Journal of Animal and Veterinary Advances 11 (23): 4340-4346, 2012
ISSN: 1680-5593
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An Analysis of Taiwanese Livestock Prices: Empirical Time Series Approaches

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Abstract: In Taiwan, the livestock production sector is the primary provider for agricultural and domestic meat consumption which is shared among pork, poultry and beef. Livestock prices fluctuate based on demand, supply and other factors such as the outbreak of diseases, increased production costs, consumer behaviour, foreign competition and natural disasters. This study attempts to model the possible cointegration of price elasticity, demonstrate the causality for a directional relationship and forecast the future prices of broiler, cattle, duck and hog in Taiwan by using time series analyses such as the unit root, Johansen cointegration, Granger causality and variance decomposition tests. The Johansen cointegration test indicated significant price elasticity among the variables. The long-run Granger causality test showed that a bidirectional relationship exists between hog and broiler prices and that a unidirectional relationship exists from the duck price to the hog price. The Autoregressive Integrated Moving Average (ARIMA) and variance decomposition methods were used to predict the future livestock price and the riskiness of shocks in a future 12 months period.

Key words: Forecasting, livestock price, price relationship, time series analysis, Taiwan

INTRODUCTION

Currently, the global population is projected to reach 9 billion people in the next 40 years. One expected result of this increase is an increase in food demand, especially agricultural commodities. The agricultural sector plays an important role in providing food and employment. The government supports this sector to meet the future food demand and increase the agricultural product output. In Taiwan, the government is attempting to develop the agricultural sector by improving techniques, technologies and infrastructure.

The annual reported Taiwanese agricultural income was NT$ 426,264 million including NT$ 144,614 million from animal production. The livestock sector therefore is a major contributor of income in Taiwan's agriculture. The largest market is the hog market which is followed by the poultry market. In Taiwan, the domestic consumption is shared among pork, poultry and beef by approximately 37, 32 and 5 kg per capita, respectively.

Livestock prices have fluctuated due to demand, supply and other factors such as the outbreak of diseases increasing production costs, consumer behaviour, foreign competition and natural disasters. Feed price is the largest cost of livestock production: 60-70% of the cost function is generated through feedstuff including corn and soybean meal. Because raw materials are limited, Taiwan has imported corn and soybean meal to meet the demand of domestic feed production both raw materials are necessary to produce feed to supply the livestock industries (USDA, 2009). An outbreak of foot and mouth disease in March 1997 decreased livestock production and temporarily reduced export sales. After Taiwan was initiated into the World Trade Organization (WTO) in 2002, farmers have faced the changeable international market and unpredictable domestic livestock circumstances. Moreover, Taiwan faced a production cost increase (grains and oil) in 2007 and the effects of Typhoon Morakot in August 2009. These examples affected livestock production directly.

Livestock prices have varied significantly; hog prices changed from NT$ 62 per kg in 1999 to NT$ 40 per kg in 2001 to NT$ 60 per kg in 2004 and to NT$ 75 per kg in 2011. Duck prices changed from NT$ 53 per kg in 2005 to NT$ 43 per kg in 2006 and then increased to NT$ 65 per kg in 2008. Cattle prices increased from NT$ 85 per kg in 2005 to NT$ 103 per kg in 2006 and then decreased to NT$ 95 per kg in 2010. As a result of this high price volatility in livestock, the government needs to be concerned about this situation it is directly related to the returns and production risks for domestic producers and also impacts consumers.

Several earlier studies attempted to apply econometric models to investigate the relationships

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among agricultural commodity prices and forecast agricultural commodity prices. For example, Liu (2005) revealed the relationship among hog, corn and soybean meal future price series by employing time series tests such as stationarity multivariate cointegration and error-correction models. The findings showed that hog, corn and soybean meal future prices are long-run relationships. In addition to revealing that the majority of the hog industry profits come from corn and soybean meal future prices, Bakucs and Ferto (2005) time series analysis of the price relationship for the Hungarian pork meat market found that there is a long-run relationship between the producer and the retail pork meat price using the Johansen Cointegration Method. Moreover, Adachi and Liu (2009) studied the price relationship by using monthly Japanese retail pork and farm hog price data to test for stationarity and cointegration.

