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Asymmetric Effect of Macroeconomic Variables on Rice Prices

Sri Herliana
Institut Technologi bandung
Jl.Ganesha 10 Bandung, Jawa Barat Indonesia
Correspondence email: sri.herliana@sbm-itb.ac.id

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ABSTRACT

Rice price movements are basically influenced by movements in macroeconomic variables. This paper analyzes whether there is an asymmetric effect of macroeconomic variables on rice prices in Thailand as the largest rice exporter in ASEAN. In analyzing the asymmetric effects of macroeconomic variables (inflation and exchange rates) on rice prices in ASEAN countries, data on rice prices, exchange rates and inflation are used. This study focused on Thailand, one of the ASEAN exporting countries. The type of data used is monthly time series data with a time span of quarterly data from 2015Q1 to 2019Q1. The estimation evaluation results indicate that using a nonlinear model to examine the effect of inflation and the exchange rate on rice prices is preferable to using a linear model. The Wald's test estimation results in the short term show that for the NARDL model with asymmetric effects in the long and short term, Thailand has only a significant inflation variable while the Exchange Rate is not significant. Long- term Wald test estimation results show that the NARDL model in Thailand is not significant in all models.

Keywords: Asymmetric; Macroeconomic; Rice; Export

INTRODUCTION

The movement of rice prices is a complex interplay of various economic, environmental, and geopolitical factors that have a profound impact on global food security and economic stability. Rice, as a staple food for billions of people worldwide, plays a critical role in both rural and urban economies. Agricultural development, constituting an indispensable and integrated component of overall national development, plays a pivotal and strategic role in the revitalization and recuperation of the national economy, serving as a linchpin for sustained growth and prosperity in a given nation (Nurpalina, Noer, & Kurniawan, 2022). Fluctuations in rice prices can have far-reaching consequences, affecting not only the cost of living for consumers but also the income of small-scale farmers who rely on rice production for their livelihoods. Climate change, with its unpredictable weather patterns, poses a significant threat to rice production, as droughts, floods, and extreme temperatures can disrupt harvests and reduce yields, thereby contributing to price volatility. Additionally, international trade policies, such as tariffs and export bans, can further exacerbate price swings. The challenge lies in finding a balance between ensuring affordable food for vulnerable populations and providing fair returns to rice producers. It's crucial for governments, international organizations, and stakeholders to collaborate and implement policies that promote price stability and food security while addressing the broader issues of sustainability and climate resilience in rice production.

Rice has a strategic role in strengthening food security, economic security, and national political stability (Timmer, 1996). The instability of rice prices in terms of prices, stocks, and production will affect the economy, social and politics of a country. Therefore, it is very important for the government and market players to maintain the stability of the country's rice prices themselves. Rice price movements are basically influenced by movements in macroeconomic variables. Several previous studies have stated that inflation and exchange rates are macroeconomic variables that have a major role in influencing rice price movements. Persistently high and fluctuating inflation rates can lead to a general escalation in the prices of goods and services, which, in turn, can consistently result in adverse consequences for economic growth that is hindered and impeded (Ramadhani & Nugroho, 2019). Price fluctuations become a problem when prices quickly spike very high and unpredictable, creating uncertainty for many people, particularly producers, traders, consumers, and governments. External factors that influence rice trade in the short term include the price of domestic rice, the price of imported rice, and the price of world crude oil. Long-term domestic rice prices are influenced by global rice prices, imported rice prices, and rice production.

According to Harri, Nalley, and Hudson (2009) the exchange rate can have an influence on food prices through export and import activities of goods and services. Therefore, the exchange rate can directly affect the prices of traded products. Mankiw (2007) states that when the exchange rate weakens, the price of domestic products is relatively cheaper than imported products. Imported goods will be in lower demand, while foreigners will purchase a greater proportion of our goods. As a result, the quantity demanded for exports will rise. The opposite happens when the exchange rate strengthens, the price of domestic products will be relatively more expensive than foreign products. Demand for imported products will increase, while exports will decrease. This action causes the quantity of export demand to decrease. If the exchange rate rises, or the rupiah appreciates, domestic prices will be relatively higher when compared to world rice prices. This reason can be used by the government in order to increase Indonesia's rice imports. Excess imports and large domestic supply will certainly reduce the price of rice.

The movement of rice prices is also influenced by inflation. Inflation is one of the important variables that determine the economic condition of a country. At the national or regional level, inflation can be indicative of a situation where there is a notable and persistent increase in the overall prices of goods and services within a given country or area, thereby contributing to a state of economic instability (Purwono, Yasin, & Mubin, 2020). Inflation is an increase in the price of goods and services in general and occurs continuously over a certain period of time. Various macroeconomic factors, commodity markets, and energy markets all contribute to inflation. Food inflation and non-food inflation are the two types of inflation (Walsh 2011).

