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Factors Influencing Farm-Gate Shrimp Prices in Thailand: An Empirical Study Using the Time Series Method

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Abstract

The objective of this research was to analyze the factors influencing the farm-gate shrimp prices in Thailand using monthly time series from January 2001 to December 2019. The econometric methodology was employed to satisfy the purpose, consisting of the cointegration test for revealing the long-run relationship and equilibrium elasticity between the variables as well as the error correction model for detecting speed adjustment to shock responses. The empirical results revealed that (1) the export shrimp prices, shrimp production in the country, and shrimp export volume indicated a long-run relationship running to the farm-gate shrimp prices in Thailand with the size of equilibrium elasticity equal to 1.083%, –0.256%, and 0.123, respectively, and (2) the farm-gate shrimp prices in Thailand would adjust to the equilibrium line with a speed equal to 20.147% if there was any kind of incident or shock which caused the relationship to deviate from the equilibrium point. There was no relationship in terms of global shrimp prices and the exchange rate for farm-gate shrimp prices in Thailand. The recommendations should emphasize the varieties of shrimp products for export to other countries beyond the main trading markets nowadays to reduce risks and fluctuations in the export prices of shrimp products.

Keywords: Cointegration, Error Correction Model, International Trade, Economic Development

JEL Classification Code: C22, Q13, Q21, Q22, N55

1. Introduction

Thailand has a comparative advantage for shrimp farming and production because of the appropriate ecosystems and suitable weather in the region for the growth of shrimp. The landscape of the country, which has 23 provinces by the sea with a total coastal length of 3,151.10 kilometers, is also beneficial. This has led many farmers in the region to become interested in shrimp farming. Hence, shrimp are leading economic aquaculture in the agricultural sector, playing an important role in the economic growth of the country and making it possible to generate revenue totaling several billion baht per year from exporting to foreign markets. Furthermore, the shrimp farming system used by farmers in Thailand has been recognized worldwide for its high level of quality, advanced technology for farming, and the standard control system for shrimp culture in every step, such as good/best aquaculture practice (G/BAP), code of conduct (CoC), aquaculture stewardship council (ASC), organic aquaculture, etc. Moreover, the return from shrimp farming in comparison with other agricultural commodities and marine aquaculture demonstrates that shrimp farming has a favorable return, making it more attractive to farmers. However, such activity requires significant investment and carries risks in farming such as shrimp disease, price volatility, and rising production costs from shrimp feed prices, among others.

The marine shrimp culture of Thailand has been continuously developed for more than 30 years. It can be said that Thailand is a global leader in shrimp culture, farming management, product processing, and other exports.

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Moreover, most of the shrimp processing factories and products of Thailand use advanced technology as well as more effective processing than competitors. Hence, they can satisfactorily develop shrimp products to respond to the needs of importing countries. Thailand also has a reputation for quality and chemical/antibiotic residue-free shrimp products. Therefore, the export of shrimp products from Thailand has a comparative advantage in comparison with competitors such as China, Ecuador, Vietnam, India, Indonesia, etc. Shrimp products from Thailand can generate significant revenue for the country and play an important role in the economic growth of the agricultural sector (Department of Fisheries, 2014). According to the 2019 report from the Office of Agricultural Economics (2020a), Thailand had a total shrimp farming area of roughly 224,486 rai (6.25 rai = 1 hectare). Almost all of the shrimp farming areas comprised Pacific white shrimp farming. There were 21,786 farms with a total production of 370,201 tons. The average farm-gate prices and production cost equaled 144.25 baht and 118.38 baht, accordingly. For shrimp product trading in Thailand, it was revealed that the export volume for shrimp products equaled 175,495 tons in 2019, which was equal to 51,719 million baht in value. Thailand's main trade partner countries for shrimp products are China, the United States of America, Hong Kong, South Korea, Taiwan, the European Union, and Canada, among others.

