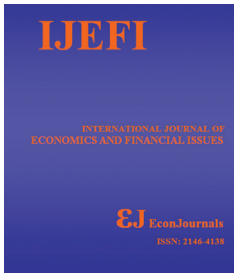

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Determinants of Agricultural Household Business Terms of Trade in Indonesia: Empirical Evidence of Nonlinear Autoregressive Distributed Lag Model Application

Arintoko Arintoko*, Herman Sambodo, Rakhmat Priyono

Department of Economics and Development Studies, Faculty of Economics and Business, Universitas Jenderal Soedirman, Purwokerto, Indonesia. *Email: arintoko@unsoed.ac.id

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ABSTRACT

This study analyzes the asymmetric effects of changes in world oil and fertilizer prices, exchange rate, price index, and agricultural credit on agricultural household business terms of trade (AHBTOT) in Indonesia. The analysis in this study applies the Nonlinear Autoregressive Distributed Lag (NARDL) model to monthly data from January 2014 to December 2023. The results of the study show that the decline in world fertilizer prices, which is passed on to the decline in domestic fertilizer prices, significantly increases AHBTOT, while domestic inflation decreases AHBTOT. Meanwhile, the decline in agricultural credit significantly decreases AHBTOT. In the short run, the weakening of the exchange rate and the decline in agricultural credit significantly decrease AHBTOT. To support the welfare of farmers, the feasibility of agricultural household businesses is absolutely necessary. The government should be able to guarantee low fertilizer prices along with the still high import of fertilizers through subsidies and distribution that ensure easy access for farmers to obtain cheap fertilizers. Meanwhile, inflation control by the government and access to agricultural credit can encourage increasing AHBTOT. Stabilizing inflation and the rupiah exchange rate through monetary policy will certainly provide support for improving the performance of agricultural household businesses.

Keywords: Agricultural Household Business Terms of Trade, Agricultural Credit, Asymmetric Effects, Nonlinear Autoregressive Distributed Lag Model, Welfare of Farmers
JEL Classifications: C32, E31, E51, Q12, Q17

1. INTRODUCTION

The agricultural sector is generally important for economic development in developing countries. This sector plays a key role in producing food and supplying the industrial sector with input needs. This sector also contributes to providing employment. The multi-role of the agricultural sector in developing countries includes maintaining food security, reducing poverty, encouraging economic growth, meeting domestic and export needs, and contributing to foreign exchange (Zhang and Diao, 2020). The development of the agricultural sector in developing countries is also inseparable from globalization (Nugroho and Lakner, 2022). Globalization can change the way developing countries manage and utilize agricultural resource endowments. Global economic dynamics can impact the domestic economy through the transmission of global commodity prices and exchange rate pass-through to domestic prices (Arintoko et al., 2024a). Global economic dynamics will certainly also impact the performance of the agricultural sector. The agricultural sector includes sub-sectors consisting of food crops, horticulture, plantations, livestock, fisheries, forestry, and agricultural service businesses.

The existence and performance of the agricultural sector will significantly depend on the role of farmers. Farmers are the main

actors in the agricultural sector. Farmers play a role in various functions. To maintain food security, farmers produce staple foods the community needs, such as rice, corn, soybeans, and vegetables. In maintaining food price stability farmers play an important role in maintaining food supplies to keep food prices stable. In improving the welfare of rural communities, farmers are the primary source of income for many people in rural areas. Farmers can also improve agricultural efficiency and productivity by bringing new perspectives and innovative ideas to agricultural practices, especially by young farmers.

However, the existence of farmers as the main actors in the agricultural sector will depend heavily on the income that guarantees their livelihoods obtained from their agricultural businesses. Agricultural businesses will survive if they can provide income guarantees for farmers. The sustainability of agricultural businesses is undoubtedly supported by the feasibility and profitability of the business, which depends on the factors that influence it (Ahearn et al., 2018). Farmers will use several main inputs as production factors and auxiliary materials to operate their businesses. Some of these inputs include fuel and fertilizer. The purchase of inputs is an expense paid by farmers. Expenditure for the purchase of inputs and materials will depend heavily on their prices, which are inseparable from world prices and import costs, which are influenced by the exchange rate. The ability to finance agricultural businesses is also greatly influenced by access to credit when their capital is insufficient in their business operations. The dynamics of input prices and prices of agricultural commodities produced by farmers are also closely related to inflation. Inflation affects the prices paid and received by farmers.

Agricultural household business terms of trade are used to assess the profit and welfare of farmer families as a complement to other welfare measures, namely farmers' terms of trade (FTOT). Agricultural household business terms of trade are also used to calculate the adequacy of farmers' living costs from month to month in a year. An increase in AHBTOT can be interpreted as increased profits from agricultural businesses. It can then increase the welfare of farmer families by increasing income from their agricultural businesses (Rachmat and Nuryanti, 2015). The terms of FTOT and AHBTOT refer to the terms NTP (Nilai Tukar Petani) and NTUP (Nilai Tukar Usaha Pertanian), which are popular in Indonesia.