Various articles related to forecasting agricultural commodity prices have been written to assist farmers and producers as they plan their production and manage the associated risks. For instance, Gjolberg and Bengtsson (1997) forecasted quarterly hog prices based on Nordic countries, namely Denmark, Finland, Norway and Sweden. ARIMA Models have been used to capture the future prices using MSE and MAPE to confirm the statistical accuracy. Huang *et al.* (2009) and Shih *et al.* (2009) forecasted the broiler price market and analysed price information in Taiwan by adapting the case-based reasoning approach model to predict the performance of broiler prices more effectively. The results provide information and suggestions for producers as they plan their production. Further, Chang *et al.* (2011) analysed the impact of joining the WTO on Taiwan's hog price to assist hog farmers and the hog industry in predicting the investment risk and understanding the negative and positive shocks using time series methods including GARCH (Generalised Autoregressive Conditional Heteroscedasticity), GJR (Glosten, Jagannathan and Runkle) and EGARCH (Exponential Generalised Autoregressive Conditional Heteroscedasticity) Models. The results revealed that negative shocks increase and positive shocks decrease volatility in hog prices. Anderson *et al.* (2007) applied a time series analysis to find the causal relationship and forecasted the error variance decomposition of the quantity and price of pork, chicken and beef in Danish markets. They found that pork, chicken and beef are close substitutes but that the price of chicken is more endogenous than the prices of pork and beef. In terms of market shocks, there are both own-market and cross-market effects on chicken and pork that occur rapidly.

The future market price is important information that can assist producers and managing and applying these results to production can increase the competitive potential in the meat market. In the livestock industry, predicting and analysing price information is complicated because many factors exist that affect price. Livestock is the core of agriculture in Taiwan. This study analyses the prices of major meat products in Taiwan including broiler, duck, cattle and hog. The motivation of this study is to investigate the causal relationships and forecast the future prices of broiler, duck, cattle and hog.

MATERIALS AND METHODS

The unit root, cointegration, Granger causality and variance decomposition tests are applied to time series in this study.

Data: The data are monthly time series of the prices of broiler, cattle, duck and hog over the period from January 2004 to August 2011 from the Council of Agriculture Executive Yuan, Taiwan. The observations include 92 samples to which the natural log was applied. The LBR, LCT, LDK and LHG are represented as proxies for the following variables: broiler, cattle, duck and hog, respectively.

Testing the stationarity of the dataset: Before analysing the time series, the observed variables that are stationary in each series must be established. Stationarity means that the data series do not depend on time, i.e., their means, variances and covariances are stable throughout the time period. The unit root must be processed before implementing the Johansen cointegration test to present price elasticity.

To examine the stationary properties of the price series in the first step, researchers used the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979, 1981) and Phillips and Perron (PP) (Phillips and Perron, 1988) unit roots with constants to present the series properties which can be written as Eq. 1:

$$\Delta X_t = \alpha + \beta_1 X_{t-1} + \delta T + \varepsilon_t \quad (1)$$

Where:

- Δ = The differencing order
- X_t = The observation (time series)
- α = The constant term
- T = The time trend effect
- ϵ_t = The error
- δ and β_1 = The parameters to be estimated

The null and alternative hypotheses for the existence of a unit root in variable X_t are:

$$H_0 : \beta_1 = 0$$
$$H_1 : \beta_1 < 0$$

If the statistical result for any variable cannot reject the hypothesis at the levels then the data must be tested for stationarity at the first difference or I (1).

Johansen cointegration test: The Johansen cointegration involved testing the relationship among variables based on a Vector Autoregressive (VAR) Model. The VAR Model determined the appropriate lag value by using the lowest value of the Schwarz Information Criterion (SIC).

After the stationarity of all the variables is established, I (1) processes the variables in the same order by integrating the first difference. The next step is to search for the long-run relationship among variables using Johansen cointegration which can be written as Eq. 2:

$$\Delta Z_t = a_0 + \prod Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \varepsilon_t \qquad (2)$$

Where:

- Z = The matrix time series
- p = The lag length
- $\prod$ = $\sum^{p}_{i=1} A_i - I$
- Γ_i = $-\sum^{p}_{j=i+1} A_j$

In this study, the likelihood ratio through trace statistic is empolyed for testing cointegration which introduced by Johansen (1988, 1991) and Johansen and Juselius (1990) in order to indicate the number of cointegrating vectors. The trace statistic can be expressed as Eq. 3:

$$\lambda_{trace} = S \sum\nolimits_{i=r+1}^{k} \ln(1 - \hat{\lambda}_i) \qquad (3)$$

Where:

- S = The sample size of observations used in the data series for estimation
- r = The null hypothesis that indicates the number of cointegrating vectors
- λ_i = The ith largest eigenvalue of the coefficient matrix

The null hypothesis (H_0) of the non-cointegrated relationship (the trace statistic at r = 0 exceeds its critical value) and at least one cointegration vector implies that the long-run equilibrium has detected two cointegrated relationships.