The shrimp industry in Thailand is highly dependent on the world market. In other words, more than 85% of shrimp produced in this country is exported to be sold in foreign markets in the form of fresh shrimp, chilled or frozen shrimp, seasoned shrimp, and products from shrimp in various forms. Hence, the price of shrimp in Thailand is dependent on economic conditions in the world market, such as the economic growth in trading countries, non-tariff barriers, demand and supply in the world market, and global shrimp prices. The economic factors in the country that also affect shrimp prices include exchange rate, climate change, shrimp disease, demand and supply in the country, to name a few (Office of Agricultural Economics, 2020a, 2020b).

For this reason, the objective of this study is to analyze the factors influencing farm-gate shrimp prices, meaning the prices that farmers charge in Thailand. Such discovery will be beneficial to culturing shrimp farmers, entrepreneurs, factory-processed shrimp products as well as private business sectors that export shrimp products to the world market to be used in the decision-making, production management, and strategic planning in business for maximum effectiveness. Furthermore, the government sector and related stakeholders can use these empirical findings as a guideline to create strategic planning to improve and promote the Thailand shrimp industry throughout the entire supply chain system. This work is structured as follows. The literature review is given in Section 2. It presents previous research articles that are related to this issue. Section 3 displays the data, variables, and research methodology. The methodology of this study applies time series techniques such as the stationary test using the ADF unit root, the cointegration test based on the concept of Engle and Granger's (1987) approach, and the short-run adjustment analysis through the error correction model. Section 4 reveals the empirical results, while the last section provides the concluding remarks along with the policy recommendation, as shown in Section 5.

2. Literature Review

According to previous research articles, it was found that few studies focused on the economic indicators that influenced shrimp prices in Thailand in comparison with studies in the same nature concerning other agricultural commodities. Nevertheless, it was shown that there were studies about the impact of macroeconomic variables toward agricultural commodities in different price levels, such as the study of Tunjaroen et al. (2019), which analyzed the factors influencing coconut prices in Thailand using multiple regression analysis based on a monthly time series from January 2008 to August 2019. The results of Tunjaroen et al. (2019) revealed that the factors influencing the coconut prices in Thailand were coconut prices in the global market, the exchange rate, and the consumer price index. Moreover, Hermawan and Maipita (2017) analyzed the factors affecting rice prices in Indonesia using multiple regression analysis based on an annual time series from 2000 to 2014. The results of Hermawan and Maipita (2017) showed that the factors affecting rice prices in Indonesia included exchange rate and personal income in the country, which coincided with the study of May (2010), who concluded that the exchange rate was one of the major factors influencing the export of several agricultural commodities in Thailand, namely, rice, rubber, tapioca, sugar, and maize. A monthly time series from 1981 to 2006 was applied using the autoregressive integrated moving average with exogenous (ARIMA) and autoregressive conditional heteroskedasticity (ARCH) approaches.

Besides, the study of Ma et al. (2015) analyzed the impact of the world oil price toward agricultural commodity prices in China such as soybean, maize, wheat, colza oil, and japonica rice. The study used a weekly time series from June 2002 to August 2013. The analysis was carried out with time series techniques such as a long-run equilibrium test using the Johansen cointegration, causal relationship test with the Granger causality analysis, and shock interactions through impulse response function. Ma et al. (2015) showed a long-run equilibrium relationship running from the world oil prices to soybean prices in China in only one direction because there are not many kinds of soybean in China, so export to the world market is not a very high proportion. Soybean is a commodity that can also be used to produce bioenergy. Hence, global oil prices have a direct influence on the soybean prices in China. This is consistent with the conclusions of Esmaeili and Shokoohi (2011) and Nazlioglu and Soytas (2012), who found that the world oil prices have a direct and indirect impact on most of the agricultural commodity prices in the world market as well. However, the results of Esmaeili and Shokoohi (2011), Nazlioglu and Soytas (2012), and Ma et al. (2015) were not consistent with the studies of Zhang et al. (2010) and Fowowe (2016), which did not find a long-run equilibrium relationship between global oil prices and agricultural commodities.

