An Analysis on Taiwan Broiler Farm Prices under Different Chicken Import Deregulation Policies

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Abstract: - According to the changes of chicken import policy, it could be divided into three periods: control import, quota import and free import. This study adopts GARCH models and weekly data to analyze the broiler farm prices during these different periods. Based on the empirical test results, it indicates that there is larger long-run persistence effect of shocks in the free import period. The reactions of broiler farm prices to the lag broiler farm prices, survey number of chick after six weeks, pig prices, colorful broiler farm prices, chick prices and feedstuff prices are different during these three periods.

Keywords: - *Import regulation periods, Volatility, Price response, GARCH model*

1 . Introduction

The broiler industry is one of the important animal husbandry programs in Taiwan with the chicken import policies undergoing three different control stages during Taiwan's application for entry into the WTO. As a WTO official member; Taiwan has to comply with relevant norms to fulfill its commitment of membership negotiations and therefore, opens its domestic primary-products market to the globe. The government enforced strict control on chicken import before its entry into the WTO in 2002. After entering the WTO, Taiwan gradually opened its import of foreign chickens. The quota import period was from 2002 to 2004, during which the import quota was 4% to 8% of the domestic chicken consumption. Within the quota, the importers were levied with lower tariffs, and vice versa. During that period, the import of chickens increased from 19,000 tons in 2002 to 45,000 tons in 2004, which was an increase of more than double. Beginning 2005, Taiwan opened its market completely, thus the broiler industry faced severe challenges. According to the statistics of the Council of Agriculture, the output value of the broiler industry in 2006 reached NT$11.6 billion, and it became the third largest industry in the animal husbandry. Although the industry development was in a growing trend, the slaughter number increased from 160 million in 1996 to 207 million in 2004, then decreased to 180 million in 2006 due to the open market policy. The govenment's policy was to avoid the impact of imported chicken on domestic chicken prices.

According to changes to chicken import controls, the time series for farm prices of broilers can be divided into three periods: control imports, quota imports, and free imports. All social circles pay attention to the effects of such control changes affecting the farm prices of broilers. Before opening chicken imports, the changing trend of domestic farm prices of broilers could be analyzed based on the quantity of controlled imports and the situation of domestic broiler breeding. During the period of controlled imports, the changes to farm prices of broilers went from NT$40.27/kg in 1999 to NT$34.15/kg in 2001, with an average price, over three years, approximate NT$36.36/kg (USD1.35/kg). However, after the opening of chicken quota imports in 2002, the quantity of domestic chicken had gradually increased, exerting heavy pressure on the domestic farm price of broilers, for example: from NT$36.53/kg in 2002 to NT$36.82/kg in 2004, and the average price over three years was approximately NT$35.42/kg, if compared be with average price of the controlled import period, the price decreased approximately NT$1 average per kilogram. After opening chicken imports in 2005, it caused volatility to the domestic farm price of broilers; domestic poultry-breeders did not adopt the measure of reducing production to react to the relatively lower production price because of free chicken imports increase in quantity, which would have offset the effects of domestic poultry-breeders' reductions exerted on price. It can be seen that it is more difficult to analyze the farm prices information about broilers after opening the market to chicken imports; moreover, volatility and reaction to industry relevant factors may be different from former stages. Based on these facts, under different chicken import control measures, the investigation of the difference between volatility and reaction of broilers farm price becomes an important research issue.

Previous researches often adopt the time series method to analyze price and to learn the price change (e.g., [1][2][3][4][5]). However, various domestic documents put emphasis on the effects of opening chicken imports to the broiler industry and pay little attention to the volatility and reaction of farm prices of broilers during Taiwan's entry into WTO [6]. There is a lack of research in comparing price changes of different chicken import stages; moreover, relevant demonstration data often adopts monthly data; whereas it is appropriate to use weekly data in order to obtain more accurate information of broiler prices, according to the characteristics of short broiler production cycles (approximately six weeks). This thesis analyzes these issues.