The study of agricultural household business terms of trade provides insight into the financial health of farmers running their agricultural businesses and a picture of the performance of the agricultural sector as a whole. The study of the feasibility of agricultural businesses run by farmers in agricultural countries is particularly important and useful in providing unique insight into the resilience and sustainability of agricultural businesses that support the agricultural sector. For Indonesia, as a country with a predominantly agricultural and rural area, studying agricultural household business terms of trade is important, considering that the agricultural sector is the mainstay of their livelihood.

Studies on agricultural household business terms of trade in Indonesia, particularly in agricultural countries, are still scarce. Studies related to farmers' terms of trade have been relatively more numerous than those on agricultural household business terms of trade. Previous studies related to farmers' terms of trade include those by Murdy (2017), Wibowo (2019), Qodri et al. (2022), and Arintoko et al. (2025). Studies on agricultural household business terms of trade are critical to complement studies on farmers' terms of trade, considering that agricultural household business terms of trade show the feasibility of agricultural businesses for farmers. The feasibility of the business is the guarantee that agricultural businesses provide income for farmers. In Indonesia, as a country that still imports oil and fertilizers, farmers' expenditures on fuel and fertilizers will likely depend on world oil and fertilizer prices, which are passed on to domestic oil and fertilizer prices.

Meanwhile, the local currency exchange rate through the exchange rate pass-through will impact the prices of imported agricultural input commodities, especially oil and fertilizers. In addition, the prices of input commodities and agricultural products are influenced by inflation, which in turn impacts farmers' expenditure and income. The ability of farmers to finance their business operations is also inseparable from access to agricultural credit.

This study is motivated by the gap between the phenomenon of farmers' lives and the lack of empirical studies related to farmers' welfare as reflected in the exchange rate of agricultural businesses. The problems of farmers' lives are very close to the problem of poverty in rural areas. Low yields, unstable market prices for agricultural commodities and inputs, and limited access to credit, land, and technology cause the problem of poverty faced by small-scale farmers in developing countries. The obstacles these farmers face lead to limitations in obtaining income that meets their basic needs. The poverty farmers face can trap them in low productivity and limited economic opportunities for farmers. This study aims to investigate important factors, both external and domestic, that are suspected of having an asymmetrical impact on the performance of agricultural businesses in Indonesia. The assumption of symmetric effects has not been consistent with real-world situations. An increase in a macroeconomic variable relative to another variable usually has a different magnitude of effect when there is a decrease. This study takes this property into account. In this study, the nonlinear autoregressive distributed lag (NARDL) model is applied to analyze the performance of agricultural businesses by farmers in the short and long run, influenced asymmetrically by factors such as world oil and fertilizer prices, exchange rates, inflation, and agricultural credit. The study's results can enrich empirical findings and new insights related to the dynamics of agricultural business performance, which are greatly influenced by its determining factors.

2. LITERATURE REVIEW

The performance of agricultural businesses run by farmers impacts their income to meet their basic needs and contributes to agricultural output and food security through the availability of agricultural commodities. Several factors can affect the performance of agricultural businesses originating from external factors such as world oil and fertilizer prices. Prices of agricultural inputs traded through international markets can affect import prices

due to the influence of local currency exchange rates. Domestic factors such as inflation and access to credit are also important factors in determining the performance of agricultural businesses.

Oil prices are one of the main factors contributing to the variability of agricultural product prices and income from agricultural businesses (Agniyazov et al., 2025). According to Fukuda (2024), the increase in world oil prices impacts the production costs of agricultural commodities. Consequently, in the context of agricultural businesses, increasing production costs increases the expenses paid by farmers, thereby reducing the exchange rate of agricultural businesses. In terms of income, increasing production costs also have the potential to reduce production, which reduces income from agricultural businesses. Aye and Odhiambo (2021) empirically prove that increasing world crude oil prices reduces agricultural output. The increase in world crude oil prices will increase production costs, which can reduce production or increase the price of agricultural products to reduce the loss of profit (Wong and Shamsudin, 2017). So, the increase in crude oil prices impacts the performance of agricultural businesses due to decreased income and increased production costs borne by farmers.

Fertilizer is one of the key inputs in the success of agricultural businesses. Fertilizer consumption by farmers depends on purchasing power, which is influenced by fertilizer prices. Global fertilizer prices have an impact on domestic fertilizer prices. The increase in fertilizer prices due to the global fertilizer crisis increases the price of non-subsidized fertilizers and reduces the volume of subsidized fertilizers. The decreasing purchasing power of farmers for fertilizers whose prices have increased reduces fertilizer consumption, thereby reducing crop productivity so that income from agricultural businesses decreases (Sarwani et al., 2023). Because fertilizer is a primary input, increasing fertilizer prices reduces the demand and use of fertilizers, reducing production and income (Komarek et al., 2017). The global fertilizer price shock, which has caused fertilizer prices to soar, has decreased fertilizer use, especially for small-scale farmers, which in turn has reduced their yields (Vos et al., 2025). The increase in international fertilizer prices is passed through to domestic fertilizer prices with a very elastic nature (Bor and Dagistan, 2024). This nature provides the potential for reducing fertilizer use in agricultural businesses, reducing farmer productivity and income, so the agricultural household businesses terms of trade decreases.

