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ASYMMETRIC PRICE TRANSMISSION IN THE ARTISAN DAIRY INDUSTRY OF HONDURAS

Jorge Fidel BARAHONA[1]
Bernardo TREJOS[2]
Jai Wei LEE[3]
Wanvilai CHULAPHAN[4]
Chalermpon JATUPORN[5]

ABSTRACT

This study investigates price transmission symmetry in the artisan dairy industry of Honduras. The data employed includes monthly prices of fluid milk, quesillo (i.e., a local cheese product with a consistency similar to mozzarella), fresh cheese, and dry cheese between January 1997 and April 2013. Both the Johansen multivariate approach and the Engle-Granger two step analyses confirm that fluid milk prices have a strong cointegration with prices of quesillo, fresh cheese and dry cheese. Furthermore, dairy products that exhibit high market competition such as fresh cheese and dry cheese showed negative asymmetric price transmission whereas those that exhibit low market competition such as quesillo showed positive asymmetric price transmission. Results also suggest that, regardless of the type of dairy product, artisan dairy producers will adjust more quickly when milk prices increase than when they decrease. Artisan dairy producers operate under low profit margins, so they will react faster when their profits shrink and slower when their profit margins increase.

Keywords: Artisan dairy industry, Asymmetric price transmission, Asymmetric ECM

[1] Department of Tropical Agriculture and International Cooperation National Pingtung University of Science and Technology Pingtung, Taiwan (R.O.C.)

[2] Department of International Tourism and Hospitality I-Shou University Kaohsiung City, Taiwan (R.O.C.).Corresponding author. **E-mail**: btrejos@isu.edu.tw

[3] Department of Tropical Agriculture and International Cooperation National Pingtung University of Science and Technology Pingtung, Taiwan (R.O.C.)

[4] Department of Tropical Agriculture and International Cooperation National Pingtung University of Science and Technology Pingtung, Taiwan (R.O.C.)

[5] Bureau of Agricultural Development Policy and Planning Office of Agricultural Economics, Ministry of Agriculture and Cooperatives Jatujak, Bangkok, Thailand

INTRODUCTION

The study of asymmetric price transmission throughout the agricultural product supply chain provides insights into market efficiency and welfare of consumers and producers (Capps and Sherwell, 2007). In the case of agricultural products, asymmetric price transmission is caused by several factors including abuse of market power (von Cramon-Taubadel and Meyer, 2000), product perishability (Ward, 1982) and distortion in the price reporting process (Bailey and Brorsen, 1989; Cutts and Kirsten, 2006). The aforementioned research was done based on data from developed countries, while the present study extends into the causes of asymmetric price transmission in developing countries. There is not much research on price transmission symmetry based on data from developing countries. One line of research found that beef and pork markets in a transition economy (i.e. Hungary) were characterized by symmetric price transmission (Bakucs and Ferto; 2005a; 2005b). Conversely and Falkowski (2010) found asymmetric price transmission in the Polish fluid milk sector. Aguiar and Santana (2002) found that farm-gate retail-price transmission for several agricultural products in Brazil had positive asymmetric price transmission regardless of the level of product storability and market concentration. In Vietnam, Le Goulven (2001) found that hog markets that had public slaughterhouse facilities were characterized by symmetric price transmission, while those with private slaughterhouses were associated with asymmetric price transmission. Asymmetric price adjustment has been reported in several sectors of the agricultural industry (Meyer and von Cramon-Taubadel, 2002; Peltzman, 2000). In the case of the dairy sector, asymmetric price transmission has been found in nations that are highly industrialized (Kinnucan and Forker, 1987; Capps and Sherwell, 2007). There is lack of studies, however, on price transmission in the artisan dairy industry. The dairy industry in Honduras is not heavily industrialized, which provides an opportunity to evaluate whether traditional dairy industries are affected by asymmetric price transmission. In Honduras, 65% of the raw milk is bought and processed by the artisan dairy plants (Molina, 2010). Moreover, the dairy industry lacks the technology and coordination among supply chain agents that is necessary for efficient price transmission along the supply chain. Therefore, the aim of this paper is to evaluate the symmetry of price transmission in the artisan dairy industry of Honduras.

