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Asymmetric price transmission in the distribution channels of pork: Focusing on the effect of policy regulation of Sunday sales by hypermarkets in Korea

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Abstract: In this paper, we investigate whether there exists market inefficiency in the distribution channel of pork by estimating a developed partial adjustment model that captures the asymmetric price transmission from wholesale to retail prices. The estimation results show that market efficiency exists for the wholesale and two types of retail markets in the distributional channel of pork in Korea. The government's regulation on Sunday sales by hypermarkets plays a significant role in increasing market efficiency, forcing more competition among hypermarkets, and changing the structure of asymmetric price transmission from wholesale to traditional market prices. The results suggest that the policy goal has been achieved in the traditional market by leading to a more efficient price forming due to a lessened degree of asymmetric price transmission from the wholesale price. Although market inefficiency has been maintained in the distribution channel between wholesale market and hypermarket, the behavior of price setting by hypermarkets has not been influenced by the policy.

Keywords: market efficiency; marketing channel; retail price; Threshold Partial Adjustment Model; wholesale price

Pork is a livestock product that has the largest share in the value of production in Korea. Its production not only plays an important role in the domestic market that meets the high demand from consumers but also it is the product of great importance in the income of farmers. However, the price of domestic pork varies over time due to several reasons such as the change in pork consumption, increase in supply and inventories, increase in pork imports, and the supply shocks caused by diseases such as foot and mouth disease (FMD) and African swine fever virus (ASFV).

As one of the features in the pork market, the asymmetric price transmission of prices has been investigated in many previous studies. For example, Abdulai (2002) examined the relationship between producer and retail prices of the pork market in Switzerland. The results indicate that asymmetric price transmission exists between the producer and retail prices. For the U.S. pork market, Miller and Hayenga (2001) found that price changes in wholesale prices are asymmetrically transmitted to retail prices. Yoon and Scott (2018) suggested that asymmetric price transmission in the U.S. pork market appears differently across the distributional channels. In this research, it is proved that the wholesale price adjustment is made relatively quickly in response to an increase in producer price and a decrease in retail price. Sim et al. (2006) showed that asymmetry of price transmission exists in the Korean pork market between producer and wholesale level using the error correction model.

While the importance of the existence of asymmetric price transmission in distribution channels has been recognized in the previous studies, economists' interest in the reasons for the presence of asymmetric price transmission has not been much investigated. The notable reasons that have been highlighted in the previous

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studies are the government regulations, technology, market power, perishability of a product, and the number of stages in the food supply chain (Garrido et al. 2016). Bettendorf and Verboven (2000) analyzed the effect of farm input cost share on price transmission and showed that low farm input cost share reduced more farm price transmissions than did the retail market power. While previous researches on farm input cost share, perishability of a product, and inflation showed a one-sided effect on price transmission (Acharya et al. 2011; Kim and Ward 2013), the effect of the government regulations on reducing or increasing farm price transmission is questionable. For example, Romain et al. (2002) analyzed that policies that promote local competition and put a ceiling on retail price result in an increasing farm price transmission from the wholesale to the retail price. On the other hand, Kinnucan and Forker (1987) suggested that government policies that support the prices received by farmers have the effect of reducing farm price transmission. In the same vein, we focus on government policy as the reason to cause the asymmetric price transmission in the present paper.

In Korea, the regulatory policy of hypermarkets was created in 2012 to protect traditional markets and small retailing shops from intense competition with hypermarkets. There are 3 representative hypermarket chains in Korea: E-mart, Lotte-mart, and Homeplus. The market share of pork by these 3 hypermarket chains reaches 25% as of 2018. According to the policy, hypermarkets have been prohibited to open the stores every second and fourth Sundays since then. However, the same policy has not been applied to online malls, the recent competitor of hypermarkets which causes a huge profit loss for hypermarkets. Based on these background situations, this study attempts to determine in which direction price transmission is occurring and whether asymmetric price transmission exists among the wholesale and two types of retail markets: traditional market and hypermarket which consist of the largest share in total retail sales.

Most studies attempted to determine the direction and existence of asymmetric price transmission in the distribution channels of pork, thus failing to focus on the reasons for the presence of asymmetric price transmission such as the influence from the policy for retail market. Motivated by these limitations, the present study examines the magnitude of asymmetric price transmission and how the structure of asymmetric price transmission changes in response to the government's regulation of Sunday sale by hypermarkets using the Threshold Partial Adjustment Model (TPAM).

Three research questions that we bring into this study are as follows. First, what is the causality in the distribution channel? The hypothesis for this research question is set for testing whether wholesale market prices affect the price formation in hypermarkets and traditional markets. Second, is there market inefficiency in the distribution channel? For this research question, we test whether there exists asymmetric price transmission. Third, what is the role of regulatory policy for hypermarkets in changing the structure of asymmetric price transmission? By exploring this question, we may have an implication regarding whether the government's policy lessens the inefficiency of the market.

There is a few previous research that investigated the changes in the structure of asymmetric price transmission when policy shock has occurred. In this context, the present study fills the gap of existing literature.

PREVIOUS RESEARCHES AND METHODS

Asymmetric price transmission is the phenomenon that refers to the situation where prices behave asymmetrically in response to the change in other prices. The asymmetry of price occurs when the market is inefficient due to several reasons such as the presence of centralized market power (Meyer and von Cramon-Taubadel 2004).

Previous studies on asymmetric price transmission by distribution stage of agricultural products include Goletti and Christina-Tsigas (1995), Goodwin and Holt (1999), Goodwin and Piggott (2001), and Kang and Ahn (2015). The first to apply the Threshold Vector Error Correction Model (TVECM) in the field of agricultural economics are Goodwin and Holt (1999) and Goodwin and Piggott (2001). Goodwin and Holt (1999) evaluated price linkages in U.S. beef markets among producers, wholesale, and retail marketing channels using the threshold cointegration method. Goodwin and Piggott (2001) used impulse response to find strong support for market integration of corn and soybean markets in North Carolina. The result indicates that shocks are being transmitted to price dynamically over time. Moreover, larger and smaller shocks show different dynamics of price transmission in terms of magnitude and speed. Using cointegration coefficients and time series analysis, Goletti and Christina-Tsigas (1995) measured market integration and market efficiency on the maize market in Bangladesh and Malawi. The determinants for efficient markets are identified as marketing infrastructure, governmental

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policy, and dissimilarities on the production level. Kang and Ahn (2015) investigated whether asymmetric price transmission exists in the marketing chain of rice in Korea. The result suggests that asymmetric price transmission exists between the wholesale and retail prices of the rice market. This implies that the rice market is not efficiently operated even though the rice market in Korea seems to be competitive.

While many kinds of research are done to utilize and apply the TVECM model to different commodities, recent studies focus more on the fundamental issues of analyzing price transmission. Kinnucan and Zhang (2015) raised the issue of the common belief regarding perfect farm to retail price transmission which is considered as the elasticity of price transmission (EPT) being equal to 1[1]. The results show that the absolute marketing margin, which is the difference between the retail and farm price, responds differently to the change in the producer's production function than does the relative marketing margin which is the ratio of the retail price to the farm price.

In the empirical analysis of the present study, we use the TPAM from Kim and Seo (2017) which extends the partial adjustment model by Nerlove (1956) to explain the nature of asymmetric price transmission. Instead of using the TVECM model which is frequently used for analyzing the asymmetric price transmission, this study uses the TPAM model because the three price data used are stationary and the model allows to examine the different price adjustment depending on the state. When the data is nonstationary but has a cointegration relationship, we take the difference of the data and use the ECM model to analyze the long-term price relationship. Through the process of making the nonstationary data to stationary one by taking a first difference, there is a loss in information. This study not only prevents information loss but also captures different price adjustment depending on the state by using the TPAM model.

In the TPAM y_t and x_t represent retail prices (hereinafter referred to as downstream prices) and wholesale prices (hereinafter referred to as upstream prices).

$$y_t^* = \alpha + \beta x_t \tag{1}$$

where: α – the distribution margins; y_t^* – the equilibrium downstream prices reflect the fair distribution margins and the linear price relationship between downstream (y_t) and upstream prices (x_t) as shown in Equation (1).