Based on above mentioned, this research adopts weekly data, dividing the changes of the farm price of broilers into three periods: control imports, quota imports, and free imports to construct a demonstration model, which compares the differences between price reaction and the volatility of farm prices of broilers during the three periods, and analyzes and explains the changes in the information of farm price of broilers after importing chicken freely. This can be regarded by relevant units as reference of price information analysis. Therefore, demonstration analysis, farm price of broilers data will be used as the stationary unit root test to construct a model of farm prices of

broilers. Generalized Auto-Regressive Conditional Heteroskedasticity; (GARCH) based on test results of residual error heterogeneity, which compares and analyzes price volatility and reaction of the three periods, then uses different predictive indices to compare the predictive ability of the demonstration model of the different periods, and proposes relevant suggestions on research results, providing poultry-breeders with reference on production strategy and agricultural administrative units to guide the industry.

2. Research Method

2.1 Unit Root Test

Because the farm price of broilers is time series data, it is necessary to determine whether it belongs to stationary before the analysis. Thus, unit root tests should be conducted, or else, spurious regression may be resulted. In Dickey and Fuller's [7] unit root test, time series only concerned the first-order autocorrelation; such results may cause the residual items to have significant autocorrelation problem. In response to this problem, Dickey and Fuller [8] proposed ADF (augmented Dickey-Fuller test) method, which assumed that the time series is p-order autocorrelation, and it adds differential sub-item of explained variable (Δy_t) lag phases in the regression equation, uses OLS to estimate the regression equation, and selects the model with the optimum lag number of periods, in order to solve the autocorrelation problem of residual items, and ensure the residual items to conform to the white-noise process. The test models can be divided into three types:

(1) A model with non-intercept items and time trend item

$$\Delta y_t = \rho y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

(2)A model including intercept items but no time trend item

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \quad (2)$$

(3) A model including intercept items and time trend item

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \alpha_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \quad (3)$$

where, $\Delta y_{t-i} = y_{t-i} - y_{t-i-1}$, Δy_{t-1} is the lag item, p is the optimum lag number of periods. The null hypothesis and alternative hypothesis are:

$H_0 : \rho = 1$

$H_1 : \rho < 1$

If test statistics are greater than DF critical value, it does not reject the null hypothesis, indicating that yt has unit root phenomenon, which is a non-stationary time series.

2.2 Residual autoregration and normality tests

In the analysis of the time-series model, the residual items may appear autoregration, and require further consideration on whether it conforms to the assumption of stationary distribution. In other words, the residual items must conform to the "non autocorrelation" and "normal distribution" rules, or else, the parameters estimated by the model may be invalid. Therefore, it is assumed that a residual item εt in the regression equation is not white noise or linear, the residual squares items would be interrupted. Common diagnostic statistics are Q test and JB test, of which the Q test checks whether the residual items in the diagnostic model have autoregration, whereas the JB test checks whether the residual items conform to "normal distribution". The autoregration Ljung-Box Q test equation is written as:

$$Q(p) = T(T+2)\sum_{i=1}^{p} \frac{r_i^2}{(T-i)} \sim \chi^2(p) \quad (4)$$

where, T is the sample number, p is the autoregration exponent number, r_i^2 is ith-order autoregration coefficient, $Q(p)$ is the χ^2 distribution close to freedom p. The null hypothesis and alternative hypothesis are written as:

$H_0 : Q(p) < \chi^2(p)$

$H_1 : Q(P) > \chi^2(p)$

If autoregration $Q(p)$ statistics is less than the χ2 distribution statistics, it cannot reject the null hypothesis. Thus, the model residual items do

not have autoregration problem.

In normality tests, when calculating JB statistics, the coefficient of the skewness (R) of the residual item and coefficient of kurtosis (S) should be calculated first. If the there are n parameters to be estimated in the model, and the total sample number of the residual items is T, then the JB test is:

$$JB = \frac{T-n}{6}\left(R^2 + \frac{1}{4}(S-3)^2 \right) \quad (5)$$

The null hypothesis and alternative hypothesis are, respectively:

$H_0 : JB < \chi^2(2)$

$H_1 : JB > \chi^2(2)$

The distribution of JB statistics belong to χ^2 distribution of freedom 2, thus, when JB statistics are less than the χ^2 distribution test statistics, it cannot reject the null hypothesis, therefore, the model's residual item is a normal distribution.

2.3 Residual Heterogeneity Test

In the time series model, residual items may have heterogeneity. The residual heterogeneity means that, the variance of time series residual items is not fixed constants, and changes with time, thus, this research used the LaGrange Multiplier (LM) test proposed by Engle [9] to test the significance of the regression coefficients of the residual squares of different periods, then determine if the variance between the two time periods contain the heterogeneity phenomenon, that is, if it has ARCH (autoregressive conditional heteroskedasicity) effect. The method provides regression to the current residual squares ε_t^2, intercept items, and lag items $\varepsilon_{t-1}^2, \varepsilon_{t-2}^2, \cdots\cdots, \varepsilon_{t-q}^2$, and obtains the coefficient of determination R^2. Test statistics was obtained by multiplying the sample number to the coefficient of determination ($T \times R^2$), which was closest to the χ^2 distribution of freedom q. This model is as follows:

$$\varepsilon_t^2 = \beta_0 + \sum_{i=1}^{q} \beta_s \varepsilon_{t-i}^2 + v_t \quad (6)$$

Where, t is the sample number, ε_t^2 is the residual squares series, obtained from estimated equations.

The null hypothesis and alternative hypothesis are:

$H_0 : TR^2 < \chi^2(q)$

$H_1 : TR^2 > \chi^2(q)$

If TR^2 statistics is less than the χ^2 distribution test statistics, it cannot reject the null hypothesis, thereby, indicating that this model does not have ARCH effect.

2.4 GARCH Mode

Bollerslev [10] expanded the ARCH model to propose the GARCH model, which allows the conditional variance of error item to cover more past information. The typical GARCH (p,q) model is shown as following:;

$$y_t = x_t b + \varepsilon_t \quad (7)$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \quad (8)$$

where $\alpha_0 > 0, \alpha_i > 0 \ \beta_i > 0$。

Eqs.(7) and (8) are average and variance equations, respectively. The necessary and sufficient condition of the conditional variance of the GARCH (p,q) is $\sum_{i=1}^{q} \alpha_i + \sum_{i=1}^{p} \beta_i < 1$. In the variance equation, there are ARCH ($\sum \alpha_i$) and GARCH ($\sum \alpha_i + \sum \beta_i$) effects. ARCH effects show the short run persistence of shocks and GARCH effects show long run persistence of shocks. These two effects can be used to measure the volatility of farm price of broilers.

To choose the lag period of broiler farm price, the Schwartz Bayesian Information Criterion(SBIC) is adopted. The decision-making process is firstly used to estimate the model with different lag periods. Then the error sum of squares (SSE) is used to calculate SBIC values. The model with lag periods has minimum SBIC values. Then which lag periods will be chose as model's optimum lag number of periods. The SBIC criterion is defined as following:

$$SBIC = T \cdot ln(SSE) + m\, ln(T) \quad (9)$$

where T is the sample size, SSE is model's error sum of squares, and m is total number of estimated parameters.

In addition, for the model diagnosis the estimated model must test whether its error item

exists autocorrelation or not, examine it is belong to normal distribution, and verify condition variance does not have heterogeneity. Those could apply Ljung-Box's Q statistics, Jarque-Bern's JB statistics, and Lagrange Multiplier's (LM) statistics to test. If all statistics would not refuse null hypothesis, it would show the estimated model is suitable.

2.5 Criteria of model predictive ability

In order to determine if the estimated model has good analogy ability, beside having R2 and all estimated parameter not equal to zero, whether data generated from the whole model conforms to the facts should also be considered. Therefore, it is necessary to weigh the accuracy between the model's predictive value and actual values. This research adopted root mean square error (RMSE), meaning absolute error (MAE), and mean absolute percentage error (MAPE) to evaluate the model predictability. The measurement definition is as follows:

Root mean square error

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}\left(Y_t - \hat{Y}_t\right)^2} \tag{10}$$

Mean absolute error

$$MAE = \frac{1}{N}\sum_{t=1}^{N}\left|Y_t - \hat{Y}_t\right| \tag{11}$$

Mean absolute percentage

$$MAPE = \frac{1}{N}\sum_{t=1}^{N}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right| \tag{12}$$

3 .Empirical Analysis

3.1. Empirical Model Specification

Variables affecting the farm price of broilers can be divided into input costs (e.g. chick price, feed price), output costs (e.g. broiler production quantity), and relevant product prices (e.g. colored chicken price, pig price), and import quantity, in addition to prior periods' price. Regarding farm price of broilers, poultry-breeders often consider prior period location of production price as reference at sale time when they set sale price. Regarding input costs, chick and fodder prices are main broiler breeding costs, when chick and fodder prices change the breed cost of broilers will change and exerts its effects on farm price of broilers. Regarding output, when the supply of broilers is high, the price will be reduced in order to increase sales; whereas when the supply is low and falls short of demand, price will be increased. Regarding relevant products, the main succedaneum are colored chickens and pigs, when the price of colored chickens or pigs increases, it will decrease the demand of colored chickens or pigs to buy broilers, which will increase the farm price of broilers. Regarding import quantity, the import quantity of chickens affect the total supply of domestic chickens; if the quantity of import chickens increases, it will bring pressure to decrease the farm price of broilers.