Apart from the macroeconomic indicators impacting agricultural commodity prices in the country, it also revealed that the prices in various levels have an influence on each other, such as the relationship among farm-gate prices, wholesale prices, retail prices, export prices, world market prices, and others. For example, Wanaset and Jatuporn (2020) studied the price response regarding the Para rubber market in Thailand using a monthly time series from January 2001 to December 2019. The data was analyzed based on the vector autoregressive (VAR) model and impulse response function. The results of Wanaset and Jatuporn (2020) showed that the domestic prices of Para rubber responded to the changes in the prices of the world market. Further, it would take 4–5 months to adjust to equilibrium. However, the world price of rubber affecting domestic prices was also confirmed by the study of Srisuksai (2020).

Furthermore, Kharin (2015) analyzed price transmission between farm-gate prices and retail prices in the dairy market in Russia using a monthly time series from 2002 to 2014. The analysis was based on the autoregressive distributed lag (ARDL) model and the Granger causality test, which revealed that there was no long-run equilibrium relationship between farm-gate prices and retail prices in the dairy market in Russia. However, short-run interaction based on the Granger causality showed that retail prices were a determinant of the changes in farm-gate prices in the dairy market in only one direction. Nevertheless, the study of Alam et al. (2012) analyzed the relationship between rice prices in the world market and rice prices in Bangladesh using the econometric technique to conduct a long-run equilibrium analysis using the Johansen cointegration and the short-run adjustment analysis by the vector error correction model (VECM). The results of Alam et al. (2012) revealed that there was a long-run equilibrium relationship between world market prices and domestic prices in the rice market of Bangladesh in only one direction. Likewise, Wulandari et al. (2020) studied the causal relationship between production input and the price of rice in East Java, Indonesia using the Johansen cointegration and VECM. The results of Wulandari et al. (2020) showed a long-run equilibrium relationship among the volume of rice production, total population, and rice price in East Java, Indonesia.

3. Research Methods and Materials

3.1. Data and Variables

This study uses secondary data based on a monthly time series from January 2011 to December 2019. The amount of data totaled 108 months, while the variables employed in the analysis consisted of dependent variables, namely farm-gate prices (P_{FG}) using the Pacific white shrimp prices of Thailand at the farm-gate price level that can be sold by farmers using the unit of baht/kilogram, and independent variables such as (1) export prices (P_{EX}) using the free on board (FOB) prices of Thailand's shrimp exports with the unit of baht/kilogram, (2) world prices (P_W) using the global shrimp prices with the unit of US$/kilogram, (3) shrimp production (Q_{FG}) using the production index of shrimp in Thailand by seasonal adjustment with the unit of the year 2005 = 100, (4) shrimp exports (Q_{EX}) using the export volume of Thailand's shrimp to the world market by seasonal adjustment with the unit of a kilogram, and (5) exchange rate using the real effective exchange rate (REER) as a reflection of real purchasing power and the production ability of a country. The increase of currency index means the baht gets stronger in comparison with the currency of Thailand's trading partners and trading competitors.

Moreover, the variables have been transformed in the form of the logarithm function (L) to describe the relationship between each other in the form of percentage change between variables or elasticity. The time series were obtained from the Thailand's Office of Agricultural Economics, the Bank of Thailand, and the World Bank.

3.2. Econometrics

Analysis based on the time series technique is necessary to initially check the data attributes; if the non-stationary time series is used for relationship analysis, the results from the analysis will be affected by the influence of time or lead to a spurious regression problem (Granger & Newbold, 1987). However, there needs to be data attribute checking for this reason, which is achievable by testing the stationarity through the Augmented Dickey-Fuller (ADF) unit root of Dickey and Fuller (1979, 1981). The testing process can be shown with equation (1) below.

$$\Delta Y_t = \alpha_0 + \delta T + \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta Y_{t-i} + \varepsilon_t$$

Where Δ is the differencing order, Y is the time series, namely LP_{FG}, LP_{EX}, LP_{W}, LQ_{FG}, LQ_{EX}, and LREER, α is the constant or the intercept term, β is the estimated coefficient, T is the time trend, t is the time period, p is the lag length selected based on the lowest value of the Bayesian Information Criterion (BIC), and ε is the error term.

The analysis of the long-run equilibrium relationship using the cointegration test according to Engle and Granger (1987) consists of two steps: (1) modeling the long-run equilibrium to capture the residual series, and (2) testing for the stationarity of the residual series using the ADF unit root, which can present the testing process as equations (2)–(4) below.

(1) Modeling long-run equilibrium to create the residual series.

$$Y_t = \alpha_0 + \beta_1 X_t + \varepsilon_t$$
$$\hat{\varepsilon}_t = Y_t - (\alpha_0 + \beta_1 X_t)$$

Where $\hat{\varepsilon}_t$ is the estimation of residual series, Y is the dependent variable (LP_{FG}), and X is the independent variables, namely LP_{EX}, LP_{W}, LQ_{FG}, LQ_{EX}, and LREER.

(2) Testing for the stationarity of the residual series using the ADF unit root.

$$\Delta\hat{\varepsilon}_t = \beta_1 Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta\hat{\varepsilon}_{t-i} + v_t$$

Where v is the white noise. According to the concept of Engle and Granger (1987), the model does not include the constant and time trend in testing the stationarity for the residual series (Asteriou & Hall, 2007).

The stationary testing of the residual series in the level stage of $I(0)$ process can be found in two conclusions.

(1) The residual series does not have stationarity in the level stage. That is to say, the residual series is not an $I(0)$ process. Therefore, it can be summarized that there is no long-run equilibrium or cointegration result. That being said, the relationship in equation (2) may have a spurious regression result.
(2) The residual series has stationarity in the level stage. That is to say, the residual series is an $I(0)$ process. Therefore, it can be summarized that there is a long-run equilibrium or cointegration result. That being said, the relationship in equation (2) has no spurious regression problem.

Once the relationship according to equation (2) has cointegrated between the variables, it will open up the opportunity to analyze the short-run dynamic adjustment to equilibrium through the error correction model (ECM), as presented in equation (5).

$$\Delta Y_t = \alpha_0 + \beta_1 \Delta X_t + \sum_{i=1}^{p} \beta_2 \Delta X_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta Y_{t-i} + \gamma \mathrm{ECT}_{t-1} + \varepsilon_t$$

Where γ is the speed of adjustment and ECT is the error correction term.

4. Empirical Results

The results in Table 1 present the ADF unit root according to equation (1) for the stationary testing, consisting of six variables including farm-gate shrimp prices (LP_{FG}), shrimp export prices (LP_{EX}), world shrimp prices (LP_{W}), shrimp production (LQ_{FG}), shrimp exports (LQ_{EX}), and exchange rate (LREER). All the variables are transformed into the logarithm function; the model of the ADF unit root is included in the constant and the time trend. In the results of the stationary test for the time series in Table 1, it shows that LP_{FG}, LP_{EX}, LP_{W}, LQ_{FG}, LQ_{EX}, and LREER variables present the statistical value for t-ratio at (0.820), (–1.439), (–2.874), (–2.900), (–1.877), and (–1.882), respectively. This means that all the variables cannot reject the null hypothesis (H_0: Non-stationarity) by considering statistical significance at a level of 0.05. For this reason, the first order of difference must be added and tested again for stationarity. Then, the results of the ADF unit root for the six variables reveal that the variables of LP_{FG}, LP_{EX}, LP_{W}, LQ_{FG}, LQ_{EX}, and LREER present t-ratio of (–8.939), (–8.865), (–4.594), (–7.650), (–11.580), and (–7.078), respectively. This means that the first order of difference for the time series can reject the null hypothesis by considering statistical significance at a

Table 1: The Results of the ADF Unit Root Test

Variable	Level Stage $I(0)$		First Difference $I(1)$	
	t-statistic	*p*	*t*-statistic	*p*
LP_{FG}	0.820	2	–8.939*	1
LP_{EX}	–1.439	0	–8.865*	0
LP_{W}	–2.874	1	–4.594*	0
LQ_{FG}	–2.900	0	–7.650*	3
LQ_{EX}	–1.877	0	–11.580*	0
LREER	–1.882	0	–7.078*	2

Note: *refers to the statistical significance at a level of 0.05, and p is the lag length of AR(p) selected by the lowest value of the BIC.

Table 2: The Results of the Cointegration and ECM Tests

Variable	Coefficient	S.E.	*t*-Ratio	*p*-Value
α_0	–1.880	1.159	–1.621	0.108
LP_{EX}	1.083	0.109	9.880	<0.001
LQ_{FG}	–0.256	0.042	–6.040	<0.001
LQ_{EX}	0.123	0.055	2.230	0.027
R-squared	0.848			
ADF(*t*-ratio)	–4.622			
ADF(*p*-value)	<0.001			
$ECT_{t-1}(\gamma)$	–0.201			
ECT_{t-1}(*p*-value)	0.002			

Note: S.E. is the standard error.

level of 0.05. Hence, the results of the stationary test can conclude that the entire time series in Table 1 contains stationarity $I(1)$ processes which have according to the requirement in the long-run relationship test based on the concept of Engle and Granger's (1987) cointegration.

The long-run relationship analysis using Engle and Granger's (1987) cointegration in Table 2 reveals the factors influencing the farm-gate prices (LP_{FG}) using a 0.05 level of statistical significance. However, the results of the analysis in Table 2 removed the variables that do not have statistical significance, namely world prices (LP_W) and exchange rate (LREER). Hence, the factors influencing farm-gate shrimp in Thailand include export prices (LP_{EX}), shrimp production (LQ_{FG}), and shrimp exports (LQ_{EX}). Then, the residual series is created from the above-mentioned model to test the stationarity using the ADF unit root, which found that the residual series presents a *t*-ratio of (–4.622). This means that, at the level stage, the result of the ADF unit root can reject the null hypothesis. Therefore, the variables of LP_{FG}, LP_{EX}, LQ_{FG}, and LQ_{EX} have a long-run relationship or there is long-run cointegration running from LP_{EX}, LQ_{FG}, and LQ_{EX} to LP_{FG}, which opens up the opportunity to analyze the short-run adjustment of the farm-gate prices (LP_{FG}) based on the ECM model by considering the ECT coefficient. The results of the short-run dynamic analysis reveal that the coefficient value (γ) is equal to (–0.201) with a statistical significance of 0.01.

The explanation of the long-run relationship based on the cointegration method in Table 2 can explain the percentage change or elasticity between the dependent variable and the independent variables presented below.

If one percent of the export price (LP_{EX}) is increased, it will impact the farm-gate price increase by 1.083% at a statistical significance of 0.01. If one percent of shrimp production (LQ_{FG}) is increased, it will impact farm-gate price decrease by 0.256% at a statistical significance of 0.01. If one percent of shrimp exports (LQ_{EX}) is increased, it will impact farm-gate price increase by 0.123% at a statistical significance of 0.05.

To analyze the model performance in Table 2, the export prices (LP_{EX}), shrimp production (LQ_{FG}), and shrimp exports (LQ_{EX}) can be used to explain the movement of the farm-gate prices (LP_{FG}) at 84.833%, while another 15.167% occurred from other factors that are not included in the model. Besides, the analysis of the adjustment into equilibrium using the ECM model can explain the speed of the adjustment in the case of a shock situation or abrupt change that can lead to deviation from the equilibrium line. The results of the analysis in Table 2 show that farm-gate prices (LP_{FG}) will return to equilibrium with a speed level equal to 20.147%.