A country's openness makes the exchange rate also impact the performance of domestic agricultural businesses. Depreciation of the local currency can increase import prices through exchange rate pass-through. Increased import prices, especially for agricultural production inputs such as oil and fertilizers, can increase production costs so that agricultural business income decreases. Sarabi et al. (2020) provide empirical findings that the depreciation of the local currency exchange rate increases the import price of agricultural inputs. Therefore, an increase in the import price of inputs will, in turn, increase production costs, reducing agricultural businesses' income and performance. Empirically, the study's results revealed that the local currency exchange rate decline reduced agricultural production (Oye et al., 2018). So, the decline in the exchange rate reduces agricultural performance. The results of a study by Ikpesu and Okpe (2019) also provide empirical findings that local currency depreciation reduces agricultural output in the short and long run. The main factor causing the increase in the cost of agricultural production with imported inputs is the increase in import prices of agricultural production inputs. Alvarez et al. (2019) revealed that currency depreciation causes an increase in the prices of imported agricultural products through incomplete exchange rate pass-through (ERPT). ERPT allows local currency depreciation to increase the production costs of agricultural businesses that use imported inputs such as fertilizers and raw materials, thereby reducing the income and performance of agricultural household businesses.

In addition to global commodity prices such as crude oil and fertilizers and exchange rates, inflation is a domestic factor that impacts agricultural businesses. Inflation affects agricultural input prices, production costs, and income from agricultural businesses. Janet (2024) provides empirical findings that inflation reduces agricultural productivity. Therefore, for small-scale farmers, inflation has a negative impact on the performance of agricultural household businesses. Another empirical finding is Soliman et al. (2023), who revealed that increases in energy inflation, agflation, and the consumer price index significantly reduce agricultural output. Conversely, decreases in energy inflation, agflation, and the consumer price index increase agricultural output. Furthermore, Aye and Odhiambo (2021) state that above the threshold, inflation has a negative and stronger impact than below the threshold. Meanwhile, according to empirical findings by Wu et al. (2024), increases in prices due to increases in international market prices or increases in agricultural input costs have a negative impact on farmers. Thus, inflation impacts increasing production costs rather than income from agricultural commodities, which can potentially reduce agricultural business performance.

Another important domestic factor influencing agricultural business performance is agricultural credit. The provision of credit for the agricultural sector, especially in financing agricultural businesses, increases farmers' production capacity and productivity. Fronda (2024) stated that microfinance can substantially improve farmers' economic conditions by increasing the productivity of agricultural businesses financed by credit. In agricultural businesses, especially food crop production, credit is significant in increasing production, which can increase income for agricultural businesses. Omoregie et al. (2018) provide empirical evidence that providing agricultural credit increases rice production. Haryanto et al. (2023) provide empirical evidence that access to credit increases the ability of farming businesses to use the best inputs and technology, thereby increasing productivity and technical efficiency. Therefore, increasing access to credit significantly improves the performance of agricultural businesses. In addition to supporting production directly, agricultural sector credit can increase investment to support agricultural mechanization by purchasing capital in the form of equipment and machinery that support agricultural production. Increasing investment that supports agricultural mechanization can increase productivity (Stavytskyy and Prokopenko, 2017). Theoretically, increasing productivity will, in turn, improve the performance of agricultural businesses.

The following hypotheses are proposed based on previous literature studies related to theoretically expected factors.

H_1: World crude oil prices negatively affect agricultural household business terms of trade asymmetrically.

H_2: World fertilizer prices have a negative effect on agricultural household business terms of trade asymmetrically.

H_3: Local currency exchange rates have a negative effect on agricultural household business terms of trade asymmetrically.

H_4: Inflation has a negative effect on agricultural household business terms of trade asymmetrically.

H_5: Agricultural credit positively affects agricultural household business terms of trade asymmetrically.

3. RESEARCH METHODOLOGY

3.1. Data and Variables

The research data are monthly data from January 2014 to December 2023. The variables in the model consist of one response variable and several explanatory variables. According to the purpose of this study, the response variable is agricultural household business terms of trade with the abbreviation AHBTOT. The explanatory variables include world crude oil prices, world fertilizer prices, the rupiah exchange rate against the US dollar, CPI inflation, and agricultural credit. The abbreviations, definitions, measurements, and data sources of each variable are presented in more detail in Table 1. All data from the variables are expressed in natural logarithms (ln).

3.2. Model

The nonlinear autoregressive distributed lag (NARDL) model is an extension of the standard ARDL model used to analyze asymmetric effects. The standard ARDL model is used to analyze symmetric effects. In the real world, asymmetric effects are more realistic than symmetric effects. Asymmetric effects apply because the effect of a variable can differ depending on whether the variable increases or decreases in influencing the dependent variable. The NARDL model allows the investigation of non-linear relationships in short-run and long-run interactions. Therefore, the NARDL model becomes a more accurate and flexible analysis tool for analyzing economic data in particular. From the experience of applying previous models, the NARDL model is designed for selected variables in this study based on references to models that have been previously used by including Hashmi et al. (2021), Arintoko et al. (2024b), and Zhang et al. (2025).

The equations of the NARDL model are stated in equations (1) and (2).

$$\begin{aligned} LAHBTOT_t = {} & \phi_0 + \sum_{i=1}^{k} \alpha_{1i} LAHBTOT_{t-i} + \\ & \sum_{i=0}^{l} \left(\alpha_{2i}^{+} LOP_{t-i}^{+} + \alpha_{2i}^{-} LOP_{t-i}^{-} \right) + \\ & \sum_{i=0}^{m} \left(\alpha_{3i}^{+} LFERP_{t-i}^{+} + \alpha_{3i}^{-} LFERP_{t-i}^{-} \right) + \\ & \sum_{i=0}^{p} \left(\alpha_{4i}^{+} LEXR_{t-i}^{+} + \alpha_{4i}^{-} LEXR_{t-i}^{-} \right) + \\ & \sum_{i=0}^{q} \left(\alpha_{5i}^{+} LCPI_{t-i}^{+} + {}_{5i}^{-} \, LCPI_{t-i}^{-} \right) + \\ & \sum_{i=0}^{s} \left(\alpha_{6i}^{+} LAGCR_{t-i}^{+} + \alpha_{6i}^{-} LAGCR_{t-i}^{-} \right) + \mathrm{u}_t \end{aligned} \quad (1)$$

From equation (1) to present the long-run parameters in equation (2), short-run parameters consisting of increases and decreases for each variable are also involved.

$$\begin{aligned} \Delta LAHBTOT_t = {} & \phi_0 + \phi_1 LAHBTOT_{t-1} + \phi_2^{+} LOP_{t-1}^{+} + \phi_2^{-} LOP_{t-1}^{+} + \\ & \phi_3^{+} LFERP_{t-1}^{+} + \phi_3^{-} LFERP_{t-1}^{-} + \phi_4^{+} LEXR_{t-1}^{+} + \\ & \phi_4^{-} LEXR_{t-1}^{-} + \phi_5^{+} LCPI_{t-1}^{+} + \phi_5^{-} LCPI_{t-1}^{-} + \\ & + \phi_6^{+} LAGCR_{t-1}^{+} + \phi_6^{-} LAGCR_{t-1}^{-} + \\ & \sum_{i=1}^{k-1} \gamma_{1i} LAHBTOT_{t-i} + \\ & \sum_{i=0}^{l-1} \left(\gamma_{2i}^{+} LOP_{t-i}^{+} + \gamma_{2i}^{-} LOP_{t-i}^{-} \right) + \\ & \sum_{i=0}^{m-1} \left(\gamma_{3i}^{+} LFERP_{t-i}^{+} + \gamma_{3i}^{-} LFERP_{t-i}^{-} \right) + \\ & \sum_{i=0}^{p-1} \left(\gamma_{4i}^{+} LEXR_{t-i}^{+} + \gamma_{4i}^{-} LEXR_{t-i}^{-} \right) + \\ & \sum_{i=0}^{q-1} \left(\gamma_{5i}^{+} LCPI_{t-i}^{+} + \gamma_{5i}^{-} LCPI_{t-i}^{-} \right) + \\ & \sum_{i=0}^{s-1} \left(\gamma_{6i}^{+} LAGCR_{t-i}^{+} + \gamma_{6i}^{-} LAGCR_{t-i}^{-} \right) + \mathrm{u}_t \end{aligned} \quad (2)$$

The calculation for the increase and decrease of each explanatory variable in the model is stated in equations (3a) and (3b) as an example of the calculation for oil prices (LOP^{+}) and LOP^{-}), which each represent the increase and decrease in oil prices. For the calculation of other variables, follow a similar calculation formula in equations (3a) and (3b).

$$LOP_t^{+} = \sum_{j=1}^{t} \Delta \mathrm{LOP}_j^{+} = \sum_{j=1}^{t} max\left(\Delta \mathrm{LOP}_j, 0 \right) \quad (3a)$$

$$LOP_t^{-} = \sum_{j=1}^{t} \mathrm{LOP}_j^{-} = \sum_{j=1}^{t} min\left(\Delta \mathrm{LOP}_j, 0 \right) \quad (3b)$$

$\sum_{i=0}^{l-i} \gamma_{2i}^{+} + \gamma_{2i}^{-}$, $\sum_{i=0}^{l-i} \gamma_{3i}^{+} + \gamma_{3i}^{-}$, $\sum_{i=0}^{l-i} \gamma_{4i}^{+} + \gamma_{4i}^{-}$, $\sum_{i=0}^{l-i} \gamma_{5i}^{+} + \gamma_{5i}^{-}$, and $\sum_{i=0}^{l-i} \gamma_{6i}^{+} + \gamma_{6i}^{-}$ are the total short-run effects of the explanatory variables captured in the model estimation based on the best NARDL model.

Meanwhile, the long-run parameters with asymmetric effect in this model for the explanatory variables, i.e. namely world crude oil prices, world fertilizer prices, exchange rates, inflation and agricultural credit are as follows.

$$-\frac{\phi_2^{+}}{\phi_1} < 0, \; -\frac{\phi_2^{-}}{\phi_1} < 0, \; -\frac{\phi_2^{+}}{\phi_1} \neq -\frac{\phi_2^{-}}{\phi_1}$$

$$-\frac{\phi_3^{+}}{\phi_1} < 0, \; -\frac{\phi_3^{-}}{\phi_1} < 0, \; -\frac{\phi_3^{+}}{\phi_1} \neq -\frac{\phi_3^{-}}{\phi_1}$$

$$-\frac{\phi_4^{+}}{\phi_1} < 0, \; -\frac{\phi_4^{-}}{\phi_1} < 0, \; -\frac{\phi_4^{+}}{\phi_1} \neq -\frac{\phi_4^{-}}{\phi_1}$$

$$-\frac{\phi_5^{+}}{\phi_1} < 0, \; -\frac{\phi_5^{-}}{\phi_1} < 0, \; -\frac{\phi_5^{+}}{\phi_1} \neq -\frac{\phi_5^{-}}{\phi_1}$$

Table 1: Description of the variables

Variable	Abbreviation	Definition	Measurement	Data source
Agricultural household business terms of trade	AHBTOT	AHBTOT compares the price index received by Farmers (It) and the Price Index Paid by Farmers (Ib), where the Ib component only includes production costs and additional capital goods.	The ratio between the price index received and paid by farmers	BPS-statistics Indonesia
International oil prices	OP	The average international crude oil price includes Brent, Dubai, and West Texas Intermediate (WTI) crude, which are the main references for oil prices.	USD per barrel	World bank
International fertilizer prices	FERP	The international price of fertilizer, a composite of natural phosphate rock, phosphate, potassium, and nitrogen, has a weighting of 16.9, 21.7, 20.1, and 41.3, respectively.	Monthly index based on nominal US dollars with a base year of 2010	World bank
Exchange rate	EXR	The exchange rate is a bilateral exchange rate that shows the price of the rupiah relative to the USD.	The exchange rate is expressed in rupiah per USD	Bank Indonesia
Consumer price index	CPI	The consumer price index measures the average price of all goods and services consumed by households. Changes in the CPI represent inflation.	Consumer prices are expressed in index, with 2012=100	Bank Indonesia
Agricultural credit	AGCR	Agricultural credit is loan provided by commercial banks, including rural banks, which is intended for use in the agricultural, forestry and fisheries sectors.	The credit value is expressed in billions of rupiah	Bank Indonesia

All variables in the model are expressed in natural logarithms (ln)

$$-\frac{\phi_6^+}{\phi_1} > 0, \quad -\frac{\phi_6^-}{\phi_1} > 0, \quad -\frac{\phi_6^+}{\phi_1} \neq -\frac{\phi_6^-}{\phi_1}$$

4. RESULTS AND DISCUSSION

4.1. Results

Descriptive statistics presented in Table 2 show a summary of data from all variables in the research model. Table 2 presents a concise and informative presentation of the variables, including agricultural household business terms of trade, world crude oil prices, world fertilizer prices, rupiah exchange rates, inflation, and agricultural credit. This summary statistic uses measures of center and variability to describe the main features of the data analyzed. The purpose of presenting descriptive statistics is to form the basis of quantitative analysis and provide insight into the distribution and characteristics of the data set analyzed in this study.

From the measures of central tendency consisting of mean and median, the variables analyzed have varied data patterns. agricultural household business terms of trade (AHBTOT), exchange rate (EXR), and consumer price index (CPI) tend to have relatively small central measures when their mean and median values are close. Likewise, these three variables based on standard deviation have minor variability compared to world oil prices (OP), world fertilizer prices (FERP), and agricultural credit (AGCR). AHBTOT above 100 indicates that the farm business by farmers is in surplus; an amount equal to 100 means breakeven, and a decrease of 100 means that the agricultural business by farmers is in loss/deficit. From the statistical summary, agricultural businesses by farmers generally experience a surplus with variations during the study period. Variations in AHBTOT align with OP, FERP, EXR, CPI, and AGCR variations. Changes in CPI indicate inflation/deflation. An increase in CPI indicates inflation; conversely, a decrease means deflation.

Table 3 summarizes the correlation between variables in the model. This correlation is additional statistical information that

Table 2: Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Standard deviation
AHBTOT	108.5735	109.0550	119.6800	100.1600	3.7189
OP	66.0543	62.4150	116.8000	21.0400	21.0329
FERP	113.1920	91.7200	293.7300	67.8200	53.46259
EXR	13,957.37	14,103.50	16,367.00	11,404.00	1,006.192
CPI	134.4578	135.5550	156.0200	110.9900	12.2476
AGCR	354,021.4	367,798.0	526,796.0	185,549.0	93,591.37

Table 3: Correlation between variables

	LAHBTOT	LOP	LFERP	LEXR	LCPI	LAGCR
LAHBTOT	1.0000					
LOP	0.1624	1.0000				
LFERP	−0.0267	0.6575	1.0000			
LEXR	0.1500	−0.0623	0.3725	1.0000		
LCPI	0.1536	0.1575	0.5059	0.8949	1.0000	
LAGCR	0.1616	0.1493	0.4748	0.8890	0.9942	1.0000

complements the presentation of statistical figures from the variables analyzed. However, a low correlation between two variables does not always indicate no influence of one variable on another. Correlation means the strength and direction of the relationship between two variables without looking at the causal relationship as well as predictors and outcomes. Table 3 shows a low coefficient correlation between AHBTOT and other variables. However, this does not mean that there is no effect between these variables on AHBTOT, especially in a non-linear relationship. The influence of one explanatory variable on the dependent variable in this study is also controlled by other variables so that there may be effects of variables with directions that do not always correspond to the correlation and direction, even when each variable has been split between its increase and decrease in the NARDL model.

The unit root test is intended to identify the characteristics of the data series of the variables analyzed, such as whether they are non-stationary and have unit roots. The application of the NARDL model and the ARDL model requires the model to be

applicable to stationary time series variables at different orders. The variables in the NARDL model can be a combination of stationary and non-stationary time series variables at the level, with the condition that the variables are stationary at the first difference but not stationary at the second difference. It is expected that the dependent variable is stationary at the first difference, I(1), and all explanatory variables are stationary at the level, I(0), or I(1), or a mixture of I(0) and I(1). The unit root test results are obtained from three tests, i.e., the Augmented Dickey-Fuller (ADF) test, the DF-GLS test, and the Phillips–Perron (PP) test. DF-GLS test as a modification of the augmented Dickey-Fuller test. Meanwhile, the PP test complements and strengthens the results of the two previous tests.

Table 4 summarizes the results of the unit root test. The test results show that based on the joint test with the ADF, DF-GLS, and PP tests, all variables are concluded to be non-stationary, but all of these variables are I(1). The properties of this data series allow the application of the NARDL model.

The NARDL model's stability in this analysis is assessed using the CUSUM test, which is intended to check that the parameters and predictions of the model remain consistent over time. If the stability of the NARDL model is met, the model will be robust, and its predictions can be relied on over time. Therefore, the stability of the model makes it a valuable tool for forecasting and analysis. Testing for model stability through the CUSUM test maps the cumulative sum of recursive residuals over time. Through the CUSUM test, a stable model will have a line within a specific significance band, for example, 5%. From the test results in Figure 1, the CUSUM line appears to remain within the significance band; therefore, this model is considered stable.

The ARDL bound test in this model uses the cointegration method developed by Pesaran et al. (2001). The ARDL bound test can also be applied to the NARDL model. This test is applied to test for a long-run relationship between variables, regardless of the variables integrated in order zero or order 1. This test can also obtain an unlimited error correction model (UECM). This test has advantages for limited samples because it can get consistent results. If the calculated F statistic exceeds the upper critical bound value, the null hypothesis of no cointegration is rejected. The test results in Table 5 show that the F statistic exceeds the upper critical bound value, or I(1) at all P-values. It means that the model contains cointegration or a long-run relationship.

The best estimated model is the NARDL (1, 0, 0, 0, 5, 3, 0, 0, 0, 0, 4) model. The estimation results of the NARDL model are summarized in Table 6 for the long-run parameters. Meanwhile, the short-run parameters are presented in Table 7. Through the Breusch-Pagan-Godfrey test and the Breusch-Godfrey Serial Correlation LM Test with P = 5%, the model estimation results do not suffer from heteroscedasticity and autocorrelation.

In the long run, oil prices (LOP) are not significant for either an increase (LOP^+) or a decrease (LOP^-) in oil prices on changes in agricultural household business terms of trade (LAHBTOT). Meanwhile, fertilizer prices (LFERP) have a significant negative

Table 4: Unit root test

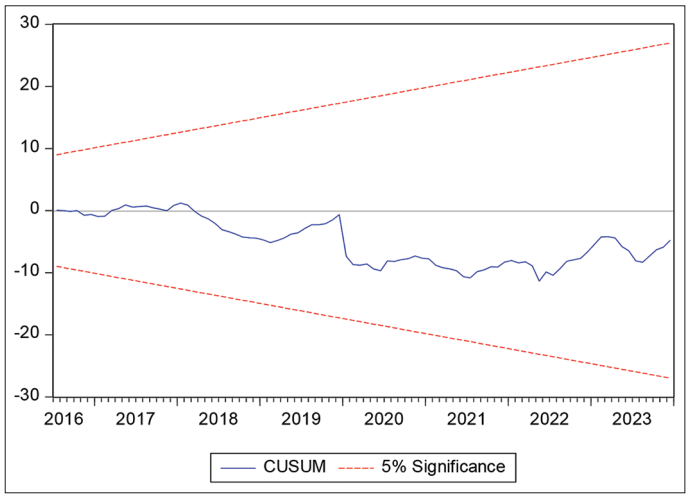
Variable	ADF test	DF GLS test	PP Test
In level			
LAHBTOT	−0.5278	−0.0115	−1.3602
LOP^+	0.3468	2.6056	0.6664
LOP−	−1.0413	2.0333	−0.8699
LFERP+	−0.3263	0.0810	0.9919
LFERP−	2.3550	5.7620	2.1951
LEXR+	−1.0249	3.7791	−1.0249
LEXR−	−0.2371	3.4307	−0.2375
LCPI+	−1.9091	0.8443	−2.0217
LCPI−	−1.6005	1.7967	−1.7380
LAGCR+	−3.0858**	1.0507	−4.9772***
LAGCR−	−0.2027	2.6251	−0.1704
In first difference			
ΔLAHBTOT	−8.9812***	−8.9838***	−9.2529***
ΔLOP+	−7.8648***	−6.7704***	−7.5980***
ΔLOP−	−7.2740***	−6.7799***	−5.9669***
ΔLFERP+	−7.1418***	−1.8064*	−6.9760***
ΔLFERP−	−6.9165***	−6.0057***	−6.9530***
ΔLEXR+	−9.7925***	−8.6174***	−9.7925***
ΔLEXR−	−10.958***	−5.1104***	−10.9564***
ΔLCPI+	−7.8266***	−6.9126***	−7.7415***
ΔLCPI−	−9.9147***	−9.4724***	−9.9142***
ΔLAGCR+	−11.6748***	−4.7342***	−11.6748***
ΔLAGCR−	−11.2442***	−10.389***	−11.2773***