Empirical modeling

In order to investigate the symmetry of price transmission, Houck (1977) developed a method based on Wolfram's (1971) price variable splitting approach (equation-1):

$$\Delta P_t^o = \propto_0 + \beta_1^+ \Delta P_t^{i+} + \beta_1^- \Delta P_t^{i-} + \varepsilon_t \qquad (1)$$

Where P_t^o and P_t^i are the firm's output (i.e. processed dairy product) and input (i.e. fluid milk) price in period *t* respectively. Houck (1977) and Wolfram's (1971) variable splitting technique segments ΔP_t^i into positive (ΔP_t^{i+}) and negative (ΔP_t^{i-}) phases, where ΔP_t^{i+}=P_t^i- P_{t-1}^i, if $\Delta P_t^i > 0$(otherwise the value is 0) and ΔP_t^{i-}=P_t^i- P_{t-1}^i, if $\Delta P_t^i < 0$ (otherwise the value is 0). Equation-1 assumes that output prices are a function of input prices. Kinnucan and Forker (1987) assumed a unidirectional causal relationship running from prices of milk to prices of processed dairy products. The present study follows this assumption; however, Granger causality tests were performed in order to verify the direction of the causal relationship between the prices of processed dairy products and fluid milk. Houck's model initially assumes that output prices respond instantly to input prices. However, responses in prices of agricultural products are generally distributed over time (Lamm and Westcott, 1981; Kinnucan and Forker, 1987). Consequentially, Meyer and von Cramon-Taubadel (2002) modified Equation 1 to accommodate for lagged prices of P_t^i (equation-2).

$$\Delta P_t^o = \propto_0 + \sum_{i=0}^{M} \beta_{1i}^{+} \Delta P_{t-i}^{i+} + \sum_{i=0}^{N} \beta_{1i}^{-} \Delta P_{t-i}^{i-} + \varepsilon_t \qquad (2)$$

Where β_{1i}^{+} and β_{1i}^{-} are coefficients that correspond to impacts of rising and falling input prices. *M* and *N* represent the number of lags associated with increases and decreases in price series. There is no reason to expect that lag length is equal, so *M* and *N* number of lags in Equation 2 can differ (Meyer and von Cramon-Taubadel, 2002). Following Bailey and Brorsen (1989), asymmetry was examined in equation-2 by testing the following null hypothesis:

$$Ho: \sum_{i=0}^{M} \beta_{1i}^{+} = \sum_{i=0}^{N} \beta_{1i}^{-}$$

Rejection of the null hypothesis implies that the price series would tend to drift apart over time; which provides evidence of asymmetric price transmission. On the other hand, failure to reject the null hypothesis provides evidence of symmetry in the price transmission. A setback of Houck's approach is that it does not consider the time-series properties of the data. If P_t^i and P_t^o are nonstationary, estimation of equation-2 will yield spurious results (Le Gouvlen, 2001). In addition, von Cramon-Traubadel and Loy (1996) and von Cramon-Traubadel (1998) demonstrated that Houck's model is not an appropriate test for asymmetry if the price series is cointegrated. In order to test for asymmetry in variables that are cointegrated, Granger and Lee (1989), von Cramon-Traubadel and Loy (1996) and von Cramon-Traubadel (1998) proposed the use of an error correction model (ECM). If two price series are cointegrated, more specifically if $P_t^o = \gamma_0 + P_t^i \gamma_1 + \mu_tand\mu_t$ is stationary at level, then the asymmetric error correction model (ECM) can be modeled in the following form (equation-3):

$$\Delta P_t^o = \propto_0 + \sum_{i=0}^{M} \beta_{1i}^{+} \Delta P_{t-i}^{i+} + \sum_{i=0}^{N} \beta_{1i}^{-} \Delta P_{t-i}^{i-} + \sum_{i=1}^{Z} \beta_{2i} \Delta P_{t-i}^{o} + \varphi^{+} ECT_{t-1}^{+} + \varphi^{-} ECT_{t-1}^{-} + \varepsilon_t \qquad (3)$$

Equation-3 is similar to Houck's model, where ECT_{t-1}^{+} and ECT_{t-1}^{-} are the lagged positive and negative residuals of the regression between $P_t^{out}$and P_t^{in}. More specifically ECT_t^{+} will equal $P_t^o - \gamma_0 - P_t^i\gamma_1$ if $P_t^o - \gamma_0 - P_t^i\gamma_1 > 0$; otherwise ECT_t^{+} will take a value of 0. In turn, ECT_t^{-} will equal $P_t^o - \gamma_0 - P_t^i\gamma_1$ if $P_t^o - \gamma_0 - P_t^i\gamma_1 < 0$, otherwise ECT_t^{+} will take a value of 0. Capps and Sherwell (2007) found that superiority between the asymmetric ECM and the Houck model was inconclusive, suggesting that both approaches can be used depending on the type of data at hand. Examination of asymmetry in the asymmetric ECM includes testing of the following null hypothesis:

$$Ho_1: \sum_{i=0}^{M} \beta_{1i}^{+} = \sum_{i=0}^{N} \beta_{1i}^{-} \text{ and} Ho_2: \varphi^{+} = \varphi^{-}$$

The null hypothesis can be tested using a joint F-test. Rejection of Ho_1implies that impact of input price decreases on output prices will be different than the impact of input prices when output prices increase. If output prices react more fully and rapidly to an increase in the input prices compared to a reduction in the input prices, then there is positive asymmetric price transmission. On the other hand, if output prices react more fully and rapidly to decreases in the input prices, then there is negative asymmetric price transmission (Meyer and von Cramon-Taubadel, 2002).

Data and empirical results

Average monthly nominal prices of fluid milk, quesillo, fresh cheese and dry cheese from three major markets in Honduras during January 1997 to April 2013 were extracted from the Agricultural Product Markets Information System (SIMPAH). In Honduras, agricultural products are commonly weighed in lbs; therefore all price series are expressed in Lempiras (i.e. the local currency) per pound (Lps/lb). Monthly data frequently exhibits cyclical patterns caused by seasonality. Data series with strong seasonal effects, including fresh and dry cheese prices, were adjusted using the U.S. Census Bureau's X12 seasonal adjustment program that is included in the EViews 7.1 software pack. After seasonal adjustment, all prices were transformed into logarithm and tested for stationarity using an Augmented Dicky-Fuller test (ADF) (Dickey and Fuller, 1979; 1981). Augmented Dicky-Fuller unit root tests are shown in Table-1. The results show that prices of quesillo, dry cheese, fresh cheese and milk are non-stationary at level (p>0.05). However, ADF tests indicate that prices for the four aforementioned products are stationary at first difference (p<0.05).

Johansen's (1998) multivariate approach and Engle-Granger two-step method (Engle and Granger, 1987) were performed pairwise between prices of milk and processed dairy products in order to determine whether the prices of milk were cointegrated with those of quesillo, dry cheese and fresh cheese. As shown in Table-2, results from the trace test statistics show that prices of aforementioned dairy products are cointegrated with prices of milk. Following Reziti and Panagopoulos (2008), Granger-causality tests were performed in order to verify the direction of the causality. A unidirectional causal relationship running from fluid milk prices to prices of quesillo, dry cheese and fresh cheese was found. This implies that prices of milk exert a strong price leadership in the artisan dairy market. Therefore, testing for asymmetric price transmission in the artisan dairy industry of Honduras would require that prices of processed dairy goods be modeled as a function of fluid milk prices.

Table 1: ADF unit root test results

Price series	Level	P value	First difference	P value
Quesillo	-0.458	0.895	-10.971	*
Dry cheese	-0.434	0.899	-13.116	*
Fresh cheese	-0.838	0.806	-18.001	*
Milk	0.0979	0.965	-15.104	*

Note: The asterisk * denotes significance at 5% level.

Table 2: Johansen's cointegration analysis and Granger causality tests

Price series	Null Hypothesis	Trace test statistic	p-value	Causality
Quesillo- Milk	r = 0	19.498*	0.012	Milk→Quesillo
	r ≤ 1	0.145	0.7035	
Dry cheese- Milk	r = 0	20.105*	0.009	Milk→Dry cheese
	r ≤ 1	0.094	0.760	
Fresh cheese- Milk	r = 0	18.255*	0.019	Milk→Fresh cheese
	r ≤ 1	0.129	0.719	

Note: The asterisk * denotes rejection of the null hypothesis of cointegration at the 5% significance level. → Denotes the direction of Granger causality.

Table 3 shows the results of the Engle-Granger two-step method. The Engle-Granger cointegration test is based on the residuals of the ordinary least square regression between two sets of variables. A unit root test (using ADF) was used to examine whether the residuals of the ordinary least squares regression (in this case, between dairy product and milk) were stationary at level. If the residuals are shown to be stationary at level, then both price series are cointegrated, and the residuals can be used as an error correction term for the asymmetric ECM. Results of the ADF tests in Table 3 indicate that the residuals are nonstationary at level, which gives further proof that prices of quesillo, dry cheese and fresh cheese are cointegrated with prices of fluid milk. This suggests that the study of asymmetric price transmission between fluid milk and other processed dairy products in the artisan dairy industry of Honduras should be modeled using an asymmetric ECM, since the use of the Houck's approach may lead to spurious results (von Cramon-Taubadel and Loy, 1996; von Cramon-Taubadel, 1998).

Results of the asymmetric ECM estimation are shown in Table-4. Testing for asymmetry would require that $\sum_{i=1}^{M}\beta_{1i}^{+}$ be significantly different from$\sum_{i=0}^{N}\beta_{1i}^{-}$. The p-values of the joint-F test indicate that we can reject the null hypothesis of symmetric price transmission between prices of dairy products such as quesillo (p = 0.006), dry cheese (p= 0.003) and fresh cheese (p = 0.003) and those of milk at a 5% confidence level. In the case of quesillo, increases in milk prices were more fully transmitted to prices of quesillo than decreases in fluid milk prices, which is indicative of positive asymmetric price transmission. Positive asymmetric price transmission has also been reported among major US dairy products (Kinnucan and Forker, 1987) and within the Polish fluid milk sector (Falkowski, 2010). Moreover, the findings go in line with von Cramon-Taubadel and Meyer's (2000) explanation of asymmetric price transmission in industries with high market power.

Table 3: Engle-Granger cointegration analysis

P_t^o	γ_0	γ_1	R^2	AIC	SIC	ADF test of $\hat{\mu}_t$
Quesillo	1.929 (99.008)	0.738 (60.291)	0.949	-2.816	-2.782	-6.803*
Dry cheese	2.328 (135.475)	0.642 (59.519)	0.948	-3.067	-3.034	-5.396*
Fresh cheese	2.0517 (122.026)	0.690 (65.357)	0.957	-3.110	-3.077	-6.036*

Note: The asterisk * denotes significance at 5% level. Engle-Granger cointegration analysis is based on unit root test of the residuals ($\hat{\mu}$) obtained from the OLS regression $P_t^o = \gamma_0 + P_t^i\gamma_1 + \mu_t$ (Where P_t^o are the weekly prices of processed dairy goods and $P_t^i$is the price of fluid milk). If the ADF test proves that$\hat{\mu}$ is stationary at level, then the price series are said to be cointegrated.

In turn, decreases in fluid milk prices were more fully transmitted to prices of fresh cheese and dry cheese than increases in fluid milk prices. These results are similar to those of Cutts and Kirsten (2006), who found that several agro-food industries in South Africa with high market concentration show a high degree of asymmetric price transmission. Quesillo and fresh cheese are dairy products that have a similar degree of storability, but the percentage of artisan dairy plants that produce fresh cheese is larger. Molina (2010) found that 44.1% of the total artisan dairy plants produce fresh cheese, while 24.4% of the artisan dairy plants produce quesillo. This provides evidence that a low degree of competition in dairy products can lead to positive asymmetric price transmission. Artisan dairy plants that produce quesillo are more willing to transmit price increases than price decreases to consumers because competition is low. However, artisan dairy plants that produce fresh cheese face higher competition and are reluctant to increase the price of fresh cheese in fear of losing sales. Similar findings are observed for dry cheese, which is produced by 62.9% of the artisan dairy plants (Molina, 2010) suggesting that dry cheese is sold in a competitive market. This implies that artisan dairy plants will be more reluctant to fully increase the prices of dry cheese in response to increases in fluid milk prices than to decrease prices of dry cheese in response to decreases in fluid milk prices. Table-4 also shows that prices of all processed dairy products used in this study respond faster to price increases than to price decreases of fluid milk. Similar results were found in other studies of price transmission in the dairy industry (Kinnucan and Forker, 1987; Lass *et al*., 2001; Capps and Sherwell, 2007). Price increases were immediately transferred from milk to fresh cheese; however, price reductions were not transferred as fast, which indicates incomplete transfer of information and the willingness to retain as much profits as possible.

Table 4: Asymetric ECM results

Coefficient	Quesillo	Fresh cheese	Dry cheese
$\propto_0$	0.012(0.038)	-0.000(0.944)	-0.003(0.433)
ΔP_t^{i+}	0.117(0.547)	0.313(0.019)	0.351(0.007)
ΔP_{t-1}^{i+}	0.611(0.002)	0.141(0.295)	0.105(0.417)
$\sum_{i=0}^{M} \beta_{1i}^{+}$	0.730(0.010)	0.455(0.018)	0.457(0.014)
ΔP_t^{i-}	-0.078(0.764)	-0.157(0.366)	-0.181(0.285)
ΔP_{t-1}^{i-}	-0.545(0.033)	-0.396(0.027)	-0.343(0.047)
$\sum_{i=0}^{M} \beta_{1i}^{-}$	-0.623(0.091)	-0.553(0.031)	-0.524(0.034)
ECT_{t-1}^{+}	-0.905(0.000)	-0.326(0.000)	-0.261(0.002)
ECT_{t-1}^{-}	0.007(0.958)	0.103(0.044)	-0.255(0.004)
ΔP_{t-1}^{o}	-	-0.150(0.031)	-
R^2	0.432	0.215	0.170
AIC	-3.184	-3.948	-4.006
SIC	-3.066	-3.814	-3.889
$\sum_{i=1}^{M} \beta_{1i}^{+} = \sum_{i=0}^{N} \beta_{1i}^{-}$	0.006 [a]	0.003 [a]	0.003 [a]
$\varphi^{+} = \varphi^{-}$	0.000 [a]	0.450 [a]	0.965 [a]

Note: Numbers inside parentheses are p- values. [a] Values reported are p-values of the asymmetric hypothesis tests: $\sum_{i=1}^{M} \beta_{1i}^{+} = \sum_{i=0}^{N} \beta_{1i}^{-}$ and $\varphi^{+} = \varphi^{-}$. Rejection of the asymmetric hypothesis requires that p-values be less than 0.05.

CONCLUDING REMARKS

Based on the empirical results, it can be concluded that the artisan dairy industry in Honduras is characterized by asymmetric price transmission. Positive asymmetric price transmission was found for quesillo, which has high market concentration and low storability. Conversely, negative asymmetric price transmission was found for dry and fresh cheese, both of which face high competition in the market. This suggests that asymmetric price adjustments are related to the degree of market competition. In addition, regardless of the type of dairy product, the price of processed dairy products had a slower response to price decreases than to price increases of fluid milk. This gives evidence that dairy artisans react faster to a shrinking of the profit margin than to an expansion of the profit margin. Artisan dairy plants operate with low profit margins and will therefore quickly transmit increases in milk prices. When milk prices decrease, however, artisan dairy plants will try to maintain the increase in profits as long as possible.

These findings are important for decision making, since policies are usually implemented in the same manner to all processed dairy products. This study provides evidence that price transmission between fluid milk and processed dairy products varies depending on market competition. Consequentially, policies for dairy products should be tailored to accommodate for market competition. The present study investigated the asymmetric price transmission that occurs within the dairy industry. Further research on how asymmetric price transmission affects the welfare of consumers and producers may provide a better understanding of the artisan dairy industry. Moreover, further research on price symmetry between domestic and export prices of dairy products may help identify market imperfections between international and domestic markets.

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