5. Concluding Remarks

The shrimp culture has an important role in the economic growth of Thailand. When shrimp products are exported in massive amounts, it brings revenue and income into the country amounting to billions of baht per year. Shrimp farmers have improved and developed the farming and production system, making it acknowledged globally. Moreover, several related industries have extensive experience and are able to have comparative advantages in the global shrimp market such as processing factory entrepreneurs, shrimp feed business and marine feed industry, medicine and chemical supplies, export business of shrimp products, and so on. However, the political conditions and economic situation, both domestically and internationally, are fluctuating, which causes uncertainty in the prices of shrimp in the country. Hence, the main objective of this empirical study is to analyze the factors that influence domestic shrimp prices at the farm-gate level in Thailand by considering related factors such as export shrimp prices, shrimp prices in the world market, and shrimp production in the country, as well as the export volume of Thailand's shrimp and the exchange rate in Thailand. For data used in this study, a monthly time series was considered from January 2011 to December 2019 with a total sampling of 108 months. The research methodology employed econometrics, including (1) the stationary test of time series using the ADF unit root, (2) the long-run relationship test using cointegration analysis in accordance with the Engle and Granger's (1987) approach to explaining the equilibrium of the relationship between the variables, and (3) the short-run adjustment analysis of the farm-gate prices using the ECM test to measure the level of speed into the equilibrium line in the case that such a relationship digresses due to shock changes in export shrimp prices, world shrimp prices, shrimp production, shrimp export volume, or exchange rate.

The empirical results revealed that export shrimp prices, shrimp production, and shrimp export volume have a long-run relationship with the farm-gate prices in Thailand. The elasticity of the equilibrium has values equal to 1.083%, –0.256%, and 0.123%, respectively. Meanwhile, the shrimp prices in the world market and the exchange rate do not have any relationship with the farm-gate shrimp prices in Thailand based on the fact that Thailand is a small-scale shrimp producer and exporter in the world market with a production proportion of only 5.95% and 5.64% in comparison with the overall output and market share in the world market, respectively (Office of Agricultural Economics, 2020b). Regarding the positive relationship, it reveals that the export shrimp prices have an influence on the farm-gate shrimp prices in Thailand with the largest amount of influence because more than 85% of shrimp production will be exported in some form. Hence, export shrimp prices or FOB shrimp prices are a variable that highly influences shrimp prices in the country. The production quantity of shrimp and the export volume of shrimp have a relationship as expected signs. Specifically, the production quantity of shrimp in the country is theoretically similar to the shrimp supply, so the sign is expected in the opposite direction with the farm-gate shrimp prices. While the export volume of Thailand's shrimp is theoretically similar to the demand for shrimp, the sign is expected in the same direction as the farm-gate shrimp prices. Regarding policy recommendations, the government and private sectors should emphasize the extension of shrimp production in terms of product varieties for export to other countries beyond the main trading markets nowadays to reduce risks and fluctuations in the export prices of shrimp products. However, Thailand has encountered severe shrimp diseases during the past ten years (such as Early Mortality Syndrome: EMS), causing the continuity of lower productivity that has still not fully recovered. It also raises the costs of shrimp culture and farming. Hence, farmers, the government sector, the private sector, and related stakeholders should actively provide policies and measures to address the problems mentioned previously, such as investment in research and development for marine shrimp species, shrimp breeding development, shrimp farming system improvement, shrimp breeding improvement to resist the shrimp disease, and climate change variability. Furthermore, the government and private sectors should also provide knowledge and marketing information to shrimp farmers as well as arrange funding to develop modern and standardized farming technology in shrimp culture. With regards to suggestions for future research, other types of models such as the VAR model, the Johansen cointegration, and the impulse response function should be included in the analysis to compare the results of this study for accuracy and efficiency. The conclusions from this study showed that export shrimp prices tend to influence farm-gate shrimp prices at a high level. Therefore, there should be an analysis of the price transmission in the shrimp market of Thailand by using models that can measure the market efficiency, such as the asymmetric price transmission (ATP) model, Threshold autoregressive (TAR) model, and nonlinear ARDL (Meyer & Von Cramon-Taubadel, 2004; Frey & Manera, 2007; Mehta et al., 2021; Qamruzzaman et al., 2021). Furthermore, research should be undertaken in terms of production costs and price analysis in various dimensions throughout the supply chain from the upstream market to downstream market for both vertical and horizontal prices. Likewise, there should be a guideline for fair sharing benefits to all stakeholders and to reduce costs in all product segments.

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