In general, theories and empirical studies do not take into account the volatility of the influence of macroeconomic factors (inflation and exchange rates) on rice prices, so econometric modeling capable of capturing various asymmetric effects has begun to become the primary focus of research (Gellecom, 2014). In this study, modeling is used to examine the effect of macroeconomic variables, specifically exchange rates and inflation, on ASEAN rice prices using an asymmetric approach and the Nonlinear Autoregressive Distributed Lag (NARDL) model introduced by Shin, Yu, and Greenwood-Nimmo (2014) by comparing positive and negative effects on the explanatory variables.

The ASEAN region, which is a producer and exporter of rice as well as a rice importer, will have an impact due to shocks in macroeconomic variables. Indonesia and the Philippines still need rice imports to meet their domestic rice needs. This is because Indonesia and the Philippines have higher levels of rice consumption than their production levels. The needs of Indonesia and the Philippines in terms of rice imports are of significant importance, considering their status as two of the world's most populous nations. Both countries heavily rely on rice as a staple food, integral to their respective cultures and cuisines. The demand for rice in Indonesia and the Philippines consistently surpasses their domestic production capacities, making them dependent on imports to meet the dietary requirements of their people. These rice imports play a vital role in ensuring food security and maintaining stable prices in local markets. However, the challenge lies in balancing these imports to meet the immediate needs of their populations while also promoting domestic rice production to reduce dependence on external sources in the long run. Sustainable agricultural practices, infrastructure development, and government policies that support the rice sector are essential to ensure that these nations can safeguard their food supply chains and cope with fluctuations in global rice prices. Furthermore, addressing issues related to climate change and its potential impacts on rice production is crucial for long-term food security in both Indonesia and the Philippines.

The impact of price shocks on developed and developing countries has different effects. Food price volatility has a greater impact on developing countries that are highly dependent on agricultural products such as rice, which is a staple food. In developed countries such as the United States and European countries, energy price volatility is more influential than food price volatility (Gilbert & Morgan 2010). According to World Bank research, only 5% of global rice production is traded on international markets, indicating that rice prices are sensitive to changes in demand and supply. From the demand side, world commodity prices, per capita income, and the rupiah exchange rate can affect price changes in rice commodities.

The analysis of exchange rate movements using a symmetrical approach, which is widely used by researchers, has been able to explain the factors that affect the exchange rate, but it still has shortcomings. One of the weaknesses of the symmetrical approach is the model's inability to identify the asymmetric effect of fundamental factor relationships on the exchange rate. Several methods for analyzing asymmetric effects on exchange rate modeling that have begun to emerge include, (1) Markovswitching ARCH, to analyze whether there are asymmetric results when there is a regime change, (2) Nonlinear Error Correction Model, to determine whether there are differences in the speed of adjustment in differences in certain conditions, and (3) Nonlinear Autoregressive Distributed Lag (NARDL), to analyze whether there is an asymmetric effect between positive and negative changes on the analyzed dependent variable. This research addresses the question of whether there is an asymmetric effect of macroeconomic variables on rice prices in ASEAN rice exporting countries, as formulated in the research problem.

LITERATURE REVIEW

International Trade

International trade is defined as trade between countries that can take the form of goods or services and is governed by mutual agreements and treaties. International trade is usually carried out to increase the country's income and meet the country's needs. The extent of international trade within a nation is quantified through the assessment of the volume of exports and imports, and this arrangement proves advantageous when the value of exports surpasses that of imports, or conversely when imports exceed exports (Rahayu, 2021). Parties conducting international trade can be individuals, companies or governments. In general, international trade is defined as the process of exchanging goods between countries on the basis of mutual agreement because the country is unable to produce goods to meet its own needs. With international trade, each country will specialize based on its comparative advantage, resulting in more efficient and effective production. Countries can concentrate production on resources where they have a comparative advantage and export excess output to benefit the country.

Price Asymmetry Transmission

Asymmetric price transmission occurs when there is a difference in price response between positive price shocks (when prices rise) and negative price shocks (when there is a price decline). According to Meyer and von Cramon-Taubadel (2004), there are three criteria in the classification of asymmetry in price transmission. The first criterion refers to the condition of spatial or vertical price asymmetry transmission. The transmission of spatial price asymmetry is related to market location because an increasing price change in one parent market will be perfectly transformed to another parent market, but not a price decline. The vertical transmission of price asymmetry is related to the level of marketing in the chain, as is the difference in response to changes in international prices and domestic prices. Changes in rising international prices will be met more quickly by rising domestic prices, but not by falling international prices. The second criterion refers to the asymmetry of price transmission in terms of the amount of price adjustment and the speed of time. Price asymmetry transmission is based on magnitude. This asymmetrical phenomenon occurs when price shocks in one market are not fully transmitted by other markets.

