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THE STUDY ON THE CORRELATION BETWEEN WHOLESALE PRICE AND TRADING VOLUME IN TAIWAN MILKFISH MARKET

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ABSTRACT

The unit root test, vector autoregressive (VAR) model, Granger causality test, and impulse response function are applied in this study to explore the correlation between wholesale price and trading volume of milkfish in Taiwan milkfish market over the period 2001- 2017. The empirical results show that both the wholesale price and the trading volume of the Taiwan milkfish market are stationary series, and there is a bidirectional causal relationship between the two. That is, the price and the volume of the milkfish affect each other, i.e., there is a short-term and interactive relationship between the wholesale price and the trading volume. When the wholesale price rises (falls), there would be a negative (positive) relationship in the first and second period, and a positive (negative) response in the seventh period. If the trading volume increases (decreases) in the current period, then the price would experience decline (increase) in the first period.

Contribution/ Originality: The paper's primary contribution is finding that there is a short-term, cyclical relationship between the wholesale price and the trading volume of the Taiwanese milkfish market. When the milkfish market is in the high-production period, the trading volume increases, causing the wholesale price to fall; otherwise, the price rises. This verifies our finding that the wholesale price and trading volume of milkfish shows a bidirectional causal relationship.

1. INTRODUCTION

As a warm-water fish mainly distributed in subtropical or tropical waters, milkfish is an important catch in Southeast Asia. In addition to Taiwan, Southeast Asian countries such as the Philippines and Indonesia perform milkfish aquaculture. For the aquaculture and fisheries in Taiwan, the milkfish has been developed for a long time and its farming technology is now mature. It can be raised in both freshwater and seawater farms. By 2017, the total aquaculture area in Taiwan reached 43,877.08 hectares, of which milkfish farm accounted for 9,647.52 hectares and was the largest farm among all fishery cultures. The annual milkfish production reached 52,220 metric tons, which accounted for 18.45% of the total production of the aquaculture industry, accounted for 11.33% of the total aquaculture production value, milkfish production was valued at the neighborhood of NT$4.1 billion, which is the highest among all aquaculture fisheries. It is clear that milkfish plays a very important role in Taiwan's aquaculture fishery.

For sustained development of Taiwan's aquaculture fisheries, the government has made great efforts to promote it, resulting in a great increase in the production capacity. Due to the constant progress in the aquaculture technology, there is an oversupply of milkfish during production period which in turn causes the market price to be sluggish. However, during the winter non-production period, the price rises. In addition, the cultivation of milkfish is susceptible to the characteristics of water supply, weather environment, culture technology, and seasonal changes, which present an imbalance between supply and demand. Therefore, how to stabilize the imbalance between production and sales is a key question for the future development of the milkfish industry.

In general, the supply and demand of agricultural products will be reflected in the price. Since the production and sales of milkfish are susceptible to weather and seasonal changes, producers will form different expected price during the farming process. The fluctuation in the expected price in turn affects the trading volume of the market. Thus, understanding the relationship between price and trading volume on the market is important. Figure 1 and 2 show the changes in the wholesale price and wholesale trading volume of the milkfish market in Taiwan over the years of 2001 to 2017. It is clear from Figure 1 that the wholesale prices per kilogram of milkfish fluctuate widely, ranging from NT$35.2 to NT$113.1 It can be seen from Figure 2 that the wholesale trade volume of milkfish also fluctuates significantly. Therefore, if the causal relationship between the price of the milkfish and the trading volume can be predicted, it will help the breeders to react in advance to the volume of milkfish, thereby increasing their income. As such, analyzing the causal relationship between prices and quantities of milkfish is an important issue.