***significant at α=0.01 **significant at α=0.05 *significant at α=0.1

Table 5: Bound tests results

F-stat	Sig.	I (0)	I (1)	Conclusion
4.0245	0.1	1.76	2.77	There is a long-run relationship
	0.05	1.98	3.04	
	0.01	2.41	3.61	

Figure 1: Model stability test



Source: Data, processed

effect and result in a decrease ($LFERP^-$) in LAHBTOT. A decrease in world fertilizer prices ($LFERP^-$) increases LAHBTOT, while an increase in fertilizer prices ($LFERP^+$) does not significantly decrease LAHBTOT. Therefore, the effect of world fertilizer prices on AHBTOT is asymmetric.

The decrease in the exchange rate ($LEXR^-$) is indicated by a reduction of Rp/US $, which means that the appreciation of the

Table 6: Long-run estimated parameters (response variable: LAHBTOT)

Regressor	Coefficient	t-statistic	Annotation
LOP^+	0.0477	0.5507	No asymmetric effect
LOP^-	−0.0714	−0.8520	
$LFERP^+$	0.0468	0.9326	There is an asymmetric effect
$LFERP^-$	−0.2847	−2.4927***	
$LEXR^+$	0.4814	1.0895	There is an asymmetric effect
$LEXR^-$	0.9847	1.7290**	
$LCPI^+$	−2.6650	−1.5509*	There is an asymmetric effect
$LCPI^-$	−1.3518	−0.2366	
$LAGCR^+$	0.3744	1.3806	There is an asymmetric effect
$LAGCR^-$	2.0314	1.8976**	

***significant at α=1% **significant at α=5% *significant at α=10%

Table 7: Short-run estimated parameter and error-correction term (ECT)

Regressor	Coefficient	Total effect	Annotation
$\Delta LFERP^-$	0.0241	0.2425	The impact of the decline in world oil prices on the decrease in AHBTOT is distributed over 5 months.
$\Delta LFERP^-(-1)$	0.0188		
$\Delta LFERP^-(-2)$	0.0958***		
$\Delta LFERP^-(-3)$	0.0284		
$\Delta LFERP^-(-4)$	0.0754***		
$\Delta LEXR^+$	−0.1260***	−0.3797	The impact of rupiah depreciation on the decline in AHBTOT is distributed over 3 months.
$\Delta LEXR^+(-1)$	−0.1445***		
$\Delta LEXR^+(-2)$	−0.1092**		
$\Delta LAGCR^-$	0.5558***	1.7563	The impact of the decline in agricultural credit on the decline in AHBTOT is distributed over 4 months.
$\Delta LAGCR^-(-1)$	0.2480		
$\Delta LAGCR^-(-2)$	0.2118		
$\Delta LAGCR^-(-3)$	0.7407***		
$ECT(-1)$	−0.1646***		

***significant at α =1% **significant at α=5%

rupiah significantly decreases AHBTOT, while the depreciation of the rupiah ($LEXR^+$) does not substantially affect AHBTOT. In this finding, there is an asymmetric effect of the influence of the exchange rate on agricultural household business terms of trade. An increase in the consumer price index ($LCPI^+$) which indicates inflation impacts a decrease in AHBTOT, and conversely a reduction in the consumer price index ($LCPI^-$) or deflation does not significantly increase agricultural household business terms of trade. There is an asymmetric effect between inflation and deflation on AHBTOT.

Agricultural credit (LAGCR) asymmetry affects the feasibility of farming businesses as measured by AHBTOT. A decrease in agricultural credit ($LAGCR^-$) significantly decreases AHBTOT, while an increase in credit ($LAGCR^+$) does not substantially increase AHBTOT.

In the short run, the influence of fertilizer prices, exchange rates, and agricultural credit affects agricultural household business terms of trade, the influence of which is distributed over several months, as shown in Table 7. The decline in fertilizer prices on agricultural household business terms of trade has a total influence of 0.2425, reducing agricultural household business terms of trade. Meanwhile, the exchange rate has a negative total influence. The depreciation of the rupiah reduces agricultural household business terms of trade. Agricultural credit has a positive total influence. It means that a decrease in agricultural credit will reduce agricultural household business terms of trade. From the total coefficient, it means that the influence of the decline in agricultural credit on agricultural household business terms of trade is the greatest compared to the influence of world fertilizer prices and the exchange rate.

