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 government’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 $\Delta y_t$ 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

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

where, $\Delta y_{t-i} = y_{t-i} - y_{t-i-1}$, $\Delta y_{t-i}$ 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 $y_t$ 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 autoregation, 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 $\varepsilon_t$ 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 autoregation, whereas the JB test checks whether the residual items conform to “normal distribution”. The autoregation Ljung-Box Q test equation is written as:

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

where, T is the sample number, p is the autoregation exponent number, $r_i^2$ is ith-order autoregation coefficient, $Q(p)$ is the $\chi^2$ 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 autoregation $Q(p)$ statistics is less than the $\chi^2$ distribution statistics, it cannot reject the null hypothesis. Thus, the model residual items do
not have autoregressive 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:

$$JB = \frac{T - n}{6} \left( R^2 + \frac{1}{4} (S - 3)^2 \right)$$ (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 $\chi^2$ distribution of freedom $2$, thus, when JB statistics are less than the $\chi^2$ 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 heteroskedasticity) effect. The method provides regression to the current residual squares $\epsilon_t^2$, intercept items, and lag items $\epsilon_{t-1}^2, \epsilon_{t-2}^2, \ldots, \epsilon_{t-q}^2$, 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 $\chi^2$ distribution of freedom $q$. This model is as follows:

$$\epsilon_t^2 = \beta_0 + \sum_{i=1}^{q} \beta_i \epsilon_{t-i}^2 + v_t$$ (6)

Where, $t$ is the sample number, $\epsilon_t^2$ 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 $\chi^2$ 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:

$$y_t = x_t \beta + \epsilon_t$$ (7)

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

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

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:

$$SBIC = T \cdot \ln(SSE) + m \ln(T)$$ (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
\[
RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (Y_i - \hat{Y}_i)^2}
\]

Mean absolute error
\[
MAE = \frac{1}{N} \sum_{i=1}^{N} |Y_i - \hat{Y}_i|
\]

Mean absolute percentage
\[
MAPE = \frac{1}{N} \sum_{i=1}^{N} \left| \frac{Y_i - \hat{Y}_i}{Y_i} \right|
\]

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
succeedaneum 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.

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:
\[
\Delta price_t = h_0 + h_1 \sum_{i=1}^{d} \Delta price_{t-i} + \lambda_d dsq + \lambda_i imq + \lambda_p pkp + \lambda_c cop
\]

\[
+ \lambda_s scp + \lambda_o cfp + \varepsilon_t
\]

(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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control Import Period (01/01/1999-31/12/2001)</th>
<th>Quota Import Period (01/01/2002-31/12/2004)</th>
<th>Free Import Period (01/01/2005-31/07/2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>price (NTD/kg)</td>
<td>dsq (million pcs/week)</td>
<td>imq (million ton/week)</td>
</tr>
<tr>
<td>SD</td>
<td>3.447</td>
<td>0.489</td>
<td>1.864</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Periods</th>
<th>Source data</th>
<th>Data after differential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-intercept item and trend item</td>
<td>Intercept item and non-trend item</td>
</tr>
<tr>
<td></td>
<td>Non-intercept item and trend item</td>
<td>Intercept item and non-trend item</td>
</tr>
<tr>
<td>Controlled Import</td>
<td>-1.322 (13)</td>
<td>-1.905 (7)</td>
</tr>
<tr>
<td>Quota Import</td>
<td>-0.382 (7)</td>
<td>-2.261 (7)</td>
</tr>
<tr>
<td>Unrestricted</td>
<td>-0.087 (2)</td>
<td>-2.396 (2)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Periods</th>
<th>LM Test</th>
<th>LB(12)</th>
<th>JB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Import</td>
<td>19.717***</td>
<td>24.641***</td>
<td>40.496***</td>
</tr>
<tr>
<td>Quota Import</td>
<td>16.352**</td>
<td>19.543**</td>
<td>35.381**</td>
</tr>
<tr>
<td>Unrestricted</td>
<td>39.453***</td>
<td>64.009***</td>
<td>56.326***</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Periods</th>
<th>LM Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Import</td>
<td>10.617***</td>
</tr>
<tr>
<td>Quota Import</td>
<td>31.326***</td>
</tr>
<tr>
<td>Unrestricted</td>
<td>14.623***</td>
</tr>
</tbody>
</table>
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 ($\alpha_i$), 0.305 ($\alpha_i + \alpha_j$) and 0.156 ($\alpha_i$), 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 NTS1, the change amount of the current farm price will be increased by NTS0.936.