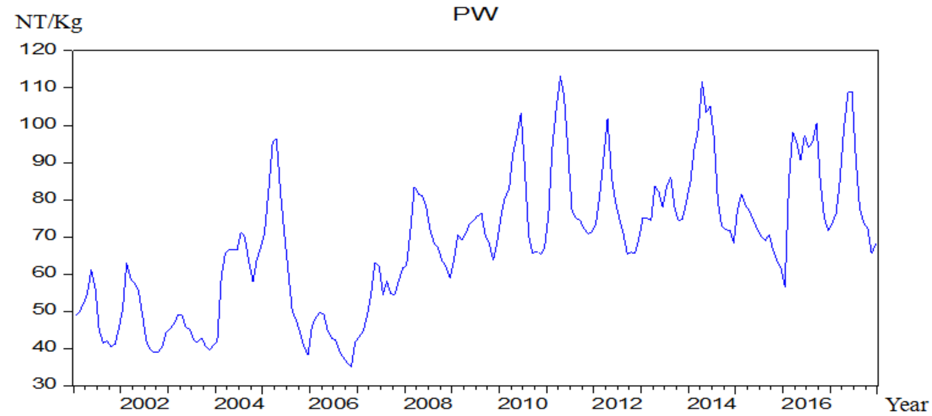

Figure-1. Wholesale price of the milkfish in Taiwan from 2001 to 2017.
Source: The data come from the Fisheries Agency, Council of Agriculture, Executive Yuan, 2001-2017.

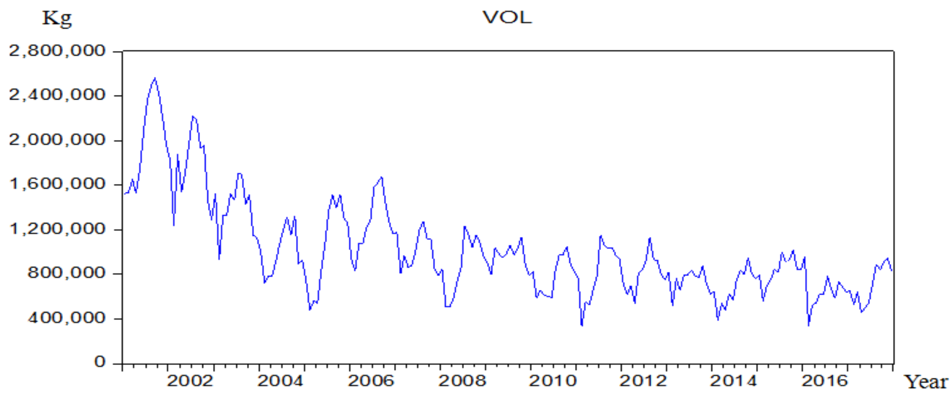

Figure-2. Wholesale trading volume of the milkfish in Taiwan from 2001 to 2017.
Source: The data come from the Fisheries Agency, Council of Agriculture, Executive Yuan, 2001-2017.

In the past, there have been many studies on the causal relationship between prices and trading volumes in financial markets, such as Chen *et al.* (2001); Lee and Rui (2002); Chen *et al.* (2004); Lee (2009) and Kappou *et al.*

(2010). However, these studies focus on the price relationship between stocks and bonds, falling short on discussion of the price relationship in other markets. As for the discussion on other markets, especially in the analysis of the fishery products market, focus is often on studying the price relationship between markets. For example, Ling (2003) analyzes the cointegration relationship between wholesale and retail prices of the milkfish market in Taiwan. Chen *et al.* (2002) use the equivalent critical model and the cointegration model to test the extent of price integration of Tilapia from two fish farms in Taipei and Taichung. Chen *et al.* (2004) use the Parity Bounds Model (PBM) and the Ravallion model to perform a comprehensive check on eleven species of fish in Taiwan's main fish market. Sun and Hsieh (2000) use the transfer function model to analyze the price relationship between canned fish market in Thailand. Xiao *et al.* (2003) use a simple predictive model, a recursive predictive model, and an ARIMA model to predict the feed cost, production volume, temperature, and price of Taiwan milkfish.

In summary, the price fluctuation of milkfish may be related to the trading volume. If the aquaculture industry can full understand the relationship between price and quantity of milkfish in advance, it will help plan for production. Therefore, the main objective of this study is to explore the correlation between the wholesale price and the trading volume of Taiwan's milkfish market. The rest of this paper is organized as follows. In section 2, we present a detailed review of relevant literature. Section 3 describes the research methods, followed by an empirical results analysis in section 4. Section 5 delivers the conclusions of this study.

2. LITERATURE REVIEW

In the current literature, there are many studies on the causal relationship between market trading volume and price (return). However, most of them focus on commodity markets or financial markets (stocks and foreign exchange markets). For example, Saunders (1988) points out that in most early works on verification of the relationship between of supply of US money and nominal price of agricultural products, the length of autoregressions (i.e., the lag) were arbitrarily chosen, so none of the directions on the causal relationship thus obtained was conclusive. Hsiao (1981) proposes using the final prediction error to select the optimal lag period for causality verification. The empirical results showed that the US currency base and the Food Consumer Price Index are connected by unidirectional causality.