RESEARCH METHOD

Types and Sources of Data

Data on rice prices, exchange rates, and inflation are used to examine the asymmetric effects of macroeconomic variables (inflation and exchange rates) on rice prices in ASEAN countries. This study focused on Thailand, one of the ASEAN exporting countries. The type of data used is monthly time series data with a time span of quarterly data from 2015Q1 to 2019Q1.

Data Analysis Method

The analytical method used in this study is a quantitative method. Spatial panel data regression was used to examine the spatial effects and factors influencing rice exports in the intra-ASEAN region using panel data regression analysis. The R Studio application helps with data processing.

The Nonlinear Autoregressive Distributed Lags (NADRL) model was used to identify the asymmetric effect of world oil price shocks on rice prices in the Intra ASEAN Region. Data processing was done using Microsoft Excel, STATA 13, and Eviews 10. This study employs the Autoregressive Distributed Lag (ARDL) Cointegration method with four models, one of which is Autoregressive Distributed Lag (ARDL) and three Nonlinear Autoregressive Distributed Lags (NADRL) models, to investigate the relationship between rice prices and macroeconomic factors that influence it both symmetrically and asymmetrically. Because cointegration is not stationary at the level, but only at the first difference, it is used in the four models tested. To find the best model, variations of these models are used.

The data analysis used in this study is exploratory data analysis (EDA), which is a method of data exploration that uses simple arithmetic and graphic techniques to summarize observational data. According to Nazir (1999), exploratory data analysis is an analysis in examining a group of objects, a condition, a system of thought, or a class of events in the present. The purpose of this analysis is to create a descriptive, systematic description or illustration that is factual about the occurring facts and characteristics, as well as the relationship between the occurring phenomena. The exploratory data analysis in this study takes the form of a study of the relationship between the rice price index and macroeconomic variables in several countries around the world, with different timescales in each country.

Autoregressive Distributed Lag* (ARDL) *Cointegration

The initial cointegration approach used in this paper is based on ARDL (Pesaran and Shin ,1999), which is better at determining cointegration relationships in small samples (Romilly, Song, & Liu, 2001). In addition, this method has the added advantage that it can be applied to either I(0) or I(1) regressors making it possible to draw statistical conclusions in long-term estimates. However, the linear cointegration ARDL method does not apply to I(2). The following is the Augmented Autoregressive Distributed Lag (ARDL) model according to Pesaran and Shin (1999):

$$Yt = \alpha + \phi_1 Y_{t-1} + \cdots + \phi_p Y_{t-p} + \beta_0 X_t + \beta_1 X_t + \cdots + \beta_q X_{t-q} + \varepsilon_t \quad (1)$$

Where Yt is dependent variable, Xt is independent variable, α ϕp is constant, ϕp is parameter for autoregressive model, βq is parameter for distributed lag model and εt is error value.

Nonlinear Autoregressive Distributed Lag* (NARDL) *Cointegration

Shin et al. (2011) introduced the Nonlinear Autoregressive Distributed Lag (NARDL) Cointegration model, using the concept of partial sum decomposition of positive and negative changes. The estimation results on the NARDL model can be used to analyze nonlinear asymmetric cointegration. The calculation formula to obtain the variables + and through the concept of partial sum decomposition of positive and negative changes is shown by the following equation:

$$\Delta y_t = \rho y_{t-1} + \theta^+ \chi^+_{t-1} + \theta^- \chi^-_{t-1} + \sum_{i=1}^{\rho-1} \gamma_i \Delta y_{t-i} + \sum_{i=1}^{q-1} \theta_i^+ \Delta \chi^+_{t-i} + \theta^- \Delta \chi^-_{t-1} + e \quad (2)$$

$$\Delta y_t = \rho \varepsilon_{t-1} + \sum_{i=1}^{\rho-1} \gamma_i \Delta y_{t-i} + \sum_{i=1}^{q-1} (\theta_i^+ \Delta \chi^+_{t-i} + \theta^- \Delta \chi^-_{t-1}) + e \qquad (3)$$

In this study, Eviews 10 was used as an analytical tool to obtain model estimation results using a symmetrical and asymmetrical approach. The following steps must be taken in order to obtain the results of the asymmetric model estimation (NARDL):

First, the data generating process is the first step before entering the estimation and model analysis stage. At this stage, various pre-estimated tests are carried out including unit root test, cointegration test, and model diagnostic testing. Following diagnostic testing of the model, the estimated model is evaluated to determine the best model to use in this study. In this study, the following measuring tools were used to calculate prediction errors: Root Mean Square Error (RMSE), Mean Average Error (MAE), and Theil's Inequality Coefficient (U-Theil). Third, Identification of asymmetric effects on an estimated regression result can be done using the Wald test.

