports to various importing countries in the world are volatile. Asia is the largest importing country for rice from Thailand. Data shows that 1.6 million tons in 2020 is the volume of rice exports carried out by Thailand. The lowest volume of rice exports was to Malaysia at 79,608 tons. Various export policies for agricultural products are often applied, such as export taxes, export quotas, exorbitant exchange rates, and tariffs. The purpose of implementing the policy is of course to correct market failures such as imperfect market information, ensure food security for the poor, and increase income for national development goals. The Thai government implements an increase in export taxes reflecting a shift in the political balance and can benefit farmers [4]. In importing countries, rice is a staple food, and this is important in line with the rate of increase in consumption accompanied by an increase in population. As in Indonesia, the government determines policy steps to maintain sufficient national rice reserves for the next one to three months of 3-5 million tons. The rice reserves are useful for addressing emergency needs such as natural disasters, famine, and maintaining the stability of domestic food supply and prices [5]. Importing countries in fact still apply many barriers to free trade between countries, these barriers are closely related to the practice and commercial interests of each country, protection is shown to protect domestic production against competition for imported goods in the domestic market. In addition, setting tariffs on imported goods is also one of the barriers to international trade [6]. Several factors that can affect export and import activities in the rice trade, both in the short and long term, include import factors in the previous year and income. Income has an elasticity of 13.5 and is moderately elastic. That is, if income increases by 1%, then rice imports will increase by 13.5%. In the short term, the elasticity of imports in the previous year was 0.77% (inelastic) while in the long term it was 0.40%. This means that every 1% change in the number of rice imports in the previous year will be responded to by the following year's rice imports of 0.77% [7]. In addition, the rice export factor is also influenced by the availability per capita and the exchange rate and imports are influenced by production, world rice prices and real national income [8]. From these various descriptions, it is important to know what factors influence rice exports in Thailand.
2. Methodology

2.1. Data
The data used is secondary data, namely time series panel data from 2010 to 2019. The types of data used include data on rice exports, Thailand's GDP, importing country's GDP, exchange rates, distances, world rice prices and production. Data were taken from several sources, including the ASEAN Statistics Database, International Trade Centre (ITC), World Bank, FAO, USDA, World Integrated Trade Solution (WITS). Rice export data used is data on rice exports in Thailand and does not specify data on certain types of rice, rice price data used is 5% broken rice data.

2.2. Data analysis method
The method used in this research is descriptive and quantitative. Descriptive analysis is used to describe rice exports in Thailand to importing countries. Data analysis was carried out using a time series panel data gravity model approach from 2010 to 2019.

2.3. Gravity model analysis
Gravity analysis is an analysis of the impact of preferential agreements in bilateral flows. This model was introduced by Tinbergen [9] who analysed trade flows in European countries, and the latter was introduced by Anderson [10], dan Sanso et al [11] known as theoretical basis. The gravity model explains the volume of trade between two countries i and j in terms of income, population and transportation costs of these countries. The gravity model simply describes the trade between countries i and j. Trade between country i and country j is proportional to the size of the economy and inversely proportional to distance, which is a proxy for transportation costs between the two countries. In general, it can be described as follows:

\[ x_{ij} = A \frac{Y_i Y_j}{D_{ij}} \]  

(1)

Where, \( x_{ij} \) is the rice trade between country i and country j. \( Y_i \) is GDP per capita for country i and \( Y_j \) for country j. \( D_{ij} \) is the geographical distance between the two countries which is often measured using the great circle. The model used is that the imports of country i from country j depend on gravity variables such as GDP per capita and distance. The basic specification of the gravity equation includes the factors of the importing country e.g., GDP per capita. The supply factor of the exporting country eg GDP per capita and also geographical distance as a proxy for transportation costs. The gravity equation can simply be formulated as follows:

\[ \ln M_{ijt} = \beta_0 + \beta_1 \ln PDB_{it} + \beta_2 \ln PDB_{jt} + \beta_3 \ln DIST_{ij} + U_{ijt} \]  