Sun and Hsieh (2000) use the transfer function model to analyze the price/volume relationship in the canned tuna market in Thailand, and find that the price of the current period is affected by the sales volume of the previous four and three periods. Long-term price trend for a period over four months shows that sales volume is negatively correlated with price. Granger causality test results, however, shows a unidirectional causal relationship where quantity would affect price, but not price quantity.

Pagan and Schwert (1990) and Nelson (1991) use EGARCH models and Chen *et al.* (2001) use Granger (1969) bivariate VAR to verify and compare the relationships among returns, trading volumes, and volativity of nine countries with major stock markets. VAR estimates show that only Switzerland, the Netherlands, and Hong Kong had a bidirectional causal relationships between return and trading volume. As to the causal relationship between return and trading volume for the rest of the countries, the volume is stronger than the return.

Lee and Rui (2002) use the Granger (1969) bivariate VAR to test whether there is a causal relationship between daily market volume and stock price indices in the three largesst stock markets, namely, New York, Tokyo, and London. They find that the trading volume s does not lead the stock price in all three stock markets.

Using a simple prediction model, a recursive prediction model, and an ARIMA model, Xiao *et al.* (2003) predicts the feed cost, output, temperature, and price of Taiwan milkfish. He finds that these three methods are only suitable for short-term prediction, and that the wholesale price of the origin does not necessarily generate positive impact on the supply volume. However, the pre-supply volume and production cost (in terms of fry price and feed price) has a positive impact on the direction of the current supply, which is in line with theoretical inferences.

Chen *et al.* (2004) use correlation analysis and Granger causality to determine the leading/ lagging relationship between return and trading volume of four major commodity futures, namely, copper, aluminum, soybean, and wheat, in mainland China. The causality check finds that, except for the aluminum futures market, all these futures reflect a significant causal relationship between the absolute return of the closing price and the trading volume.

Hua and Chen (2007) use Johansen (1988) cointegration assay, error correction model, Granger causality test, and impulse response analysis the relationship of futures market between mainland China and the world. It is found that there is a cointegration relationship between the futures prices on the Shanghai Futures Exchange and those on the London Metal Exchange for aluminum and copper.

Chen *et al.* (2002) apply the parity bounds model to test the aquaculture fish market integration in Taipei and Taichung, and compare the results with other cointegration models. The results show the parity bounds model in high-degree of market integration and it provides more information regarding market integration.

Later, Chen *et al.* (2004) use the parity bounds model to study market integration of Taipei and Taichung aquaculture markets and compare the results with those of the Ravallion model. The results show that most of fishes boast high-degree of market integration. In addition, the degree of market integration for cultured fishes is lower than that for cold storaged fishes, that means the marketing system for cultured fishes should improve.

Ling (2003) analyze the interdependent behavior of lead-lag milkfish price adjustments between vertically-related markets (from production to consumption) as well as between five major horizontally-related wholesale markets in Taiwan. Empirical results show that there is a bidirectional lead-lag cointegrating price relationship between milkfish wholesale and retail markets.

Petersen and Muldoon (2006) employ cointegration analysis to test for relationships between wholesale and retail prices of each of the eight key species of live reef food fish marketed in Hong Kong. The results indicate that wholesale and retail prices of live reef fish species have a long-run cointegration relationship.

Jiménez-Toribio and García-Del-Hoyo (2006) use cointegration tests and vector error correction models to analyze the wholesale and retail markets prices of the red seabream (Pagellus bogaraveo) in Spain. The results show the existence of a long-run equilibrium relationship between all pairs of red seabream price.

Garcia and Salayo (2009) apply the cointegration and Granger causality in the major markets of aquaculture species in the Philippines. Results indicate cointegration between wholesale and retail prices of milkfish within most provincial locations. Moreover, the Granger causality shows that the retail price of milkfish generally leads the wholesale price and prices at the wholesale and farm level follow the trends of the retail market.

Using VAR model, Jan and Huang (2012) analyze the price transmission and dynamic relationship between Taiwan Grouper wholesale prices and its export price to China. The results show that the domestic wholesale market price and export price of Grouper has a long-run positive relationship.