The following stage is the formulation of the asymmetric effect model. In this study, the macroeconomic variables used were inflation and exchange rate, with these two variables being used as independent variables to see the asymmetry relationship between rice prices and macroeconomic variables, with one ARDL model and three variations asymmetry model from NARDL models. Thailand is a rice exporter in ASEAN as the object of research.

In this study, to look at the symmetric Autoregressive Distributed Lag (ARDL) Cointegration, short-term asymmetric NARDL, long-term asymmetric NARDL, and short-term and long-term NARDL asymmetry between macroeconomic variables (inflation and exchange rates) and rice prices. The models used are as follows:

Model 1. ARDL

$$\Delta RP_{it} = \alpha + \partial_1 RP_{it-1} + \partial_2 INF_{it-1} + \partial_3 ER_{it-1} + \beta_{1i} \sum_{i=1}^{k-1} \Delta RP_{it-i} + \beta_{2i} \sum_{i=0}^{l-1} \Delta INF_{it-i} + \beta_{3i} \sum_{i=0}^{m-1} \Delta ER_{it-i} + \varepsilon_t \qquad (4)$$

Model 2. (NARDL with Asymmetric Short Term)

$$\Delta RP_{it} = \alpha + \partial_1 RP_{it-1} + \partial_2 INF_{it-1} + \partial_3 ER_{it-1} + \beta_{1i} \sum_{i=1}^{k-1} \Delta RP_{it-i} + \beta_{2i}^+ \sum_{i=0}^{l-1} \Delta INF^+_{t-i} + \beta_{3i}^- \sum_{i=0}^{l-1} \Delta INF^-_{it-i} + \beta_{4i}^+ \sum_{i=0}^{m-1} \Delta ER^+_{t-i} + \beta_{5i}^- \sum_{i=0}^{m-1} \Delta ER^-_{it-i} + \varepsilon_t \qquad (5)$$

Model 3. (NARDL with Asymmetric Long Term)

$$\Delta RP_{it} = \alpha + \partial_1 RP_{it-1} + \partial_2^+ INF^+_{it-1} + \partial_3^- INF^-_{it-1} + \partial_4^+ ER^+_{it-1} + \partial_5^- ER^-_{it-1} + \beta_{1i} \sum_{i=1}^{k-1} \Delta RP_{it-i} + \beta_{2i} \sum_{i=0}^{l-1} \Delta INF_{it-i} + \beta_{3i} \sum_{i=0}^{m-1} \Delta ER_{it-i} + \varepsilon_t \qquad (6)$$

Model 4 (NARDL with Asymmetric Long Term and Short Term)

$$\Delta RP_{it} = \alpha + \partial_1 RP_{it-1} ++ \partial_2^+ INF^+_{it-1} + \partial_3^- INF^-_{it-1} + \partial_4^+ ER^+_{it-1} + \partial_5^- ER^-_{it-1} + \beta_{1i} \sum_{i=1}^{k-1} \Delta RP_{it-i} + \beta_{2i}^+ \sum_{i=0}^{l-1} \Delta INF^+_{it-i} + \beta_{3i}^- \sum_{i=0}^{l-1} \Delta INF^-_{it-i} + \beta_{4i}^+ \sum_{i=0}^{m-1} \Delta ER^+_{it-i} + \beta_{5i}^- \sum_{i=0}^{m-1} \Delta ER^-_{it-i} + \varepsilon_t \qquad (7)$$