(2)

Where, \( M_{ijt} \) is the trade import between country i and country j. \( PDB_{it} \) is GDP for country i and GDP \( PDB_{jt} \) for country j in year t. \( DIST_{ij} \) is the geographical distance between the two countries. It is necessary to test the gravity model for bilateral trade analysis, test the assumption of panel data to find out the estimated bias. If the model selected in the Hausman test is REM, then the model estimate is assumed to be the best linear unbiased estimator (BLUE) so there is no need to test the three main assumptions of the BLUE model (non-multicollinearity, homosedasticity, and non-autocorrelation). Testing of model parameters is carried out to determine the feasibility of the model where to know whether the estimated coefficients are in accordance with the theory or hypothesis. The tests carried out include the coefficient of determination (R2), the overall regression coefficient test (F-test/F test) and the partial regression coefficient test (t test).
2.4. Modeling
The specification of the model used in the study refers to the gravity model used by Thuong [12]. Thuong's model uses gravity analysis in his research entitled "The effect of sanitary and phytosanitary measures on Vietnam’s rice exports" which defines bilateral exports as a function of GDP, population, distance, land, production, price ratio, tariffs and SPS for the period 2000-2015 with using data on Vietnam's rice exports to 20 major rice importing countries. This research model includes several variables including the GDP of the exporting country, the GDP of the importing country, distance, production, price and Non-Tariff Measures. The rice export factor model in Thailand can be seen in the following equation:

\[
\ln X_{ijt} = \beta_0 + \beta_1 \ln GDPX_{it} + \beta_2 \ln GDPM_{jt} + \beta_3 \ln DIST_{ij} + \beta_4 \ln RER_{jt} + \beta_5 \ln PROD_{jt} + \\
\beta_6 \ln PRICE_{jt} + \epsilon_{ijt}
\]  

(3)

Where:

- \(i\): Thailand (Exporter)
- \(j\): Importer
- \(\ln X_{ijt}\): Volume of rice exports from Thailand to Indonesia in the t-year natural log (ln) (tons/year)
- \(\ln GDPX_{it}\): Exporting country GDP year t, in natural log (ln) (US Dollar)
- \(\ln GDPM_{jt}\): GDP in rice importing countries year t, in natural log (ln) (US Dollars)
- \(\ln DIST_{ij}\): Economic distance of rice trade between Thailand and Indonesia, in natural log (ln)
- \(\ln RER_{jt}\): Real exchange rate of importing country against US Dollar in year t, in natural log (ln) (Rp/US$)
- \(\ln PROD_{jt}\): Total production in importer in year t, in natural log (ln) (tons/year)
- \(\ln PRICE_{jt}\): World rice prices (Thailand 5%) in natural log (ln) (US$/ton)
- \(\beta_0\): Constant/intercept
- \(\beta_{1,2,3,4,5,6}\): Estimated parameters
- \(\epsilon_{ijt}\): Error term

3. Results and discussion
World rice trade continues to grow along with the need for rice consumption in various countries which requires a country to import or export to other countries. Various rice export policies in a country were formed, namely to meet domestic consumption needs first from the production of rice produced. If a country experiences a surplus of production and domestic consumption has been met, then the country exports rice to other countries. Thailand is a world rice exporting country, Thailand's population is empowering the agricultural sector, where 50% of agricultural land in Thailand is devoted to producing rice and 55% of the rice produced is used for domestic consumption and the remaining 45% is used for exports to various countries. Thailand accounts for 20% of the country's total revenue. Thailand's rice exports to all countries in the world averaged 16.135 billion tons from 2008 to 2012. On average, Thailand's rice exports reached 4.62 billion tons to various countries including Vietnam, India, Pakistan, and the United States.

Thailand exports rice to various countries such as China and the Philippines. China is a country with high rice consumption in the world. China consumes an average of 2 million tons of rice per year, China has a large population that requires a high import of rice every year. There are various influencing factors such as domestic rice production, the amount of production, and fluctuations in rice prices. Likewise in the Philippines, rice is a very important agricultural product because rice is a commodity used to meet domestic food needs. The Philippine government is responsible for meeting domestic food needs as well as managing rice reserves for the provision of rice in emergency conditions such as natural disasters, price stability. In addition, the Philippine government in the long term also increases food production...
by increasing food self-sufficiency so as to achieve the goal of minimizing imports from abroad to 0% and 1% (Ma Jiacheng, 2018).

Thailand is a country with unique climatic conditions, Thailand is a country that has the largest rice-producing potential in the world where the Chao Phraya Plain is a vast and fertile plain famous for growing rice and tropical fruits which covers 50% of the land area of Thailand. Thailand is a country that has great competitiveness in the export of agricultural commodities, especially rice with a market share in 2011 of 0.09% and has a comparative advantage of 20% with the largest export index value. As the largest exporting country, Thailand is a country that has a low level of rice consumption, which totals less than 20%. Various policies by the Thai government were also formed, one of which is to reduce the cost of domestic rice production which includes transportation costs and production costs, this is because cost is the main factor to limit the competitiveness of the Thai rice market. The main policy carried out by the Thai government is to reduce production costs, strengthen promotion, provide knowledge about plant fertilization, conservation and reduce production equipment costs. Policy in ensuring the quality of rice quality in the international market, the Thai government establishes a set of procedures for checking the quality of rice quality related to export instruction documents, packaging, and rice quality provided that the proportion of rice mixed with other varieties does not exceed 8%.

Thailand's main rice export markets, such as China, Japan, the United States and Nigeria, which require rice imports from Thailand every year through sustainable economic development, continue to increase demand for rice so that several countries continue to depend on rice imports from Thailand. Although Thailand is not the only rice exporter, it still must maintain good relations to maintain market share between exporting and importing countries. The results of the analysis show that Thailand exports rice to various countries such as Australia, Cameroon, China, Cot Divoire, Ghana, Indonesia, Japan and Malaysia. Rice trade to various importing countries is influenced by several factors with a real level of 10%, including importers' GDP, exporters' GDP, prices, production, distance and exchange rates. The results of the estimation of the factors that influence rice exports in Thailand can be seen in Table 2 below.

| Variable                  | Coefficient | Std. Error | t-Statistic | Prob.  |
|---------------------------|-------------|------------|-------------|--------|
| LNGDPM (GDP Importir)     | 0.731180    | 0.238545   | 3.065162    | 0.0030 |
| LNGD PX (GDP Eksporir)    | -0.981714   | 0.603733   | -1.626071   | 0.1082 |
| LNP RICE (Harga Beras)    | -1.378992   | 0.586875   | -2.349722   | 0.0215 |
| LNPROD (Produksi)         | -0.230709   | 0.092290   | -2.49882    | 0.0147 |
| LNRER (Nilai Tukar Riil)  | 0.736481    | 0.684453   | 1.076014    | 0.2855 |
| LNDIST (Jarak)            | -0.376675   | 0.197885   | -1.903499   | 0.0609 |
| C                         | 28.31626    | 18.06731   | 1.567265    | 0.1214 |