Garcia *et al.* (2015) study the cointegration and Granger causality in regional Tilapia and roundscad markets in the Philippines. Results indicate there are more regions that exhibit long-term relationships between the wholesale and retail prices in the roundscad market than in the tilapia market. On the other hand, the Granger causality shows the wholesale price generally leads the retail price in the roundscad markets. However, the reverse is true in the tilapia markets.

In order to eliminate seasonality tends, Rodriguez *et al.* (2017) use seasonal cointegration analysis to study the relationship between retail and wholesale prices of milkfish, tilapia and tiger prawn in the Philippines. Results indicate that, except the wholesale price of tiger prawn, all of the price series have unit roots at all frequencies. However, none of the pairs of price to the cointegrated at all frequencies. Nevertheless, the retail and wholesale price of tilapia to the cointegrated at zero and annual frequencies.

Based on the above review, we find that earlier studies that discuss the relationship between price and quantity are mostly concentrated on financial commodities. However, in the agricultural products market, due to the biological characteristics of the agricultural products market, the quantity would have a lagging in response to price fluctuation. As such, there are relatively few studies on the relationship between price and quantity of agricultural products, especially those on the analysis of fishery products. Therefore, this study will verify the causal relationship between the wholesale price and the trading volume of Taiwan's milkfish market.

3. METHODOLOGY

This study uses the unit root test, VAR model, Granger causality test, and impulse response function to explore the correlation between the price and trading volume of the wholesale market of milkfish in Taiwan.

3.1. Unit Root Test

Since time series data may have non-stationary problems, in order to avoid the occurrence of "false regression" in the empirical process of non-stationary time series, a single root test must be performed in the time series empirical analysis to ensure that the data is in a fixed or non-stationary state. If the data is in a non-stationary state, the data must be fixed by differential means, and the series after being differentiated at d level would entail the integrated order as d level, expressed as I (d). This study is performed using (Dickey and Fuller, 1981) ADF and Phillips and Perron (1988) PP single root assay.

3.2. VAR model

In order to explore the correlation between variables, this study uses the vector self-regression model proposed by Sims (1980). The model mainly treats all variables as endogenous variables, through a set of multi-variables and multiple regression equations. The interaction between variables is discussed, and each regression equation uses the delaying item of the variable as the explanatory variable. The VAR regression model is Equation 1:

$$Y_t = \Phi_0 + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + \varepsilon_t \qquad (1)$$

In addition, the lag length of variables in the VAR model is also determined. This study uses the Schwarz Criterion minimum as the basis.

3.3. Granger Causality Test

We apply the causality test proposed by Granger (1969) which is a statistical hypothesis test, for determining whether one variable is useful in forecasting another.

The causal model is expressed as follows：

$$Y_t = \beta_0 + \sum_{i=1}^{k} a_i X_{t-i} + \sum_{i=1}^{k} \beta_i Y_{t-i} + \varepsilon_{2t} \qquad (2)$$

$$X_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i X_{t-i} + \sum_{i=1}^{k} b_i Y_{t-i} + \varepsilon_{1t} \qquad (3)$$

where $\varepsilon_{1t}, \varepsilon_{2t}$ are white noise, and k is a proper lagging number.

Suppose the two variables, X and Y are stationary time series. If the null hypothesis, $H_0: a_1 = a_2 = \cdots = a_k = 0$ from Equation 2, is rejected, it follows that there exists a Granger causality and X's lagged values have the capability to explain Y. Thus, we can establish that X Granger causes Y. Similarly, if we can reject the null hypothesis, $H_0: b_1 = b_2 = \cdots = b_k = 0$ from Equation 3, the Y's lagged values will have an impact on the current changes in X, so Y is the cause of X.

If both of the above null hypotheses are rejected, there is a Granger causality with bidirectional feedback between X and Y. If only one is established, Granger causality between X and Y is uni-directional.

3.4. Impulse Response Function

Through the impulse response function, one can observe all possible reactions generated in the time process when the spontaneous disturbance of a certain variable causes the reaction of other variables in the time process or when a certain variable is spontaneously interfered by other variables. The relationship of the impulse response function between the variables is Equation 4:

$$\begin{bmatrix} P_t \\ Q_t \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} P_{t-1} \\ Q_{t-1} \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \end{bmatrix}$$

$$\Rightarrow \quad Y_t = \Lambda Y_{t-1} + e_t \qquad (4)$$

By plotting the impulse response function, one can examine whether the interaction between the variables is positive or negative, whether it is continuous or beating, and whether it is long-term or short-term.