RESULTS

Data Exploration

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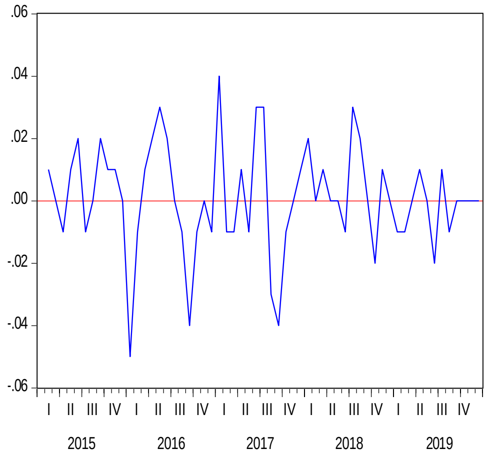
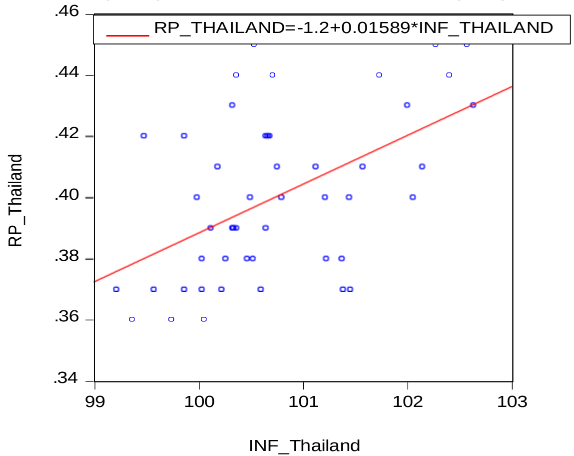
The analysis begins by providing an overview of the movement of the rice price index. Furthermore, the plot analysis of the relationship between inflation and exchange with rice prices is described. The period used is the period 2015Q1 - 2019Q4.
Figure 1 shows the movement of changes in the rice price index in Thailand compared to the previous quarter. A positive change value indicates an increase in rice prices over the previous quarter or an appreciation in rice prices, whereas a negative change value indicates a decrease in rice prices over the previous quarter or a depreciation in rice prices. In general, positive and negative changes tended to be balanced from 2015Q1 to 2019Q4.

Figure 1. Rice Price Index Movements in Thailand for the 2015-2019 period



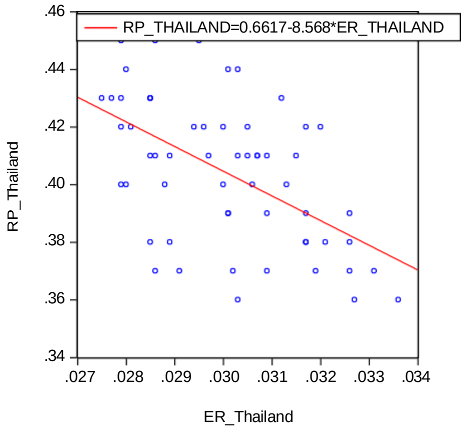
The relationship between Rice Price Index (RP) and Inflation (INF) is shown in Figure 2. Figure 2 shows a plot of the relationship between inflation (INF) and rice prices in Thailand, which has a positive correlation. This means that as inflation rises, so does the price of rice. When inflation falls, so does the price of rice.

Figure 2. Plot of the Inflation (INF) and Rice Price Index (RP) Relationship in Thailand



The relationship between the Rice Price Index (RP) and the Exchange Rate (ER) is shown in Figure 3.

Figure 3. Plot of the Exchange Rate (ER) and Rice Price Index (RP) Relationship in Thailand



Model Identification with Symmetrical and Asymmetrical Approach

The results of the symmetrical estimation model (ARDL model) can be used to analyze the relationship of macroeconomic variables (exchange rate and inflation) that affect rice prices symmetrically. This means that any change in the independent variable, positive or negative, is assumed to have the same effect on rice prices. Meanwhile, the estimation results using the asymmetric approach (NARDL model) can provide information on whether there is an asymmetric relationship between the independent variables and the rice price. A series of steps were carried out to evaluate the ARDL and NARDL models to obtain the best model in analyzing the relationship between macroeconomic variables (exchange rate and inflation) that affect rice prices.

Data Stationarity Test

The test method used to test the stationarity of the data is the Augmented Dickey Fuller test (ADF) and the Phillips-Perron test (PP). In this test, automatic lag selection is used based on the Schwarz Information Criterion (SIC) criteria. If the p-value of t-ADF or t-PP is smaller than the critical value of MacKinnon, it can be concluded that the data used is stationary.

The Phillips-Perron test results in Table 1 show that all variables are not stationary at the level in the ADF test. In contrast to the PP test at the level, all variables have a probability value less than the 5% significance level at the first difference. With a significance level of 5%, this demonstrates that in the first difference, all variables are stationary or do not have a unit root problem.

Table 1. Stationarity test results for Phillips and Perron data

	level		***First Difference***	
	t-Stat (intercept)	**Prob**	**t-Stat (intercept)**	**Prob**
RP_Thailand	-3.865858	0.0041	-6.397704	0.0000***
ER^{+}	-2.256811	0.1898	-6.429798	0.0000***
ER^{-}	-0.600346	0.8621	-7.887156	0.0000***
ER Thailand	-0.735887	0.8290	-5.556811	0.0000***
INF^{+}	1.483176	0.9991	-6.994496	0.0000***
INF^{-}	0.028546	0.9571	-8.352163	0.0000***
INF Thailand	-2.188755	0.2125	-6.400282	0.0000***

Cointegration Test
In this study, the cointegration test was used to identify long-term relationships. Cointegration test on the model was carried out by comparing the value of $F_{statistics}$ with the lower bound I(0) and upper bound I(1), following the Bound Testing Cointegration according to Pesaran et al (2001). The results of the cointegration test of ARDL and NARDL models can be seen in Table 2.