According to above effects, the variables of Taiwan farm price of broilers, and results of unit root tests, this research will set the demonstration model as following:

$$\Delta price_t = b_0 + b_1\sum_{i=1}^{m}\Delta price_{t-1} + \lambda_1 dsq + \lambda_2 imq + \lambda_3 pkp + \lambda_4 cop_t + \lambda_5 scp + \lambda_6 cfp + \varepsilon_t \tag{13}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i h_{t-i} \tag{14}$$

(13) Expresses the reaction equation of the farm price of broilers, among which endogenous variable- $\Delta price_t$ ($price_t - price_{t-1}$) meaning NTD/kg after undertaking order differences, meaning the variables of the farm price of broilers. Secondly, exogenous variable mean $\Delta price_{t-1}$ is the lag period of the farm price of broiler variables, dsq is a survey number after six weeks of domestic chick (dsq), imq is import quantity of domestic chicken (imq), pkp is pig price (NTD/kg), cop is colored chicken location of production price (NTD/kg), scp is chick price (NTD/a chick), cfp is chicken fodder price (NTD/kg). (14) shows, conditional variances equations, and current condition variance is affected by prior period. residual squares and prior conditional variances.

3.2. Sample Descriptive Statistics

The empirical data of this research adopted weekly data for analysis. The research period was from January 1999 to July 2007, and data were collected from statistical data of the Taiwan Poultry Association and the National Animal Industry Foundation. The import quantity of chickens only has monthly data, thus, the data

were revised to weekly data based on the number of weeks in that month. The weekly time series data were divided into three periods. The first period was the controlled import period, which was compared to the quota import of the second period, and adopted the data of the same length (three years), namely from January 1999 to December 2001, totaling 156 pieces of data. The second period was the quota import period, from January 2002 to December 2004 with a total of 156 pieces of data. The third period was the unrestricted import period, from January 2005 to July 2007, with a total of 135 pieces of data..

The descriptive statistics of the main variables are as shown in Table 1. In terms of the farm price of broilers, the average price during the unrestricted import period was the highest (NT$37.212/kg). As for other variables, the average pig price was NT$43.129/kg during the controlled import periods, which was relatively lower than the average price during quota and unrestricted import period. The average farm prices of colored chicken and chick were NT$50.763/kg and NT$13.422/chick, respectively, which were relatively higher than the average price of other periods. As for chicken import quantity, the import quantity increased greatly during the unrestricted import period. The survey number of domestic chick after six weeks (which is the possible supply of chicken during the current period) was 3.78 million during the quota import period, which was more than the average quantity of other periods. As for fodder price, the average price was NT$12.051/kg during unrestricted import period, which was higher than the average price during other periods.

Table 1 Sample Descriptive Statistics

Control Import Period (01/01/1999-31/12/2001)							
Variable	*price* (NTD/kg)	*dsq* (million pcs/week)	*imq* (million ton/week)	*pkp* (NTD/kg)	*cop* (NTD/kg)	*scp* (NTD/pc)	*cfp* (NTD/kg)
Average	36.387	3.309	2.287	43.129	41.921	11.77	11.039
SD	3.447	0.489	1.864	18.353	11.945	2.995	0.154
Quota Import Period (01/01/2002-31/12/2004)							
Variable	*price* (NTD/kg)	*dsq* (million pcs/week)	*imq* (million ton/week)	*pkp* (NTD/kg)	*cop* (NTD/kg)	*scp* (NTD/pc)	*cfp* (NTD/kg)
Average	35.362	3.782	6.256	50.447	42.068	10.611	10.968
SD	2.495	0.419	4.485	11.932	9.942	2.608	0.615
Free Import Period (01/01/2005-31/07/2007)							
Variable	*price* (NTD/kg)	*dsq* (million pcs/week)	*imq* (million ton/week)	*pkp* (NTD/kg)	*cop* (NTD/kg)	*scp* (NTD/pc)	*cfp* (NTD/kg)
Average	37.212	3.459	14.296	50.803	50.763	13.422	12.051
SD	2.536	0.409	10.041	3.562	12.277	2.816	0.975