In the long run, the decline in world fertilizer prices increases agricultural household business terms of trade. Fertilizer is an essential input in agricultural production. The decline in world fertilizer prices will reduce the burden of production costs for domestic agricultural businesses. In the long run, inflation affects the decline in agricultural household business terms of trade. Inflation causes production costs to increase relative to sales revenues, which increases agricultural household business terms and trade falls. Agricultural sector credit in this study positively affected agricultural household business terms of trade. The decline in agricultural credit impacts the feasibility of agricultural businesses. Increasing credit can increase agricultural production capacity. Access to credit can increase the ability of farmers to produce efficiently, thereby providing more significant benefits for agricultural businesses. In the short and long run, the influence of credit is huge for agricultural household businesses.

4.2. Discussion

The study results show that the increase and decrease in world crude oil prices do not significantly impact the agricultural household business terms of trade in Indonesia. This condition is made possible by fuel subsidies that dampen the effect on fuel costs for farmers' household businesses. The results of this study are consistent with the results of a previous study by Arintoko et al. (2025) that the increase in world oil prices does not significantly increase the costs paid by farmers because it is made possible by fuel subsidies. With fuel subsidies removed, the rise in oil prices impacts the costs paid by small-holder farmers in agricultural production, as empirically found by Sennuga et al. (2024).

In the long run, the asymmetric effect of world fertilizer prices on agricultural household business terms of trade in this study. The increase in world fertilizer prices did not significantly reduce agricultural household business terms of trade. The existence of fertilizer subsidies allows the price of fertilizer paid by farmers to be stable and not affected by the increase in world fertilizer prices. This finding aligns with the understanding that fertilizer subsidies can increase the productivity of small-scale agricultural businesses, as found in a study by Nasrin et al. (2018). Conversely, a decrease in world fertilizer prices significantly increases agricultural household business terms of trade. The decline in world fertilizer prices can be transmitted to the reduction in domestic fertilizer prices, especially non-subsidized fertilizers, so that it can reduce the cost of purchasing fertilizer for farmers, thereby increasing efficiency. The results of this study also confirm previous empirical findings in a study by Arintoko et al. (2025) related to farmers' terms of trade.

Rupiah depreciation against the US dollar only significantly impacts the decline in agricultural household business terms of trade in the short run. Rupiah depreciation passed through to the

increase in import prices impacts the rise in production costs from purchasing imported agricultural inputs. The increase in agricultural production costs impacts the decline in agricultural household business terms of trade. Empirical findings related to exchange rate pass-through to agricultural import prices have been obtained by Alvarez et al. (2019). So, the performance of agricultural household businesses is responsive to changes in exchange rates in the short run.

In the long run, the increase in CPI, which means significant inflation, lowers the agricultural household business terms of trade. Inflation is likely to increase the cost of agricultural production relative to the revenue from farmers' sale of farm products. This study's results align with empirical findings by Janet (2024) and Wu et al. (2024). Even at the macro level, inflation has a negative effect on the growth of the agricultural sector, as stated in the study by Mekonen (2020).

According to the study results, agricultural credit is the main supporting factor for farmers in operating agricultural businesses. Agricultural credit positively impacts agricultural household business terms of trade in the short and long run. Agricultural credit increases the capacity and productivity of agricultural businesses, thus increasing income due to increased sales of agricultural products. Reduction in agricultural credit impacts decreasing agricultural household business terms of trade. This study's results align with empirical findings by Yuni et al. (2022) and Haryanto et al. (2023) that agricultural credit increases the productivity of agricultural businesses.

5. CONCLUSION

World crude oil prices do not significantly impact agricultural household business terms of trade in the short and long run. This condition is made possible by fuel subsidies that cause the rise and fall of world oil prices and do not affect fuel expenditure for agricultural business operations. Small-scale agricultural businesses and small-holder farmers generally consume subsidized fuel. Meanwhile, the increase in world fertilizer prices does not significantly impact agricultural household business terms of trade, which is also possible due to fertilizer subsidies. However, the decline in world fertilizer prices can increase the use of fertilizers, especially non-subsidized fertilizers, thereby increasing agricultural productivity.

Rupiah appreciation reduces agricultural household business terms of trade in the short run through increased production costs from imported inputs. Conversely, inflation has a negative impact on agricultural household business terms of trade in the long run through increased production costs rather than its effect on farmer income. Overall, agricultural credit is the most important supporting factor in increasing the capacity and productivity of farming businesses, both in the short and long run, as it is related to the need for working capital and investment in agricultural businesses.

An important implication of the findings of this study is that fuel subsidies and fertilizer subsidies can be a dampener from the volatility of world oil and fertilizer prices so that they do not have a negative impact on agricultural businesses. Meanwhile, the stabilization of inflation and exchange rates and the expansion of agrarian credit can support the performance of agricultural businesses. Fuel and fertilizer subsidy policies must always be in synergy with monetary policy in supporting the improvement of agricultural businesses for small-holder farmers.

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