Since the observed downstream price data (y_t) is the equilibrium downstream prices (y_t^*) plus the error terms (u_t) as shown in Equations (2) and (3) can be obtained by subtracting lagged downstream prices (y_{t-1}) from both sides where ρ denotes the adjustment coefficient.

$$y_t = y_t^* + u_t \tag{2}$$

$$y_t - y_{t-1} = \rho\left(y_t^* - y_{t-1}\right) + u_t, \quad (0 < \rho \leq 1) \tag{3}$$

The closer the adjustment coefficient is to 1, it is interpreted that the faster the price adjustment is made. On the contrary, we can infer that the slower the price adjustment is made if the adjustment coefficient is closer to 0. Equation (3) implies that the change in downstream price from the previous period is partially (if $0 < \rho < 1$) or fully explained (if $\rho = 1$) by the equilibrium downstream prices (y_t^*) and lagged downstream price (y_{t-1}).

$$s_t = y_t^* - y_{t-1} = \alpha + \beta x_t - y_{t-1} \tag{4}$$

$$\begin{aligned}\Delta y_t = {} & \rho_1\left(\alpha + \beta x_t - y_{t-1}\right) \times 1\left(s_t \leq 0\right) + \\ & + \rho_2\left(\alpha + \beta x_t - y_{t-1}\right) \times 1\left(s_t > 0\right) + u_t\end{aligned} \tag{5}$$

If we define the differences between the equilibrium downstream price (y_t^*) and the lagged downstream price (y_{t-1}) as state variables (s_t) as Equation (4), we can allow two states depending on the case where the state variable is less than or equal to zero and the state variable is bigger than zero as Equation (5). In this case, the adjustment coefficients for state 1 (ρ_1) represent the state where s_t is less than or equal to zero, and the adjustment coefficients for state 2 (ρ_2) represent the state where s_t is bigger than zero. If the coefficients ρ_1 and ρ_2 are the same, we can conclude that adjustment takes place symmetrically, however, if the coefficients are different from one another, we can say that there exists asymmetric price adjustment. The adjustment coefficients ρ_1 and ρ_2 deliver some additional meanings. If these are combined with the coefficient β, they reveal the asymmetry (or the symmetry) of the transmission from upstream to downstream prices. In other words, if $\rho_1\beta$ is statically different from $\rho_2\beta$, we can conclude that price transmission from upstream to downstream is asymmetric. Since two combined coefficients $\rho_1\beta$ and $\rho_2\beta$ share the same component β,

[1]However, the definition of EPT in this study is inconsistent with the arguments made in Gardner's (1975) model.

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testing whether ρ_1 is the same as ρ_2 reveals whether or not there exists an asymmetric price transmission.

$$\begin{aligned}\Delta y_t = {} & \rho_1\left(\alpha+\beta x_t - y_{t-1}\right)\times 1\left(s_t \le 0\right) + \\ & + \rho_2\left(\alpha+\beta x_t - y_{t-1}\right)\times 1\left(s_t > 0\right) + \\ & + D\begin{bmatrix}\delta_1\left(\alpha+\beta x_t - y_{t-1}\right)\times 1\left(s_t \le 0\right) + \\ + \delta_2\left(\alpha+\beta x_t - y_{t-1}\right)\times 1\left(s_t > 0\right)\end{bmatrix} + u_t\end{aligned} \quad (6)$$

In the empirical equation, policy dummy of *D*, which is 1 for the period whereof policy regulation for the hypermarkets is effective and 0 for the other period, is added to investigate the effect of the policy regulation as Equation (6). In this equation, the coefficients δ_1 and δ_2 represent the effect of the policy regulation depending on two states of asymmetric price adjustment.

Before estimating the empirical Equation (6), we investigated the time-series properties of the pork prices. First, unit root tests were conducted to confirm the stationarities of the wholesale and retail market price data. The adopted unit root tests are the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS). Second, after selecting the optimal time lag of the variables using the vector-autoregressive (VAR) model, the Granger causality test was conducted to examine the direction of price change in distribution channels. Third, the TPAM was conducted to test whether asymmetric price transmission exists. Lastly, using price adjustment coefficients (ρ_1, ρ_2, δ_1, and δ_2) we examined the change of structure of asymmetric price transmission in response to the regulatory policy of Sunday sale by hypermarkets.

DATA

The data used in this study are extracted from the Korea Agricultural Marketing Information Service, which is provided by the Korea Agro-Fisheries and Food Trade Corporation, and livestock distribution information website as explained in Table 1. In this study, a total of 468 wholesale prices and retail prices for hypermarkets and traditional markets are used from January 2007 to December 2019.

Representative hypermarket retail prices from 19 regions and traditional market retail prices from 16 regions are averaged and used as representative retail prices for each distribution channel. The descriptive statistics of the key variables are as follows.