Table 2 Cointegration Test Result

Model	**Chi Square Probability**
1. ARDL	0.9852
2. Short-Term Asymmetric NARDL	0.7910
3.Long-Term Asymmetric NARDL	0.9883
4. Short- and Long-Term Asymmetric NARDL	0.9828

Autocorrelation Test
Table 3 shows the value of the chi-square probability in the ARDL model and variations in the NARDL model, which is greater than the 5 percent significance level. Thus, it can be concluded that in the four models, there is no autocorrelation between the rice price variable and the independent variable. The ARDL model and the NARDL variation are declared to be free from autocorrelation, i.e., each error or residual factor is not correlated with each other.

Table 3 Autocorrelation Test Result

Model	F-Statistic	Bound Table 95%		Result
		1(0)	1(1)	
1. ARDL	3.165923	3.1	3.87	Cointegration
2. Short-Term Asymmetric NARDL	2.445469	2.56	3.49	Cointegration
3.Long-Term Asymmetric NARDL	2.578189	2.56	3.49	Cointegration

4. Short- and Long-Term Asymmetric NARDL	2.658176	2.56	3.49	Cointegration

Heteroscedasticity
The heteroscedasticity test aims to identify whether there is a heteroscedasticity problem, namely the variance of the residuals from the regression model depending on the value of the independent variable. Heteroscedasticity test was carried out by comparing the chi-square probability value with the real level. The results of the heteroscedasticity test on the ARDL and NARDL models can be seen in Table 4.

Table 4. Heteroscedasticity Test Result

Model	**Chi Square Probability**
1. ARDL	0.2747
2. Short-Term Asymmetric NARDL	0.5789
3.Long-Term Asymmetric NARDL	0.1989
4. Short- and Long-Term Asymmetric NARDL	0.3434

The results of the heteroscedasticity test in Table 3 show that the chi-square probability value in the short-term and long-term asymmetric NARDL model in Thailand, the chi-square probability value in the model, is greater than the 5 percent significance level. Thus, it can be concluded that the residuals in the ARDL model and the NARDL variation have no problems.

Normality
The normality test aims to identify whether the residuals in the model are normally distributed. According to Dave Giles, abnormal data is not a big problem in OLS because the normality test only gives a rough idea. The normality test is done by comparing the Jarque-Bera probability value with the real level. The results of the normality test can be seen in Table 5.

Table 5. Normality Test Result

Model	**Probabilitas *Jarque-Bera***
1. ARDL	0.4651
2. Short-Term Asymmetric NARDL	0.4508
3.Long-Term Asymmetric NARDL	0.4444
4. Short- and Long-Term Asymmetric NARDL	0.4909

According to Table 5, Thailand has a Jarque Bera probability value greater than the 5% significance level in the ARDL and NARDL models, indicating that the residuals are normally distributed.

Validity test
The Ramsey Regression Equation Specification Error Test (RESET) was used to test the validity of the model. According to Table 6, the model validity test results show that the probability value in the ARDL and NARDL models for Thailand is greater than the 5% significance level. This implies that the model is valid.

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Table 6. Validity Test Result

Model	***F-Statistic***	**Probabilities**
1. ARDL	0.606484	0.4402
2. Short-Term Asymmetric NARDL	1.109534	0.2982
3.Long-Term Asymmetric NARDL	0.693395	0.4096
4. Short- and Long-Term Asymmetric NARDL	0.030824	0.8615

Model Stability Test

In this study, the stability of the model was identified through parameter stability and error variance stability. Parameter stability was identified through information from the CUSUM test results. Graphically, the results of the CUSUM test on the ARDL and NARDL models, respectively, can be seen in the following figures. Figures 4, 5, 6 and 7 show the movement of CUSUM and the boundary of the significance line in the ARDL model and the short-term asymmetric NARDL model. CUSUM in both models is within the boundary of the significance line which indicates that the model has stable parameters.