Granger causality: The Johansen cointegration test implies the existence of Granger causality but it does not identify the direction of the causality relationship. Therefore, the Granger causality (Engle and Granger, 1987) based on the Vector Error Correction (VEC) Model is employed to detect the direction of the causality. If a long-run directional relationship is detected among the variables in at least one direction then Granger causality exists. Furthermore, this causality explains both the unidirectional and bidirectional long-run causal relationships between variables in which all series should be integrated at the first difference or I (1). The Granger causality test can identify the existence of a long-run relationship by estimating the following from Eq. 4 and 5:

$$\Delta X_t = \alpha_1 + \sum_{i=1}^{p-1} \beta_{11i} \Delta X_{t-i} + \sum_{i=1}^{p-1} \beta_{21i} \Delta Y_{t-i} + \varepsilon_{1t} + \gamma_1 ECT_{t-1} \qquad (4)$$

$$\Delta Y_t = \alpha_2 + \sum_{i=1}^{p-1} \beta_{12i} \Delta Y_{t-i} + \sum_{i=1}^{p-1} \beta_{22i} \Delta X_{t-i} + \varepsilon_{2t} + \gamma_2 ECT_{t-1} \qquad (5)$$

where, X and Y are the observed time series. The Chi-square statistic is applied to test a long-run causal relationship: β_{21} and β_{22} are equal to 0.

Selected ARIMA Model: The Autoregressive Integrated Moving Average (ARIMA) Model is the most widely applied model for forecasting a time series (Box and Jenkins, 1970). The ARIMA term has three parameters (p, d, q): p is the autoregressive term which is defined by the order of the autoregressive process; d is the integrated variable which is defined by the order of the stationary data and q is the moving average which is defined by the order of the moving average process. The general form of the ARIMA (p, d, q) is shown in Eq. 6:

$$\Delta PR_t = \alpha_3 + \sum_{i=1}^{p} \delta_i \Delta PR_{t-i} + \sum_{j=1}^{q} \gamma_j \varepsilon_{t-j} + \varepsilon_t \qquad (6)$$

Where:

- PR_t = The variable price at time t
- ϵ = The current and earlier values of random information
- δ_i = The autoregressive parameters
- γ = The moving average parameter

The purpose of the ARIMA Model is to identify the most appropriate values for p, d and q. Finally, to select the best fit ARIMA (p, d, q), four criteria are most commonly used to select the best fit model: the Akaike Information Criterion (AIC), the Schwarz Information Criterion (SIC), the Q-statistic test for autocorrelation and the Lagrange Multiplier LM (SC) for serial correlation.

The generalised variance decomposition: Finally, the forecast generalised variance decomposition is employed to determine the proportion of forecast error variance in one variable caused by the other variables including itself for the following 12 months period as developed by Pesaran and Shin (1998). The forecasted generalised error variance decomposition can be written as shown in Eq. 7:

$$\Theta_{ij}(n)=\frac{\sigma_{ii}^{-1}\sum_{l=0}^{n}(e_i{}'M_l\sum e_j)^2}{\sum_{l=0}^{n}(e_i{}'M_l\sum M'_l e_i}, \quad i, j=1,...,m \qquad (7)$$

Where:

M = The m×m coefficient metrics

n = 0, 1, 2, …, 12 and e_j = The white noise

RESULTS

In the first step, the properties of the individual series need to be tested to identify the stationarity or non-stationarity of the dataset. All of the variables in this study (Broiler (BR), Cattle (CT), Duck (DK) and Hog (HG) prices) are tested for stationarity by employing the most commonly used tests of the unit root in the time-series, the Augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) tests. The unit root model is examined in the models with a constant. The null hypothesis (H_0) of the ADF and PP unit roots is rejected when the t-test is less than the critical value or when $p<0.05$. To select an appropriate lag length, researchers used the Schwarz Information Criterion (SIC) to choose the lowest value of the optimal lag (p) for the ADF and PP unit root models.