As shown in Table 2, there is a big difference between wholesale and retail prices. In particular, we can notice that the retail prices in the traditional market are higher than those of hypermarkets. Considering the fact

Table 1. Data description

Classification	Definition (average)	Source
Wholesale price	17 regional prices	Korea Institute of Animal Products Quality Evaluation (2020)
Hypermarket retail price	representative hypermarket retail prices from 19 regions	Korea Agricultural Marketing Information Service (2020)
Traditional market retail price	representative traditional market retail prices from 16 regions	Korea Agricultural Marketing Information Service (2020)

Source: Own elaboration

Table 2. Descriptive statistics (USD)

Classification	Wholesale price (100 g)	Retail price of hypermarket (100 g)	Retail price of traditional market (100 g)
Mean	0.38	1.57	1.58
Median	0.39	1.58	1.62
Maximum	0.62	2.19	2.04
Minimum	0.24	1.08	1.05
SD	81.58	251.03	282.25
Skewness	0.31	0.12	–0.27
Kurtosis	3.49	2.65	2.23

The average exchange rate (1 149.5 won/USD) in October 2020 is applied; number of observations = 156
Source: Korea Institute of Animal Products Quality Evaluation (2020); Korea Agricultural Marketing Information Service (2020)

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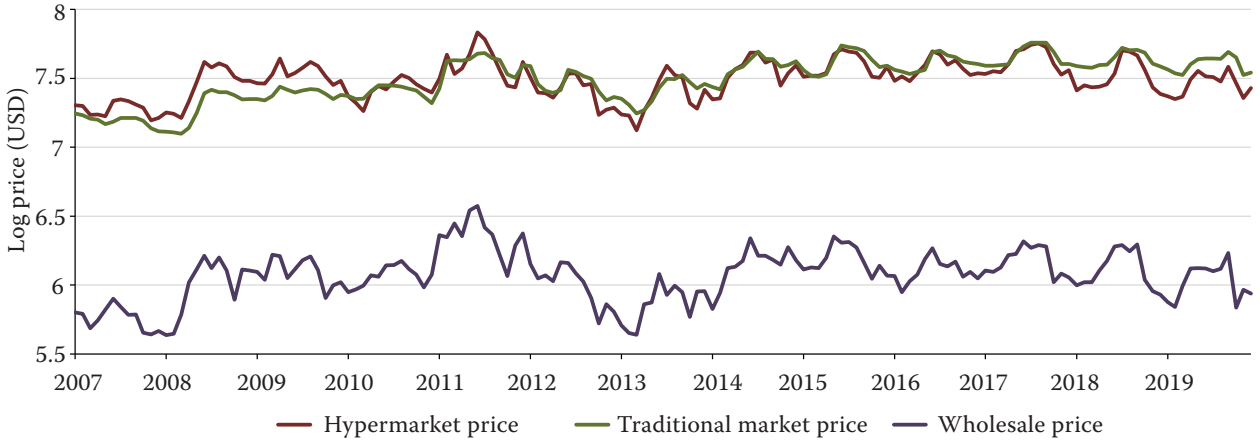

Figure 1. Changes in wholesale and retail prices

The trend of wholesale, hypermarket and traditional market prices in log form are shown

Source: Own processing based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

that the volume handled by hypermarket is far greater than the one by the small individual retail merchant in the traditional market, this trend of price movement is reasonable.

Figure 1 shows the trend of wholesale and two retail prices for pork. While the overall trend of the wholesale price and the hypermarket retail price follows a similar trend, the trend of the retail price in the traditional market moves differently. When the wholesale price goes up, the retail price for the traditional market goes up simultaneously, however, the retail price for the traditional market falls slowly when the wholesale price drops. Moreover, the retail price for the traditional market responds to hypermarket retail price with time lags. Another noticeable feature in Figure 1 is that the fluctuation of the wholesale price (coefficient of variation is calculated to be 0.19) is greater than that of retail price (coefficients of variation are 0.14 for hypermarket price and 0.15 for the traditional market price). This difference in the price fluctuations is consistent with the findings in previous studies that pointed out the retail price fixity (Mankiw 1985; Caplin and Spulber 1987; Shonkwiler and Taylor 1988; Slade 1999). The less volatile retail price relative to wholesale price may result from many reasons such as retailers' rational response to high costs of price adjustment which is referred to as menu costs.

Reflecting on the trend of wholesale and retail prices, two cases are considered in this study as described in Table 3. The first case compares wholesale and hypermarket retail prices (case I) and the second case compares the wholesale price with traditional market retail prices (case II).

Table 3. Two different cases for the empirical estimation

Case	Variables
I	wholesale prices, hypermarket retail prices
II	wholesale prices, traditional market retail prices

Source: Own elaboration

ESTIMATION RESULTS

Unit root test and causality results. The result of the unit root and stationary tests indicate that all three price variables are stationary as indicated by Table 4.