Figure 4. Cumulative Sum of Recursive Residual (CUSUM) Stability test results (ARDL)

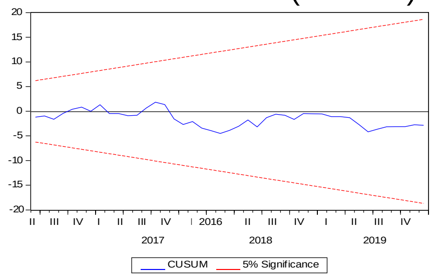

Figure 5. Cumulative Sum of Recursive Residual (CUSUM) Stability test results (Short Term NARDL)

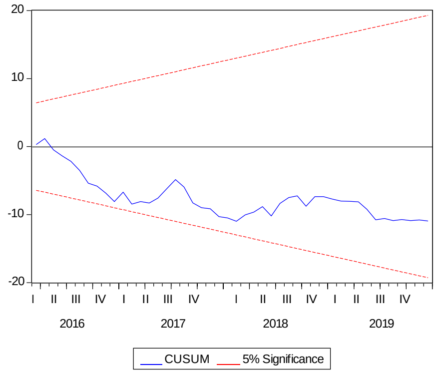

Figure 6. Cumulative Sum of Recursive Residual (CUSUM) Stability test results (Long-Term NARDL)

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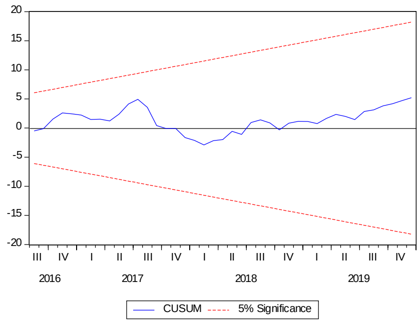
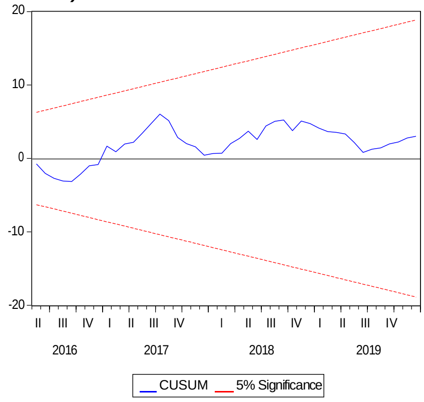


Figure 7. Cumulative Sum of Recursive Residual (CUSUM) Stability test results (Short- and Long-Term NARDL)



Model Accuracy Level Test

Estimation evaluation was performed by comparing the root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and Theil's Inequality Coefficient (U-Theil) in the four models across four countries.

Table 7. Model Accuracy Level Test Result

Model	***RMSE***	**MAE**	**MAPE**	***Theil's inequality***
1. ARDL	0.014	0.011	2.675	0.017
2. Short-Term Asymmetric NARDL	0.013	0.010	2.619	0.017
3.Long-Term Asymmetric NARDL	0.014	0.011	2.636	0.017
4. Short- and Long-Term Asymmetric NARDL	0.014	0.011	2.633	0.017

Table 7 shows the RMSE, MAE, MAPE and U-Theil values for the estimated regression model, where the best model is selected from the smallest value of the three estimation evaluation values. The result is that model 2 (NARDL model with short-term asymmetry) is selected as the best model in Thailand. In general, it can be said that the use of nonlinear models (models 2, 3, and 4) to see the effect of inflation (INF) and exchange rate (ER) on rice prices (RP) is better than using a linear model (model 1).

Long-Term and Short-Term Asymmetric Effects Using the Wald Test

The short-term Wald's test estimation results (Table 8) show that for the NARDL model with short-term and long-term asymmetric effects (model 9), only the INF variable is significant for Thailand, while ER is not.

Table 8. Wald's Test Results in the Short Term

Model 1	**Model 2**	**Model 3**	**Model 4**

W (INF)	W (ER)	W (INF)	W (ER)	W (INF)	W (ER)	W (INF)	W (ER)
X	X	X	X	X	X	V	X

The long-term Wald's test estimation results (Table 9) show that there are no significant results in Thailand for the NARDL model with short and long-term asymmetric effects (model 4).

Table 9. Wald's Test Results in the Long Term

Model 1		**Model 2**		**Model 3**		**Model 4**	
W (INF)	W (ER)	W (INF)	W (ER)	W (INF)	W (ER)	W (INF)	W (ER)
X	X	X	X	X	X	X	X

DISCUSSION

The analysis begins by providing an overview of the movement of the rice price index in the period 2015Q1 - 2019Q4. Figure 1 illustrates the changes in the rice price index in Thailand during this period, where a positive change value signifies an increase in rice prices compared to the previous quarter, while a negative value indicates a decrease. Over this timespan, the changes in rice prices generally displayed a balance between appreciations and depreciations.