Note: *price* is farm price of broilers, *dsq* is chick survey number of after six weeks, *imq* is chicken import quantity, *pkp* is pig price, *cop* is colored pig place of production price, *scp* is chick price, *cfp* and is chicken fodder price

3.3 Test of farm prices characteristics of broiler

This research first adopted ADF to test whether source data is stationary. If variances are found to be non-stationary, the source data were treated with first-order differential, and further tested. The optimum lag number of periods is determined based on AIC values.

The data on farm price of broiler can be divided into three stages: controlled import, quota import, and unrestricted import. The test model can be divided into three types: intercepted items and trend items, intercepted items and non-trend items, and non-intercepted items and trend items. As shown in Table 2, the unit root test on source data indicates that under the significance levels of 1%, 5%, and 10%, the source data results cannot reject the null hypothesis. In other words, the source data of all three stages have unit root phenomenon, indicating that they are non-stationary data. Therefore, the source data were differentiated, and tested according to three models of ADF test. The results showed that it is under significance level of 1%, all rejecting the null hypothesis. In

other words, the first-order differential of the three periods has no unit root phenomenon, indicating that they are stationary data. Therefore, future studies will conduct empirical analysis on the farm price of broilers in the three periods by first-order differential data.

Table 2 Test of farm price of broilers

Periods	Source data			Data after differential		
	Non-intercept item and trend item	Intercept item and non-trend item	Intercept item and trend item	Non-intercept item and trend item	Intercept item and non-tend item	Intercept item and trend item
Controlled Import	-1.322 (13)	-1.905 (7)	-3.526 (6)	-3.659*** (13)	-3.815*** (13)	-3.845*** (13)
Quota Import	-0.382 (7)	-2.261 (7)	-2.335 (7)	-5.736*** (6)	-5.721*** (6)	-5.807*** (6)
Unrestricted import	-0.087 (2)	-2.396 (2)	-2.491 (2)	-5.182*** (1)	-5.162*** (1)	-5.281** (1)

Note: 1. The number in (.) indicates the lag number of periods.
2. * means significance level of 10%, ** means significance level of 5%, *** means significance level of 1%.

3.4 Results of residual error autocorrelation and stationary test

In terms of autocorrelation and stationary test of residual items, as shown in Table 3, in Ljung-Box's Q statistics, the residual item lag 6 periods and 12 periods of the farm price of broilers during the controlled import, quota import, and unrestricted import periods were selected, and the LB (6) statistics were 19.717, 16.352, and 39.453, respectively. LB (12) statistics were 24.641, 19.543, and 64.009, respectively. The results suggested that the residual items of the time series data of the farm price of broilers have autocorrelation during the three periods. As for stationary tests, JB statistics were 40.496, 35.381, and 56.326, respectively, during the three periods, indicating that the residual items of the time series data of the farm prices during the three periods did not conform to normal distribution.

Table 3 Self-correlation and normality test of farm price of broilers

Q test &JB test / Periods	LB(6)	LB(12)	JB
Control Import	19.717***	24.641***	40.496***
Quota Import	16.352***	19.543***	35.381***
Unrestricted import	39.453***	64.009***	56.326***

Note: LB indicates Ljung-Box's Q statistics; JB indicates Jarque-Bera statistics.Results of residual error heterogeneity test

In residual item heterogeneity test, as shown in Table 4, under significance levels of 10%, 5%, and 1%, LM test values were 10.617, 31.326, and 14.623, respectively. Thus, the residual item variance of the farm price of broilers during the three periods had heterogeneity. As shown by the residual error heterogeneity test, all three periods are suitable to be tested by the GARCH model.