The results of the ADF and PP unit root tests at the original level and the first difference are shown in Table 1 according to MacKinnon (1996) critical values. Table 1 shows that all variables fail to reject the null hypothesis of non-stationarity in the original level but can reject the null hypothesis in their first difference level at $p<0.05$. The same result was observed for the logarithmic form the null hypothesis of a unit root in the original level cannot be rejected but the null hypothesis in the first difference level at $p<0.05$ can be. Therefore, the stationarity of the series is found at the first difference, i.e., all of the variables are integrated at order 1 or I (1), processes. Next, researchers tested for a long-run relationship using the Johansen cointegration test to determine whether the stationary variables, I (1) are cointegrated.

Table 1 shows that all of the variables are integrated at the first order. The next procedure is to test for possible cointegration relationships among the variables. In this study, researchers tested for cointegration among four variables by using the Johansen cointegration approach. The Johansen cointegration proposed two likelihood ratio tests, trace and max-eigenvalue statistics to test for the number of cointegrated relationships.

Table 2 shows the results from the Johansen cointegration tests. The trace test indicates one significant cointegrating vector at $p<0.05$. With zero cointegrating vectors ($r = 0$), researchers can reject the null Hypothesis (H_0) of a non-cointegrated relationship (the trace statistic at $r = 0$ exceeds its critical value). Therefore, at least one cointegration vector implies that a long-run equilibrium has been detected among the broiler, cattle, duck and hog prices. The results of the normalised equation reveal the price elasticity among the variables if the broiler price has changed by 1% then the hog, cattle and duck prices can fluctuate by 0.157, 0.361 and 0.462%, respectively.

Table 1: Results for the ADF and PP unit root tests

	ADF		PP		
Variables	t-test	Lag (p)	t-test	Lag (p)	Conclusion
Level					
BR	-1.752	2	-1.700	2	Non-stationary
CT	-2.188	1	-2.278	1	Non-stationary
DK	-2.125	1	-1.726	1	Non-stationary
HG	-0.716	3	-0.703	3	Non-stationary
LBR	-1.824	2	-1.746	2	Non-stationary
LCT	-2.131	1	-2.221	1	Non-stationary
LDK	-2.438	1	-1.851	1	Non-stationary
LHG	-0.683	3	-0.684	3	Non-stationary
First difference					
ΔBR	-7.122*	1	-7.628*	1	Stationary
ΔCT	-7.209*	0	-7.209*	0	Stationary
ΔDK	-6.559*	0	-6.559*	0	Stationary
ΔHG	-8.011*	2	-22.99*	2	Stationary
ΔLBR	-7.322*	1	-7.744*	1	Stationary
ΔLCT	-7.218*	0	-7.218*	0	Stationary
ΔLDK	-6.569*	0	-6.569*	0	Stationary
ΔLHG	-8.278*	2	-29.56*	2	Stationary

Δ and * denote the different orders and rejection of the hypothesis at the 5% level, respectively. The number in parentheses is the lowest optimal lag value (p) that is selected based on the Schwarz information criterion. Non-stationarity is used for the null hypothesis, H_0

Table 2: Results of the Johansen cointegration test

Null hypothesis	Trace test statistics	Trace critical value (5% level)	Prob.
None (r = 0)	54.278*	47.856	0.011
At most 1 (r≤1)	29.442	29.797	0.054
At most 2 (r≤2)	10.065	15.494	0.275
At most 3 (r≤3)	1.661	3.841	0.197

Cointegrating equation: LBL = -0.478+0.361LCT+0.462LDK+0.157LHG; r and * denote MacKinnon *et al.* (1999) p-values, the number of cointegrating vectors and the rejection of the hypothesis at the 5% level. A lag length of two is the lowest optimal VAR lag selection that is selected based on the Schwartz information criterion. The null hypothesis H_0 is no-cointegrating vector

Cointegration implies the existence of Granger causality however it does not indicate the direction of the causal relationship. The Error Correction Model (ECM) is also obtained from the cointegration result to detect the direction of the long-run causality. The long-run Granger causality based on the ECM in Table 3 shows the directions of causality in the long-term interactions between variables. One bidirectional relationship was found to exist between hog and broiler prices and a unidirectional relationship was found from the duck price to the hog price at $p<0.01$.

The Autoregressive Integrated Moving Average (ARIMA) Model is selected from the integrated order of four variables, LBR, LCT, LDK and LHG on which stationary processes were conducted at the first difference containing a unit root I(1), d = 1. Next, all four variables are modelled to indicate the best fit of ARIMA (p, d, q) by Ordinary Least Squares (OLS) estimation. Various ARIMA Models are shown in Table 4. The residual diagnosis (autocorrelation and serial correlation) is considered to select the potential ARIMA Model.