4. EMPIRICAL RESULTS ANALYSIS

4.1. Data Sources

Data on wholesale price and trading volume of the milkfish market in Taiwan from January 2001 to December 2017 is used in this study. The data is obtained from the Fisheries Department of the Executive Yuan Agriculture Committee. All variables are first logarithmically analyzed, The wholesale price and trading volume after the logarithm are expressed as lpw and lvol, respectively.

4.2. Unit Root Test

In order to facilitate subsequent empirical analysis, it is necessary to first determine whether the data is stationary. If the data is stationary, the VAR model can be used to investigate whether there is a short-term equilibrium relationship between variables. Table 1 lists the results of ADF and PP single root verification of the wholesale price and trading volume of Taiwan milkfish. Both the wholesale price and the trading volume of the two verification results reject the null hypothesis of the single root, indicating that the two variables do not have a single root, which is a fixed sequence. Thus, the VAR model analysis can be performed.

Table-1. Tests of unit roots hypothesis.

Variable	ADF		PP	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
lpw	-3.8218***(1)	-5.4583***(1)	-3.0548**(2)	-3.7873**(1)
lvol	-2.6698*(12)	-3.2777*(12)	-3.9279**(0)	-5.3109***(1)

Note: ADF and PP are unit roots of null hypothesis. (.) denotes optimal lag length (ADF) or optimal bandwidth (PP). *** 、** and * denote the 1% 、5% and 10% significant level respectively.

4.3. VAR Analysis

Before performing VAR analysis, we must first determine the optimal lag length of variables. This study is based on the SC criterion minimum. Therefore, the VAR model with four periods as the optimal period is the best interpretation model. VAR (4) estimation and the results of the verification are shown in Table 2.

When the lpw is used as the variation analysis, the results in Table 2 reveals that the monthly rate of change in milkfish wholesale price is affected by lpw (-1), lpw (-2), and lpw (-3). At the same time, it is also affected by lvol(-1), lvol(-2), lvol(-3), and lvol(-4). If the lvol is the variable, the results show that the monthly trading volume of the milkfish is affected by lvol(-1), lvol(-2), and lvol(-4). Also, the monthly trading volume is also affected by lpw(-2) and lpw(-4). It can be seen that there may be an interactive relationship between the changes in the wholesale price and trading volume of Taiwan milkfish.

Table-2. Vector autoregression estimates.

Variable	lpw		lvol	
	Coefficient	t-statistics	Coefficient	t-statistics
lpw (-1)	1.0747	(11.6043)***	0.0373	(0.1703)
lpw(-2)	-0.5126	(-3.7753)***	0.5774	(1.7995)*
lpw(-3)	0.3066	(2.2802)**	0.1218	(0.3833)
lpw(-4)	-0.0115	(-0.1499)	-0.6993	(-3.8700)***
lvol(-1)	-0.1349	(-3.6432)***	0.6756	(7.7185)***
lvol(-2)	-0.1261	(-2.9957)***	0.6388	(6.4209)***
lvol(-3)	0.0801	(1.9224)*	0.0639	(0.6480)
lvol(-4)	0.0948	(2.6089)***	-0.4513	(-5.2550)***
C	1.7820	(2.9372)***	0.8443	(0.5889)

Note: *** 、** and * denote the 1% 、5% and 10% significant level respectively.

4.4. Granger Causality Test

Based on the above VAR verification results, the Granger causality test is used to understand whether there is a causal relationship between the wholesale price and the trading volume of the Taiwan milkfish market. Table 3 shows the Granger causality test results. From Table 3, it is observe that the price leads the trading volume and trading volume leads price at the same time in Taiwan milkfish market. In other words, there is a bidirectional causal relationship between price and trading volume in Taiwan's milkfish market. In other words, the change in the wholesale price of Taiwan's milkfish market will affect Granger test changes in wholesale trade volume, and wholesale trade volume will also affect Granger test changes in wholesale prices.

Table-3. Results of Granger causality tests.

The null hypothesis	Chi-square statistic	P-value
lpw dose not Granger cause lvol	33.7226***	0.0000
lvol dose not Granger cause lpw	41.0559***	0.0000

Note: *** 、** and * denote the 1% 、5% and 10% significant level respectively.