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

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

<table>
<thead>
<tr>
<th>Periods</th>
<th>Model</th>
<th>Condition Variance Equation</th>
<th>α₀</th>
<th>α₁</th>
<th>α₂</th>
<th>β₁</th>
<th>Σαᵢ + βⱼ</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,1)</td>
<td></td>
<td>0.021 (0.017)</td>
<td>0.168 (0.069)**</td>
<td>-----</td>
<td>0.805 (0.063)**</td>
<td>0.973</td>
</tr>
<tr>
<td><strong>Quota Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,2)</td>
<td></td>
<td>0.064 (0.021)**</td>
<td>0.012 (0.233)**</td>
<td>0.293 (0.159)**</td>
<td>0.649 (0.006)**</td>
<td>0.954</td>
</tr>
<tr>
<td><strong>Free Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,1)</td>
<td></td>
<td>0.083 (0.024)**</td>
<td>0.156 (0.273)**</td>
<td>-----</td>
<td>0.832 (0.055)**</td>
<td>0.988</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Periods</th>
<th>Model</th>
<th>SBIC Value</th>
<th>Log likelihood</th>
<th>LB(6)</th>
<th>LB(12)</th>
<th>JB</th>
<th>LMS Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,1)</td>
<td>3.239</td>
<td>-210.391</td>
<td>5.888</td>
<td>9.233</td>
<td>5.297</td>
<td>1.784</td>
</tr>
<tr>
<td><strong>Quota Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,2)</td>
<td>2.148</td>
<td>-126.041</td>
<td>20.142</td>
<td>33.977</td>
<td>6.907</td>
<td>0.026</td>
</tr>
<tr>
<td><strong>Free Import Period</strong></td>
<td>ARIMA(1,1,0)-GARCH(1,1)</td>
<td>1.872</td>
<td>-89.159</td>
<td>19.491</td>
<td>29.21</td>
<td>6.981</td>
<td>0.005</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Table 6</th>
<th>Predictive ability indices of the empirical model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Periods</td>
</tr>
<tr>
<td></td>
<td>Empirical model</td>
</tr>
<tr>
<td>ARIMA (1,1,0) -GARCH (1,1)</td>
<td>Quota import period</td>
</tr>
<tr>
<td>ARIMA (1,1,0) -GARCH (1,2)</td>
<td>Unrestricted import period</td>
</tr>
<tr>
<td>ARIMA (1,1,0) -GARCH (1,1)</td>
<td></td>
</tr>
</tbody>
</table>
Table 7 Out-of-sample predictive performance of farm price of broilers during the unrestricted import period

<table>
<thead>
<tr>
<th>Unrestricted import Period</th>
<th>Farm price (NTD/kg)</th>
<th>Predictive value (NTD/kg)</th>
<th>Predictive error</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/2007 (1st week)</td>
<td>38.38</td>
<td>38.26</td>
<td>0.22</td>
</tr>
<tr>
<td>08/2007 (2nd week)</td>
<td>39.06</td>
<td>38.92</td>
<td>0.14</td>
</tr>
<tr>
<td>08/2007 (3rd week)</td>
<td>40.22</td>
<td>40.16</td>
<td>0.06</td>
</tr>
<tr>
<td>08/2007 (4th week)</td>
<td>40.22</td>
<td>40.18</td>
<td>0.04</td>
</tr>
</tbody>
</table>

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.

References:


