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20 December 2010

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December 2010

* The third author wishes to acknowledge the financial support of the National Science Council, Taiwan.
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Abstract

The paper examines the effectiveness of the price stabilization mechanism for the broiler and poultry industry in Taiwan during the period 1999 to 2008. After presenting some background information on the domestic marketing system and price stabilization mechanisms for the broiler and pork industry in Taiwan, the paper discusses the smooth transition autoregressive (STAR) methodology. Monthly hog and broiler price data from 1999 to 2008 at farm, import and retail levels are analyzed using the nonlinear, non-asymmetric logistic STAR model in order to determine price transmission structure. A price threshold parameter is used so that price transmission levels can vary, thereby allowing an examination of the efficacy with which the hog and broiler price stabilization mechanisms take effect.

Keywords: Broiler industry, Pork industry, Price stabilization, Domestic marketing system, Smooth transition autoregressive (STAR) methodology.

1. Introduction

Successful food price stabilization is a key target for policymakers who are required to manage the risk associated with food price volatility. Sudden large fluctuations in food prices can lead to high costs for consumers and production losses for producers. Over-production in conjunction with import price transmission can pose serious risks of food price volatility. For small countries such as Taiwan, these threats are especially prevalent, and developing an effective price stabilization mechanism takes on increased importance.

While studies pertaining specifically to hog and broiler price stabilization are rare, some useful insights can be gained from previous studies regarding grain commodity price stabilization policies. Wright and Williams [10] show that the use of buffer stocks can be an effective method for stabilizing food prices, an approach which in the past has often been preferred to relying on trade mechanisms (Bigman and Reutlinger [2]). Athanasiou et al. [1] show that a government can stabilize commodity prices through a strategy of releasing or increasing commodity storage by small amounts relative to the equilibrium quantity level. However, the necessary amount rises as nonlinearity of the supply function increases.

Dawe [4] observes that food price stabilization is an especially effective way for governments of developing Asian countries to protect poor consumers and producers from volatile prices, while simultaneously abiding by international trade agreements. These price stabilization efforts have been largely effective for Asian countries over the past 30 years (see Cummings et al. [3]). Bigman and Reutlinger [2] argue that governments often use a variety of mechanisms in their price stabilization policies. The case is no different for Taiwan which, in addition to a buffer stock program, implements farmer and production plant subsidies, along with import control in order to stabilize hog and broiler prices.

The analysis in this paper examines the effectiveness of the price stabilization mechanism for the broiler and poultry industry in Taiwan during the period 1999 to

2008. The remainder of the paper is as follows. Section 2 presents background information on the domestic marketing system and price stabilization mechanisms for the broiler and pork industry in Taiwan. Section 3 discusses the methodology, specifically in regard to the use of smooth transition autoregressive (STAR) modeling. Section 4 discusses the empirical results. Some concluding remarks are presented in the final section.

2. Taiwan's hog and broiler markets and price stabilization mechanisms

The pork and broiler marketing channels in Taiwan possess some structural differences. Over 95% of pork is processed through twenty-three wholesale markets located throughout Taiwan. These markets operate under an auction system which posts daily prices which farmers then use to decide where to sell their product, thereby effectively balancing pork distribution throughout the island. As for the broiler market, only 30% of broilers are sold through wholesale markets; with the rest being sold through traditional markets, supermarkets and processing plants. This is due mainly to differing demands among Taiwanese consumers. Some consumers still prefer to see poultry alive before slaughter and purchase, which can only be accomplished in a traditional marketplace.

Imports account for a significant portion of Taiwanese pork and broiler consumption. From 1999 to 2008, Taiwan imported nearly 1,150 tons of pork either fresh or chilled, 277,744 tons of frozen pork, 1,169 tons of fresh or chilled broiler meat, and 395,128 tons of frozen broiler meat. During this time, imports were 20% and 40% of pork and broiler meat consumption, respectively. USA and Canadian imports accounted for 49% and 36%, respectively, of pork categorized as either fresh or chilled. Frozen pork imports were 60% from the USA and 36% from Canada. The majority of broiler meat imports was from the USA, with only 4% of fresh or chilled broiler and 7% of frozen broiler from Canada.

Taiwan hog and broiler price stabilization is managed by a government organization, together with assistance from private farmer collectives. The government established the National Animal Industry Foundation (NAIF) in 2000 with a main goal of facilitating price stabilization for Taiwan's meat products. The

NAIF collects pricing information from hog and broiler wholesale markets, and reacts quickly when prices differ from the historical average. When prices are high, the NAIF acts to increase import quantity of the affected product. When prices are low, the NAIF provides subsidies to encourage farmers to decrease production and hog and broiler processing plants to increase stock. The NAIF can also work to decrease imports, if possible. However, due to WTO restrictions, increasing stocks is usually a more feasible approach to reducing supply in the market.

The majority of Taiwanese hog and broiler producers are members of the Hog Producer Association or the Broiler Producer Association, respectively. Each association acts in the interest of its members with the main goal of supporting hog and broiler farm prices. Both Associations collect daily pricing information from wholesale markets to provide members with production level guidance. The Hog Producer Association collects from all twenty-three hog wholesale markets, and the Broiler Producer Associations from the three largest broiler wholesale markets. The Broiler Producer Association can act through a price watch council to reduce chick supply to broiler houses should the broiler price dip precariously low.

Furthermore, both Associations carefully monitor import prices in order to give production level guidance to farmers. The result of the efforts of both the National Animal Industry Foundation and the the Hog and Broiler Producer Associations is a price stabilization mechanism that provides both price floor support and price fluctuation limitation for hog and broiler products.

In this paper we analyze the efficacy of the hog and broiler price stabilization mechanisms through changes in price transmission within the hog and broiler marketing channels, both international and domestic. Econometric analysis allows the examination of the linkage between vertically connected markets, with close association among prices generally being a sign of efficient linkage under nonlinear conditions (Schlenker and Robert [7]). For Taiwan, a nonlinear model with an asymmetric adjustment assumption is needed to analyze price transmission changes in the broiler and pork marketing channels. The STAR time series model, suggested by Teräsvirta [8] (see also Tong [9]) fits this requirement. Specifically, we first determine that the logistic form, LSTAR, is the most appropriate for analyzing Taiwan's hog and broiler price data.

Monthly hog and broiler price data from 1999 to 2008 at farm, import and retail levels are analyzed using the nonlinear, non-asymmetric LSTAR model in order to determine price transmission structure. In the analysis we find a price threshold parameter at which price transmission levels vary, allowing the examination of the efficacy with which the hog and broiler price stabilization mechanisms take effect.

3. Smooth transition autoregressive model

Nonlinear time series models was advanced considerably when Tong [9] proposed the threshold autoregressive model (TAR), with other models following afterwards. Presently, economists most frequently adopt the smooth transition autoregressive model (STAR) that was proposed by Teräsvirta [8]. We apply the general STAR model, as follows:

$$y_t = \mathrm{A}_0 + \sum_{i=1}^{p} \mathrm{B}_i X_t + (C_0 + \sum_{i=1}^{p} D_i X_t) G(y_{t-d};\gamma,c) + \varepsilon_t \tag{1}$$

where y_t represents the domestic pork and broiler retail price; X_t represents both pork and broiler farm price and lagged retail price for domestic channels, and both import price and lagged retail price for international channels; $G(y_{t-d};\gamma,c)$ is a transition function, whereby y_{t-d} is the transition variable, γ is the transition rate, c is the threshold value, and $\mathrm{G} \in [0,1]$; the residual (ε_t) is an independent random variable with distribution $\varepsilon_t \sim iid(0,\delta^2)$.

The transition function $G(y_{t-d};\gamma,c)$ is suggested by Teräsvirta [8] to be either the logistic or exponential functional forms. In logistic form, the STAR model becomes LSTAR, with functional form given by:

$$G_1(y_{t-d};\gamma,c) = [1 + \exp(-\gamma(y_{t-d} - c))]^{-1}, \tag{2}$$

where $y_{t-d} = c$, $G_1 = 1/2$ in equation (2) can be rearranged as $y_t = \alpha_0' + \alpha_1' y_{t-1}$; when y_{t-d} approaches infinity, $G_1 = 1$; and when y_{t-d} approaches negative infinity, $G_1 = 0$.

In exponential form, the STAR model is designated as ESTAR, and its functional form is given as:

$$G_2(y_{t-d};\gamma,c) = 1 - \exp\left(-\gamma(y_{t-d} - c)^2\right). \tag{3}$$

When $y_{t-d} = c$, $G_2 = 0$; and when y_{t-d} approaches positive or negative infinity, $G_2 = 1$.

When $G(y_{t-d};\gamma,c)$ is expressed as a third-order Taylor approximation, equation (1) is specified as:

$$y_t = \mathrm{A}_0 + \sum_{i=1}^{p} \mathrm{B}_i' X_t + D_1' X_t(y_{t-d}) + D_2' X_t(y_{t-d})^2 + D_3' X_t(y_{t-d})^3 + u_t \quad . \tag{4}$$

For the appropriate selection of either LSTAR or ESTAR, we can set nested multiple null hypothesis of the nonlinear model of equation (4) as follows:

$$H_{03} : D_3' = 0$$
$$H_{02} : D_2' = 0 \mid D_3' = 0 \quad \text{, and}$$
$$H_{01} : D_1' = 0 \mid D_2' = D_3' = 0 . \tag{5}$$

If H_{03} is not rejected and H_{02} is rejected, then ESTAR should be selected. If H_{03} and H_{02} are not rejected but H_{01} is rejected, then LSTAR should be selected. Moreover, if H_{03} is rejected, then LSTAR should be selected. However, when all the hypotheses are rejected, we can base selection on the p-values. If the p-value of H_{02} is lower, ESTAR should be selected. Otherwise, LSTAR should be selected id its p-value is lower.

4. Empirical results

We use monthly farm, retail and import price data for pork and broiler meat in Taiwan from January 1999 to December 2008. First, we use the ADF test of Said and Dickey [6] and the PP test of Phillips and Perron [5] to examine for unit roots among these variables. Table 1 presents the results of these tests, showing that there are no unit roots, and that the first differences among monthly hog and broiler farm, retail and import prices are stationary.

It is then necessary to investigate the STAR model using the first price difference in order to determine whether the STAR model should be logistic (LSTAR) or exponential (ESTAR). Tables 2, 3, 4 and 5 display F statistics of different null hypotheses H_{03}, H_{02}, and H_{01} based on the methodology proposed by Teräsvirta [8] for hog and broiler marketing channels, both domestic and international. Table 2 shows that the analysis rejects all the respective null hypotheses, and that the p-value of H_{03} is lowest when X_t represents both farm and lagged retail chicken price. Therefore, the LSTAR model would seem to be more suitable than ESTAR for analyzing domestic broiler producer to consumer price transmission.

Analogously for broiler imports, the model rejects all the respective null hypotheses, and shows that the p-value of H_{03} is the lowest when X_t represents import and lagged retail chicken price (see Table 3). This illustrates that the LSTAR model is also the more suitable for analyzing international producer to consumer price transmission.

For the domestic pork channel, Table 4 shows that H_{03} is rejected when X_t represents domestic farm and lagged retail pork price. Therefore, the LSTAR model would seem to be more suitable for analyzing domestic hog producer to consumer price transmission.

As in the case of pork imports, Table 5 shows that the test rejects H_{03} when X_t represents import and lagged retail pork prices, thereby demonstrating that LSTAR is more suitable for analyzing international hog producer to consumer price transmission. As the analysis shows that the LSTAR model with asymmetric assumptions is more appropriate for analyzing producer to consumer price transmission than ESTAR, it follows that price transmission in the Taiwan broiler industry is asymmetric.

Table 6 shows the LSTAR price transmission analysis for hog and broiler marketing channels from 1999 to 2008. Farm hog price lagged one month has a positive transmission coefficient of 0.229 on retail pork price. Retail pork price lagged one month has a negative transmission coefficient of -0.180 when analyzing domestic price transmission, and -0.208 when analyzing international price transmission. Import pork price to retail price transmission has a positive coefficient of 0.152, and price transmission from import pork price lagged one month to retail price has a positive coefficient 0.116. The threshold parameters show that when farm hog price or import pork price fluctuation reaches 2.45 NTD/kg and 3.21 NTD/kg, respectively, then the price transmission changes within the domestic and international hog and pork marketing channels are statistically significant.

The lower half of Table 6 assumes that retail price fluctuation is equal to the threshold parameter within its respective domestic and international marketing channel. When retail pork price fluctuation equals the threshold value of 2.45 NTD/kg in the domestic marketing channel, the farm price lagged one month retains its positive price transmission coefficient of 0.229. This can be attributed to D in equation (1) not being significant for hog farm price lagged one month. Therefore the second half of equation (1) is not used, and the transmission coefficient for farm price lagged one month does not change. However, for pork price lagged one month, D in equation (1) is significant when retail pork price fluctuation equals the threshold parameter. Therefore, according to function (1) $B + 0.5D$, retail pork price lagged one month has a negative price transmission coefficient of -0.489 in the domestic marketing channel.

Regarding international price transmission observed in the pork and hog price data, when retail pork price fluctuation equals the threshold parameter of 3.21 NTD/kg, the lagged import pork price has a negative transmission coefficient of -0.081, according to function (1) $B + 0.5D$. This illustrates that, within the hog industry, consumer price stabilization can be accomplished through controlling imports, but not through managing domestic hog production as the lagged farm price (*D* of equation 1) is not statistically significant.

Broiler farm price has a positive transmission coefficient of 2.344 on retail broiler price fluctuation. Retail broiler price lagged one month exhibits transmission coefficients of -2.466 and -2.560, respectively, on the domestic and international marketing channels. Import broiler price has a positive transmission coefficient of 1.820. The threshold parameters show that, when farm and import broiler price reach 4.64 NTD/kg and 6.32 NTD/kg, respectively, then the price transmission changes within the domestic and international broiler marketing channels are statistically significant.

When retail chicken price fluctuation equals the domestic price transmission threshold parameter of 4.64 NTD/kg, the lagged farm chicken has a positive transmission coefficient of 1.161, resulting from function (1) $B + 0.5D$. The one month lagged retail broiler price has a negative price transmission coefficient of -0.1283, resulting from function (1) $B + 0.5D$. For the international transmission threshold parameter of 6.32 NTD/kg, one month lagged broiler imports have a positive transmission coefficient of 0.874, resulting from function (1) $B + 0.5D$.

These empirical results illustrate a reasonable capacity for domestic broiler farmers, together with importers, to have a slight control of price stabilization in the short term. The results demonstrate that regulators have some influence over broiler retail prices through domestic farm and import channels, but have yet more influence over retail pork prices.

5. Concluding remarks

This paper used the smooth transmission autoregressive (STAR) model and price data to investigate the price stabilization structure of the Taiwan hog and broiler markets from January 1999 to December 2008. The empirical results showed that farm and import level price transmission on to the retail stage was nonlinear and asymmetric in the Taiwan hog and broiler industries, with price fluctuation transmission ceilings of retail pork prices and retail broiler prices being 3.21 NTD/kg and 6.32 NTD/kg, respectively.

Pork imports have a more rapid influence on retail pork prices than do domestic hog farm prices. Domestic and international broiler producers have less ability to stabilize prices than do their counterparts in the hog industry. We attribute this to the hog industry's universal wholesale market system, and suggest that implementing a similar system would be effective in establishing effective price stabilization mechanisms for additional agricultural products in Taiwan. A similar analysis can be applied to other countries that produce and consume pork and broilers in large numbers..

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Table 1

Unit root tests for hog, pork and broiler prices

Variables	Hog / Pork		Broiler	
	ADF	PP	ADF	PP
Farm price	-2.04	-2.32	-1.11	-1.78
First difference farm price	-4.55***	-7.34***	-5.42***	-10.25***
Import price	-1.22	-1.89	-2.29	-2.09
First difference import price	-5.88***	-12.85***	-4.83***	-9.19***
Retail price	-0.59	-0.75	-0.56	-0.60
First difference retail price	-5.10***	-13.82***	-5.11***	-13.04***

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 2

Selection of LSTAR or ESTAR for the broiler domestic channel

F Statistics for testing H_{03}	F Statistics for testing H_{02}	F Statistics for testing H_{01}
4.88**	3.65**	2.51*

Note: All the hypotheses are rejected, the p-value of H_{03} is the lowest, and LSTAR is selected.

Table 3

Selection of LSTAR or ESTAR for the broiler international channel

F Statistics for testing H_{03}	F Statistics for testing H_{02}	F Statistics for testing H_{01}
5.09**	3.77**	2.61*

Note: All the hypotheses are rejected, the p-value of H_{03} is the lowest, and LSTAR is selected.

Table 4

The selection of LSTAR or ESTAR for the hog domestic channel

F Statistics for testing H_{03}	F Statistics for testing H_{02}	F Statistics for testing H_{01}
3.14*	2.14	2.46*

Note: H_{03} is rejected, so that LSTAR is selected.

Table 5

Selection of LSTAR or ESTAR for the hog international channel

F Statistics for testing H_{03}	F Statistics for testing H_{02}	F Statistics for testing H_{01}
3.85*	2.04	3.05**

Note: H_{03} is rejected, so that LSTAR is selected.

Table 6

LSTAR estimates of pork and broiler price transmission

	1999-2008 hog / pork prices		1999-2008 broiler prices	
Variables	Domestic transmission	International transmission	Domestic transmission	International transmission
Constant	-0.006	-0.023	15.817***	19.245*
Farm price$_t$	-	-	2.344**	-
Farm pricet$_{t-1}$	0.229***	-	-	-
Retail price$_{t-1}$	-0.180*	-0.208**	-2.466***	-2.560*
Retail price$_{t-2}$	0.107	0.041	-	-
Import price$_t$	-	0.152***	-	1.820***
Import price$_{t-1}$	-	0.116**	-	-
Constant	4.595**	14.681*	-15.484***	-18.876*
Farm price$_t$	-	-	-1.672*	-
Farm price$_{t-1}$	-0.248	-	-	-
Retail price$_{t-1}$	-0.603*	-0.630*	2.367***	2.465*
Retail price$_{t-2}$	-1.006*	-2.786*	-	-
Import price$_t$	-	-0.466*	-	-1.892***
Import pricet$_{-1}$	-	-0.691	-	-
Transition Rate	48.09*	50.12*	142.71*	197.20*
Threshold Parameter	2.45***	3.21***	4.64***	6.32***

Note: *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.