4.5. Impulse Response Analysis

In order to examine whether the direction of mutual influence between the two variables is positive or negative, this study uses the impulse response function to perform correlation analysis. Figure 3 shows the reaction function relationship when the price and trading volume are positively impacted by a unit change of trading volume and price. From Figure 3, we observe that when the wholesale price increases by one unit of standard deviation, the response of the trading volume are all negative, except the seventh period where there is a positive relationship. On the other hand, if the trading volume increases by one unit of standard deviation, the price has a negative, downward relationship from the first period to the sixth, and then there is a negative, upward reaction relationship.

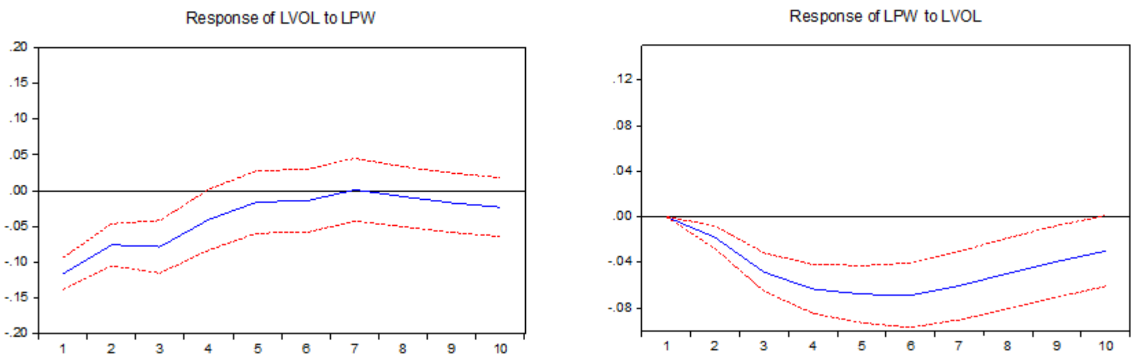

Figure-3. Impulse responses to one standard error shock in the output equation.

Source: The data in Figure-3 were analyzed using Eviews.

5. CONCLUSION

Although the research on the relationship between price and quantity began with the commodities in financial markets, the recent literature has gradually expanded to the agricultural product market. However, the discussion of the price/volume relationship of the fishing market is relatively rare. Due to biological characteristics, fishery products take a relatively long period to go from breeding to harvest. As such, the results of the study on the price/volume relationship of fishery products may be different from that of the swift-in-response financial commodities. The milkfish plays a very important role in the aquaculture fishery in Taiwan. Milkfish production has a strong seasonality, with high-production seasons mainly in July through November each year, and the low seasons in January through May. In addition to the area of aquaculture, volume of production also depends on the stocking density and weather, in which the weather effect is particularly obvious. At the beginning of each year, price is often on an upward trend due to lack of volume, and reaches a high level from April to June. After the start of the harvest period in June, the supply increases and the price gradually falls until November when the quantity decreases again and the price is on a gradual rise. This puts the price and volume relationship of the milkfish into a cyclical change. This study used a unit root test to determine whether the wholesale price and trading volume of the milkfish market in Taiwan is a stationary series. Then the VAR model was used for estimating and Granger causality for testing the casual relationship between price and volume. Finally, the direction of the relationship between price and volume was analyzed using the shock response function. Based on the above analytical results, this study found that both the wholesale price and the trading volume of the Taiwan milkfish market are stationary series, and there is a bidirectional causal relationship between the two. That is, the price and the volume of the milkfish affect each other, i.e., there is a short-term and interactive relationship between the wholesale price and the trading volume. In other words, the historical price can be used to predict the trading volume, and the trading volume can also be used to predict the price.From the analysis based on the impulse response function, it was found that, in the short run, when the wholesale price rises (falls), the trading volume will have a negative (positive) response in the first and second period, but a positive (negative) reaction relationship in the seventh period; if trading volume increases (decreases) in the current period, the price declines (increases) in the first period. This phenomenon may be interpreted as there is a short-term, cyclical relationship between the wholesale price and the trading volume of the Taiwanese milkfish market. When the milkfish market is in the high-production period, the trading volume increases, causing the wholesale price to fall; otherwise, the price rises. This verifies our finding that the wholesale price and trading volume of milkfish shows a bidirectional causal relationship.

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