Moving on to the relationship between the Rice Price Index (RP) and inflation (INF), Figure 2 presents a plot indicating a positive correlation between Rice Price Index (RP) and inflation (INF) in Thailand. It does imply that as inflation increases, means the increase of rice price, and conversely, when inflation decreases, rice prices tend to jump down. It inevitably shows that Rice Price Index (RP) and inflation (INF) have a strong correlation to each other.

Figure 3 demonstrates the relationship between the Rice Price Index (RP) and the Exchange Rate (ER) in Thailand. It is evident that the data exploration phase lays the groundwork for a more detailed analysis of the interplay between these variables. The subsequent modeling phase involved the use of both symmetrical and asymmetrical approaches. The symmetrical estimation model, the ARDL model, were employed to assess the impact of macroeconomic variables (exchange rate and inflation) on rice prices, under the assumption that any change in the independent variables has an effect on rice prices, regardless of being positive or negative. Conversely, the asymmetrical approach, implemented through the NARDL model, was utilized to determine whether there exists an asymmetrical relationship between the independent variables and rice prices. A meticulous series of tests was conducted to evaluate these models and ascertain the most suitable model for analyzing the complex relationship between macroeconomic variables and rice prices.

The initial data stationarity test, employing the Augmented Dickey Fuller test (ADF) and the Phillips-Perron Test (PP), demonstrated that all variables were not stationary at the level but became stationary in the first difference. It does imply that these variables did not possess a unit root problem when examined in the first difference. To identify long-term relationships, a cointegration test was conducted. The results of this test indicated that the models exhibited cointegration, providing valuable insights into the existence of long-term relationships between the variables under consideration.

Further tests were conducted to evaluate parameters such as autocorrelation, heteroscedasticity, and normality. These tests confirmed the adequacy of the models, showing no issues related to autocorrelation, heteroscedasticity, or non-normality of residuals, thereby validating the reliability of the models. Model stability was assessed through parameter and error variance stability using the CUSUM test, which graphically demonstrated that the models had stable parameters. Additionally, the model accuracy level was assessed using various metrics such as root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and Theil's Inequality Coefficient. The evaluation indicated that the NARDL model with short-term asymmetry was the best model for Thailand, reaffirming the efficacy of nonlinear models in analyzing the impact of inflation and exchange rates on rice prices.

Finally, long-term and short-term asymmetric effects were examined using the Wald test. In the short term, it was found that only the inflation variable was significant for Thailand, while the exchange rate was not. In the long term, there were no significant results, suggesting that the NARDL model with both short- and long-term asymmetric effects did not demonstrate significance in Thailand. These findings contribute to a more comprehensive understanding of the intricate dynamics between macroeconomic variables and rice prices, particularly in the context of Thailand.

CONCLUSION

This study is in purpose to investigate the existence asymmetric effect of macroeconomic variables on rice prices in ASEAN rice exporting countries. This study is primarily focusing on Thailand, where the data on rice prices, exchange rates, and inflation are used to examine the asymmetric effects of macroeconomic variables (inflation and exchange rates) in ASEAN countries. In the broader context of this empirical study, it has come to light that the nonlinear model, which was employed to scrutinize the relationship between macroeconomic variables, namely the exchange rate and inflation, and their influence on rice prices, demonstrated a superior performance compared to the linear model. This compelling finding underscores the critical importance of selecting an appropriate modeling framework, given that the application of the linear symmetrical model in this specific analytical domain could potentially lead to erroneous and misleading conclusions, particularly when engaged in the asymmetric examination of rice prices in response to macroeconomic variables. This contrast in model effectiveness highlights the imperative role played by nonlinear models in effectively capturing the nuanced and asymmetric dynamics of these price determinants in the realm of rice economics.

Moreover, a meticulous evaluation of the estimation results substantiates the supremacy of employing nonlinear models when investigating the multifaceted relationship between inflation and the exchange rate and their repercussions on rice prices. This robust demonstration of the nonlinear models' utility stands as a testament to their aptness in disentangling the complex web of interdependencies within this economic framework. Furthermore, the utilization of the Wald's test for estimation assessment has brought to the forefront some interesting insights. When scrutinizing the NARDL (Nonlinear Autoregressive Distributed Lag) model within the context of both short- and long-term asymmetric effects, it was unveiled that Thailand exhibited noteworthy statistical significance only in relation to inflation variables, while the exchange rate was found to lack statistical significance. To expand upon this analysis, the long-term Wald test estimation results provided further clarification, indicating that the NARDL model's significance in the context of Thailand is notably absent across all model variations and specifications, reaffirming the intricate and nuanced nature of the relationships between macroeconomic variables and rice prices in this specific geographical context.

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