Table 4 Heterogeneity Test of Farm price of broilers

Heterogeneity Test / Periods	LM Test
Control Import	10.617***
Quota Import	31.326***
Unrestricted import	14.623***

3.5. Empirical Results

The estimation model coefficient is calculated by using E-View5.0 econometric software, which chooses the optimum model based on the principle of SBIC minimum value, results are shown in Table 2. The suitable models for the three periods are ARIMA(1,1,0)-GARCH(1,1), ARIMA(1,1,0)-GARCH(1,2) and ARIMA(1,1,0)-GARCH(1,1). The coefficient value of the conditional variance equation all meet the restrictive requirements, that is $\alpha_0 > 0$, $\alpha_i > 0$, $\beta_i > 0$ and $\sum \alpha_i + \sum \beta_i < 1$, all meet the stationary conditions. Regarding the goodness of fit about those models, according to LB, JB, and LM statistics of the three periods, which show that error terms are not exit autocorrelation and has a normal distribution, and its variances does not have heterogeneity characteristics. Thus, estimated results of the three periods are appropriate.

3.5.1. The volatility of broiler farm prices

Price volatility is not fixed, and the volatility of each period has Autocorrelation. The analysis of the GARCH model on price volatility is mainly based on variance equations, which include both ARCH and GARCH effects.

As for ARCH effect, during the three periods, the current residual item conditional variances have significant relationship with the previous residual squares, its values are 0.168 (α_1), 0.305 $(\alpha_1 + \alpha_2)$ and 0.156 (α_1), respectively, indicating that the volatility of previous farm price of broilers has durative effect over a short time on the current volatility of farm price, among which the volatility of quota import period is larger than that of the controlled and unrestricted import periods. It indicates that, there are higher durative effects to short volatility periods of farm price of broilers during the controlled import periods.

As for the GARCH effect, previous residual squares and previous residual item condition variances have significant effects on the current residual item conditional variance during the three periods. The values were 0.988, 0.954, and 0.973, respectively, indicating that the volatility of previous farm price of broilers has durative effect over the long term on the current volatility of farm price, among which the volatility of the unrestricted import period is larger than that of the quota import and controlled import periods. It shows that the previous volatility of farm price of broilers has longer durative effects on the current farm price during the unrestricted import period. If the previous farm price is more volatile, the current farm price would be volatile as well, indicating that the impact on the unrestricted import of chicken after Taiwan's entry into WTO has led to longer impact on the farm price of broilers. In other words, poultry-breeders have to face higher risks in production under the volatility of farm prices.

3.5.2. The reaction analysis of broiler farm prices

The expected results of the farm price reaction to main exogenous variable changes during the three periods are shown in Table 5. The changes of farm price of broilers lagging one period have significant effect on the change amounts of the current farm price during the three periods. The values were 0.936, 0.902 and 0.771, respectively. The unrestricted import period has the strongest effect; when the change amount of lag from one period of farm price increases NT$1, the change amount of the current farm price will be increased by NT$0.936.

As for broiler production quantity, the chick survey number after six weeks showed significant negative effects on the change amounts of the current farm price of broilers, indicating that when the supply of the broilers of current period may increase, it would move the change amounts of the current farm price to a negative trend, thus the chicken prices would decrease. The estimated coefficient during the unrestricted import period is relatively small, indicating that the supply of broilers has a small effect on the current price during that period. In terms of chicken import, the chicken import quantities of the three periods and the previous period have no significant effects on the change amounts of the current farm price of broilers. There are two possibilities for this: one is that the imported chicken were released to the market gradually, thus the short-term effect was not significant; another is that the scale of domestic poultry-breeders was adjusted appropriately, so that the import of chicken had no significant effect on the domestic farm price of broilers.

In terms of substitution product prices, pig prices have significant positive effect on the change amounts of the current farm price of broilers during the unrestricted and controlled import periods. The estimated coefficients were 0.018 and 0.012, respectively, among which the effect during the unrestricted import period was

Table 5 Estimated Results of Demonstration Model during Control Import, Quota Import and Free Import

Periods	Model	Price Reaction Equation	Intercept Item	Farm price of broilers(lag one period)	Chick Survey Number after six weeks	Chick Survey Number after six weeks(lag one period)	Chicken Import Quantity
Control Import Period	ARIMA(1,1,0)-GARCH(1,1)		5.264 (5.887)	0.771 (0.049)***	-0.791 (0.169)**	-0.551 (0.181)***	-0.096 (0.103)
Quota Import Period	ARIMA(1,1,0)-GARCH(1,2)		5.908 (1.389)***	0.902 (0.021)***	-0.552 (0.101)***	-0.322 (0.099)*	-0.031 (0.023)
Free Import Period	ARIMA(1,1,0)-GARCH(1,1)		4.105 (1.099)***	0.936 (0.017)***	-0.406 (0.137)***	-0.272 (0.103)***	-0.007 (0.009)

Periods	Model	Chicken Import Quantity (lag one period)	Pig Price	Colored Chicken Place of production price	Chick Price (lag six periods)	Chicken Fodder price (lag four periods)	Chicken Fodder price (lag five periods)
Control Import Period	ARIMA(1,1,0)-GARCH(1,1)	-0.059 (0.113)	0.012 (0.004)***	0.012 (0.009)	0.064 (0.051)	-----	0.519 (0.551)
Quota Import Period	ARIMA(1,1,0)-GARCH(1,2)	-0.029 (0.022)	0.001 (0.003)	0.015 (0.007)**	0.003 (0.013)	0.007 (0.152)	-----
Free Import Period	ARIMA(1,1,0)-GARCH(1,1)	-0.012 (0.009)	0.018 (0.014)*	0.001 (0.004)*	0.019 (0.014)*	0.006 (0.041)*	-----

Periods	Model	Condition Variance Equation	α_0	α_1	α_2	β_1	$\Sigma\alpha_i+\beta_1$
Control Import Period	ARIMA(1,1,0)-GARCH(1,1)		0.021 (0.017)	0.168 (0.069)***	-----	0.805 (0.063)***	0.973
Quota Import Period	ARIMA(1,1,0)-GARCH(1,2)		0.064 (0.021)**	0.012 (0.233)**	0.293 (0.159)***	0.649 (0.006)**	0.954
Free Import Period	ARIMA(1,1,0)-GARCH(1,1)		0.083 (0.024)*	0.156 (0.273)***	-----	0.832 (0.055)**	0.988

Periods	Model	SBIC Value	Log likelihood	LB(6)	LB(12)	JB	LMS statistics
Control Import Period	ARIMA(1,1,0)-GARCH(1,1)	3.239	-210.391	5.888	9.233	5.297	1.784
Quota Import Period	ARIMA(1,1,0)-GARCH(1,2)	2.148	-126.041	20.142	33.977	6.907	0.026
Free Import Period	ARIMA(1,1,0)-GARCH(1,1)	1.872	-89.159	19.491	29.21	6.981	0.005

Note: 1, * means notable level 10%, ** means notable level 5%, *** means notable level 1%. 2, Number in (.) is progressive standard deviation

the strongest. Thus, when pig prices increase, the change amount of the current farm price of broilers would increase as well. As for farm price of colored chicken, there has positive effect on the change amount of the current farm price of broilers during the quota and unrestricted import periods. The estimated coefficients were 0.015 and 0.001, respectively, indicating that there was small effect of the change amount of the current farm price during the unrestricted import period.

As for input costs, since the growing period of chicks requires five to six weeks before they can be sold, the chick prices lag for six periods may affect the current farm price of broilers. The chick price has positive effect on the change amount of the current farm price of broilers during the unrestricted import period. The estimated coefficient was 0.019, indicating that when the price of six lag periods increases, the change amount of the current farm price of broilers would also increase. In terms of fodder price, chicken fodder is used during the most period of the breeding course, thus, the lag of four to five weeks of fodder price may have effect on the current farm price of broilers. Fodder price has significant positive effect on the change amount of the current farm price of broilers during the unrestricted import period. The estimated coefficient was 0.006, indicating that when the fodder price lagging 4 periods increases, the change amount of the current farm price of broilers would also increase.

3.5.3 Model predictive ability and performance

The comparative analysis of the predictive abilities of the models during the three periods was conducted by root mean square error (RMSE), meaning absolute error (MAE), and mean absolute percentage error (MAPE). The results are shown in Table 6. The predictive ability indices of RMSE, MAE, and MAPE during the unrestricted import period were 0.368, 0.288, and 0.757, respectively, which were less than those of other periods. Since the smaller the index value, the better the predictive ability, thus, ARIMA (1,1,0)+GARCH(1,1) set in the unrestricted import period was a better model to predict the future farm price of broilers.

This research used four sets of weekly data from August 2007 for out-of-sample prediction, in order to compare the predictive value estimated from the model and the actual values, and further analyze the predictive performances of farm prices of broilers models during the unrestricted import period. This method is based on progressive renewal predictive methods, and substitutes the observational value of the T period and T-1 period into model to find T+1 predictive values, in order to deduce the results. The results are shown in Table 7. The four sets of weekly data from August 2007 generated the predictive values of farm price of NT$38.26/kg, NT$38.92/kg, NT$40.16/kg and NT$40.18/kg, respectively. If compared with actual values, the predictive error of each week was NT$0.22/kg, NT$0.14/kg, NT$0.06/kg and NT$0.04/kg, respectively. The error value was within NT$0.3/kg, and fairly close to the actual values. Therefore, the empirical model of farm price for the unrestricted import period is feasible to analyze the changes of domestic farm prices of broilers in the future.

Table 6 Predictive ability indices of the empirical model

Periods / Empirical model	Control import period		
ARIMA (1,1,0) -GARCH (1,1)	RMSE	MAE	MAPE
	0.446	0.361	1.087
	Quota import period		
ARIMA (1,1,0) -GARCH (1,2)	RMSE	MAE	MAPE
	0.396	0.319	0.859
	Unrestricted import period		
ARIMA (1,1,0) -GARCH (1,1)	RMSE	MAE	MAPE
	0.368	0.288	0.757

Table 7 Out-of-sample predictive performance of farm price of broilers during the unrestricted import period

Farm price / Unrestricted import Period	Actual value (NTD/kg)	Predictive value (NTD/kg)	Predic-tive error
08/2007 (1st week)	38.38	38.26	0.22
08/2007 (2nd week)	39.06	38.92	0.14
08/2007 (3rd week)	40.22	40.16	0.06
08/2007 (4th week)	40.22	40.18	0.04

Note: the predictive value is converted from the change of prices.

4. Conclusions

The price volatility analysis on the farm price of broilers showed significant short-term durative effect (ARCH effect), of which the volatility during the quota import period was larger than that of other two periods, and that of the unrestricted import period was the lowest. The long-term durative effect (GARCH effect) was the highest in the unrestricted import period, indicating that if the farm price of broilers in the previous period was subjected to impact, there was long-term durative effect on the current farm price of broilers. Especially after opening unrestricted import of chicken, the volatility of the current farm price of broilers is affected by that of the previous period. At the same time, there is long durative volatility of the farm price, indicating that the change of import policy would lead to increasing risks faced by poultry-breeders.

The reaction analysis of farm price of broilers showed that, the effect of the previous farm price on the current farm price is greater during the unrestricted import period. The effect of the possible supply quantity on the current farm price is smaller during the unrestricted import period. It indicates that after Taiwan's entry into the WTO, broiler breeders may be more careful on the planning of the production quantity. There is no great increase or decrease as in the controlled import periods, thus, the effect on the current farm price is moderate. Although the quantity of imported chicken has no significant effect on the farm price of broilers, there is still pressure the farm price. In other words, importers may stock imported chickens and sell according to the market demand, which will affect the market of aggregate supply and price. As for the effect of the farm prices of pig and colored chicken, the effect of pig price on the current farm price of broilers during unrestricted import period is relatively larger than that of other two periods. However, the effect of the farm price of colored chicken on the farm price of broilers is relatively smaller than that of other two periods. In terms of the input cost variables, chick price and chicken fodder price have significant positive effects on the farm price of broilers only during the unrestricted import period. In other words, when the chick price and chicken fodder price increase, the predictive breeding cost increases, which will increase the farm price of broilers. Based on this, the change of chicken import policy would affect the farm prices of broilers, among which there is significant reaction to the chick and chicken fodder prices during the unrestricted import period. Because the raw materials of fodder in Taiwan are most imported, the volatility of international crop prices would affect the domestic fodder price; it not only affects the broiler breeding costs, but also increases the chick prices due to the rise of chick breeding cost, and indirectly affects the broiler breeding cost. Because the farm price of broilers in Taiwan lacks a price warning price system, the GARCH model constructed by this research can be used to predict price under unrestricted import of chicken. It is an urgent issue for agricultural bureaus to establish a price warning price systems for domestic farm price of broilers, in order be updated with the price fluctuation and related information, provide reference data to breeders on decision-making related to production and agricultural bureaus for industrial guidance, and promote the sustainable development of broiler industry in Taiwan.

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