R-squared: 0.190908  
F-statistic: 2.870767  
Prob(F-statistic): 0.014430

Based on the estimation results in table 2, the rice export factor variables have a significant effect at the 10% level. The GDP of the importing country has a positive coefficient of 0.73 this indicates that every 1 percent increase in GDP will increase Thailand's export volume by 0.73 percent. The better the aggregate capacity of Thailand, the better its ability to export rice. The increase in income that occurs in importing countries will increase rice exports in Thailand. This indicates that an increase in a country's income will have a positive effect on the increase in demand for rice or export commodities. The GDP of exporting countries has a negative coefficient of 0.98, this indicates that the size of Thailand's rice exports to importing countries decreases by 0.98 percent if there is a decrease in GDP by 1%.
Export costs or proxy costs as transportation costs in this study are measured using the economic distance of a country, distance is one of the important measures in the gravity model. The magnitude of the economic distance affects the rice export trade, the estimation results show that the DIST variable or distance has a negative variable coefficient value of 0.37. This indicates that if the distance to the destination of rice exports from Thailand is far away by 1%, it will reduce rice exports by 0.37%. In accordance with the theory that distance greatly affects the flow of trade, the farther the distance of rice exports from Thailand to the importing country, the greater the transportation costs in trading rice from Thailand.

Price is one of the factors that affect the demand for goods in a country. If the price of rice in the international market increases, the rice producing country will be able to increase its production, but if the price in the international market decreases, it will increase the demand for goods in the importing country and have an effect on increasing exports. The results of the analysis show that the price has a negative coefficient of 1.37. This indicates that if prices in the international market increase by 1%, the volume of rice exports will decrease by 1.37%. In addition to the price, the factor that influences Thailand's rice exports is rice production in the importing country. Domestic production of an importing country has a negative relationship to the volume of imports of a country. That is, if domestic production increases, the volume of imports will decrease, and vice versa if production decreases, the amount of rice imported will increase and affect rice exports from exporting countries. Production is an activity to increase or add value to a product or an item that is shown to satisfy other people through the process of exchanging goods. The results of the analysis show that production has a negative variable coefficient value of 0.23%. This shows that if production in the importing country increases by 1%, it will reduce rice exports by 0.23%.

The real exchange rate or RER (Real Exchange Rate) has a positive coefficient of 0.73. If the real exchange rate in the importing country appreciates against the dollar, the price of rice commodities in Thailand becomes cheaper so that purchasing power in the international market increases demand in international trade. This shows that if there is an increase in the real exchange rate by 1%, it will increase rice exports from Thailand by 0.73%. In international trade, it is important to identify the factors that influence trade or exports and imports of rice between countries, so that a country can determine good trade policies.

4. Conclusions

Based on the description above, it can be concluded that the factors that influence rice exports in Thailand include the GDP of the importing country, the GDP of the exporting country, distance, international rice prices, production and the real exchange rate. Factors that have positive coefficients are importers' GDP and real exchange rates, while those with negative coefficients are exporters' GDP, rice prices, production and distance. Positive coefficients include importer's GDP and Real Exchange Rate. The GDP of the importing country has a positive coefficient of 0.73 this indicates that every 1 percent increase in GDP will increase Thailand's export volume by 0.73 percent. The better the aggregate capacity of Thailand, the better its ability to export rice. The real exchange rate or RER (Real Exchange Rate) has a positive coefficient of 0.73. If the real exchange rate in the importing country appreciates against the dollar, the price of rice commodities in Thailand becomes cheaper so that purchasing power in the international market increases demand in international trade. This shows that if there is an increase in the real exchange rate by 1%, it will increase rice exports from Thailand by 0.73%. In addition, the negative coefficient values include exporters' GDP, rice prices, production and distance. The GDP of exporting countries has a negative coefficient of 0.98, this indicates that the size of Thailand's rice exports to importing countries decreases by 0.98 percent if there is a decrease in GDP by 1%. The price has a negative coefficient value of 1.37. This indicates that if prices in the international market increase by 1%, the volume of rice exports will decrease by 1.37%. The production variable has a negative variable coefficient value of 0.23%. This shows that if production in the importing country increases by 1%, it will decrease rice exports by 0.23% and the distance variable has a negative variable coefficient.
value of 0.37. This indicates that if the distance to the destination of rice exports from Thailand is far away by 1%, it will reduce rice exports by 0.37%.

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