Table 3: Results of the long-run Granger causality tests

Independent variable	Dependent variable ΔLBR	ΔLCT	ΔLDK	ΔLHG
ΔLBR	-	0.081	1.350	6.394***
ΔLCT	0.064	-	0.868	1.331
ΔLDK	0.003	0.204	-	7.019***
ΔLHG	6.883***	0.806	2.658	-

Δ and *** denote the first different order and the rejection of the hypothesis at the 1% level. A lag length of two is the lowest optimal VAR lag selection that is selected based on the Schwartz information criterion. The null hypothesis is X does not Granger cause Y

Results of Table 4 show that the ARIMA (4, 1, 3), ARIMA (5, 1, 4), ARIMA (3, 1, 4) and ARIMA (4, 1, 3) Models are the most appropriate ARIMA (p, d, q) for LBR, LCT, LDK and LHG, respectively. The Granger causality test indicates the existence of causality between variables. However, it does not provide any indication of the importance of the causal impact of each variable. Variance decomposition indicated the proportion of movements in each variable due to exogeneity and its own shocks.

Table 5 shows the results of the forecasted generalised variance decomposition of the variables and identifies the proportions of the error variance that are explained exogenously and by the variables themselves for the next 12 periods equal to 1 year. As for the results of the LBL variable, the proportions of the error variance that are most closely shared by that variance >60% throughout all 12 periods of forecasting. Thus, the broiler price itself is the major cause of shocks to the broiler price. The influence of the hog price on broiler price is approximately 20% and the influences of the cattle and duck prices are minimal. For the LCT variable, the proportions of the error variance that are mostly shared by that variance exceed 95% throughout all 12 periods of forecasting. Therefore, the cattle price is the major cause of shocks for the cattle price itself and the influence of the broiler, duck and hog prices is minimal. The results for the LDK are variable, the proportions of the error variance shared by itself is approximately 80% at the first month and <30% at the last month. For the duck price, the error

Table 4: Estimated results of selected ARIMA (p, d, q) models

Variables	Model	Coefficient	t-statistic	Residual diagnostics Q (AC)	LM (SC)	AIC/SIC
ΔLBR	ARIMA (4, 1, 3)					
	AR (3)	0.454	4.579	Q = 1.825	F = 0.359	AIC = 2.788
	AR (4)	-0.205	-2.582	p = 0.177	p = 0.699	SIC = 2.902
	MA (1)	0.576	10.960			
	MA (3)	-0.746	-25.129			
ΔLCT	ARIMA (5, 1, 4)					
	AR (2)	0.383	2.832	Q = 1.028	F = 0.044	AIC = 4.899
	AR (3)	0.222	1.933	p = 0.311	p = 0.956	SIC = 5.070
	AR (5)	-0.335	-3.110			
	MA (1)	0.387	3.473			
	MA (2)	-0.458	-2.831			
	MA (4)	-0.295	-2.040			
ΔLDK	ARIMA (3, 1, 4)					
	AR (1)	1.131	33.837	Q = 1.312	F = 0.189	AIC = 3.691
	AR (3)	-0.492	-13.814	p = 0.252	p = 0.827	SIC = 3.832
	MA (1)	-0.949	-11.778			
	MA (3)	0.199	1.659			
	MA (4)	0.328	3.116			
ΔLHG	ARIMA (4, 1, 3)					
	AR (1)	0.210	1.949	Q = 1.199	F = 0.119	AIC = 4.511
	AR (3)	-0.976	-50.267	p = 0.273	p = 0.887	SIC = 4.624
	AR (4)	0.219	2.083			
	MA (3)	0.961	52.825			

Q (AC) refers to the Q-statistic test for Autocorrelation. LM (SC) refers to the Lagrange Multiplier test for Serial Correlation. AIC and SIC are the Akaike Information Criterion and Schwarz Information Criterion, respectively

Table 5: Forecasting generalised variance decomposition

Dependent variables	Forecasting period[a]	Value	Shock variance (risk shock) ΔLBR	ΔLCT	ΔLDK	ΔLHG
ΔLBR	1	42.813	100.000	0.000	0.000	0.000
	3	43.278	90.601	0.069	1.055	8.274
	6	43.381	75.461	1.083	7.216	16.238
	9	43.367	69.753	1.977	10.256	18.012
	12	43.346	67.114	2.425	11.624	18.835
ΔLCT	1	109.682	0.390	99.609	0.000	0.000
	3	109.075	0.100	99.120	0.079	0.698
	6	106.159	0.101	98.286	0.184	1.427
	9	105.146	0.193	97.880	0.188	1.736
	12	105.734	0.268	97.630	0.184	1.916
ΔLDK	1	60.799	18.845	0.093	81.061	0.000
	3	60.344	41.811	0.090	56.931	1.165
	6	60.767	56.535	0.984	39.312	3.167
	9	61.408	61.106	1.767	32.790	4.335
	12	61.158	63.112	2.217	29.733	4.936
ΔLHG	1	71.817	0.082	1.576	1.897	96.443
	3	71.740	0.913	4.714	0.983	93.388
	6	73.056	0.633	8.524	0.662	90.179
	9	71.818	1.225	11.242	0.401	87.131
	12	72.978	1.633	12.648	0.283	85.434

[a] is the time forecasting period (month); Δ denotes the different operators

shock variance is shared by the broiler price and is approximately 63% at the 12 months period. For the LHG variable, the proportions of the error variance that are mostly shared by variance exceed 80% throughout all 12 periods of forecasting. Therefore, the hog price itself is the major cause of shocks to the hog price. The influence of the cattle price is approximately 13% at the 12 months period and the influence of the broiler and duck prices is minimal. Therefore, the forecasts for the following 12 months period present proportions of the error variances for their own variables as follows: LBR variable 67%, LCT variable 98%, LDK variable 30% and LHG variable 85%.

DISCUSSION

The price fluctuation of livestock is a major problem in many countries because meat is the largest proportion of commodity consumption. When livestock prices increase, they impact consumer and producer consumption directly. Taiwan has experienced the impact of livestock price changes which increased to the highest level on record in 2010. Livestock production plans are important and designing one without a reasonable knowledge of the changes in the past and present market prices is impossible.

The main objectives of this study were to investigate the cointegration, causal relationship and future prices among broiler, cattle, duck and hog prices in Taiwan using monthly time series over the period of January 2004 to August 2011. The time series approaches namely the unit root tests, Johansen cointegration, Granger causality, forecast price value and generalised variance decomposition are applied to present the stationarity of the time series and the elasticity, long-run causal relationships and future risks for variable prices. Before testing the cointegration of variables, the ADF and PP tests were used for unit root testing. These tests indicated that the time series of broiler, cattle, duck and hog prices appear to be non-stationary at one level but stationary at the first differences for the logarithmic form. The Johansen cointegration analysis revealed a significant cointegration and found price elasticity among the variables such that if broiler prices changed by 1% then the hog, cattle and duck prices fluctuate by 0.157, 0.361 and 0.462%, respectively. In terms of testing the long-run price movement using the Granger causality test based on ECM, the results showed the directions of causality which appear in both a bidirectional relationship between hog and broiler prices and a unidirectional relationship from duck price to hog price at the 1% level of statistical significance. The empirical results of the Granger procedure indicate that a long-run Granger causality exists between the prices of hog to broiler and duck; this causality implies that the hog price is closely linked to broiler and duck prices. Another possible explanation for this relationship includes showing hog and broilers as substitutes. The ARIMA Model was determined to predict the future livestock price in 2011(IX)-2012(IX). The most suitable ARIMA Models are ARIMA (4, 1, 3) for the LBR variable; ARIMA (5, 1, 4) for the LCT variable; ARIMA (3, 1, 4) for the LDK variable and ARIMA (4, 1, 3) for the LHG variable. Therefore, the models with forecasting accuracy are meaningful for policy-makers to prepare appropriate management plans to address the variation in livestock prices. The results of the variance decomposition show the forecasted riskiness shocks in the 12 months period ahead. The major shock prices are the broiler, cattle, duck and hog prices themselves. Moreover, the forecasted generalised variance decomposition indicates that the broiler price has a strong influence on the duck price for the next 12 months. Therefore, if the price of duck increases consumers tend to consume broilers as a substitute for duck. The hog and duck prices influence the broiler price for the next 12 months which means that if the price of broilers increases the consumers tend to consume hogs and ducks as substitutes for broilers. In addition, the cattle price influenced the hog price for the following 12 months.

CONCLUSION

In this study, researchers conclude when the price of hog increased the consumer substituted cattle for hog.

The empirical analysis reflects the situation of the livestock market in Taiwan. Producers can use this understanding of consumer behavioural trends to make the most beneficial decision to increase or decrease their production when prices have fluctuated. Finally, policy makers should consider these findings because they can help in the design of future livestock policy that minimises future risks and increases the benefits of producer and consumer preferences.

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