Table 5 shows the results of the Granger causality test. Causality analysis is primarily intended to know the direction in which prices are passed from one to the other in the distribution channels of pork. The optimal lags used in this analysis are selected as lag 2 and 3 in consideration of Akaike Information Criterion (AIC) and Schwarz Criterion (SC) values.

According to the results, the null hypotheses that hypermarket retail prices do not Granger cause wholesale prices and wholesale prices do not Granger cause hypermarket retail prices are both rejected at 5% and a 1% significance level. This implies that once the price is formed at the wholesale market level, the hypermarket retail prices are determined by reflecting the changes in wholesale prices, and the price formation of hypermarkets does affect the price of the wholesale market.

Moreover, the hypothesis that wholesale prices do not Granger-cause traditional market retail prices is rejected at a 1% significance level whereas the reverse hypothesis turns out to be invalid. This implies that once the prices are formed at the wholesale market level,

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Table 4. Unit root and stationary tests results

Classification		ADF (trend and intercept)	KSPP (trend and intercept)
Wholesale price	*t*-Statistic (ADF) / LM-Statistic (KPSS)	–3.7767	0.1016
	P-value (ADF) / 1% level (KPSS)	0.0203	0.2160
Hypermarket price	*t*-Statistic (ADF) / LM-Statistic (KPSS)	–4.5859	0.0894
	P-value (ADF) / 1% level (KPSS)	0.0015	0.2160
Traditional market price	*t*-Statistic (ADF) / LM-Statistic (KPSS)	–4.6199	0.1391
	P-value (ADF) / 1% level (KPSS)	0.0014	0.2160

To check the stationarity of a time series, the Augmented Dickey-Fuller (ADF) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are used; ADF – tests the null hypothesis stationarity; KPSS – tests the hypothesis that the random walk has zero variance using Lagrange Multiplier (LM) statistics

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

Table 5. Granger causality test results

Null hypothesis	Statistics	Probability	*df*
Hypermarket retail prices do not Granger cause wholesale prices	3.5468	0.0161	3
Wholesale prices do not Granger cause hypermarket retail prices	39.2821	0.0000	3
Traditional market retail prices do not Granger cause wholesale prices	1.0674	0.3465	2
Wholesale prices do not Granger cause traditional market retail prices	79.4920	0.0000	2

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

the traditional market retail prices are determined by reflecting the changes in wholesale prices.

To sum up, the causality test results show that we can set the empirical equations in the forms of Equation (5) or (6), where the downstream wholesale price is set as the left-hand side variable.

Asymmetric price transmission for the whole period. Table 6 shows the results of the analysis based on Equation (5), which extends the linear model to the TPAM. The result shows that the asymmetric price transmission exists among wholesale prices and two retail prices for the case I and II for the whole period.

For both cases, the adjustment coefficients in state 1, ρ_1, are slightly higher than the adjustment coefficients in state 2, ρ_2. This implies that the adjustment speed for state 1, where the differences between the equilibrium downstream prices (y_t^*) and the lagged downstream prices (y_{t-1}) are negative, is faster than the adjustment speed for state 2 where the difference is positive. In other words, faster adjustments take place when a downward gap ($y_t^* - y_{t-1} \leq 0$) exists between lagged downstream prices and equilibrium downstream prices, which is composed of a linear relationship between upstream and downstream prices.

If we interpret the results in Tables 6 and 7 from the perspective of asymmetric price transmission, the combined coefficient $\rho_1\beta$ is greater than $\rho_2\beta$ for both cases. This suggests that there exists asymmetry in the price transmission from wholesale to retail

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Table 6. Threshold partial adjustment model results I

	Coefficient	SE	*t*-statistic	Probability
ρ_1	0.5796***	0.0819	7.0747	0.0000
ρ_2	0.5284***	0.0732	7.2231	0.0000
α	3.5921***	0.1852	19.3988	0.0000
β	0.6421***	0.0305	21.0545	0.0000
R-squared	0.5587	mean dependent variable		0.0008
Adjusted *R*-squared	0.5529	SD dependent variable		0.0797
SE of regression	0.0533	Akaike info criterion		–3.0074
Sum squared residuals	0.4315	Schwarz criterion		–2.9484
Log likelihood	236.0697	Hannan-Quinn criterion		–2.9834

***Denote significant at 1%; ρ_1 – the adjustment coefficient in state 1 which implies that a downward gap ($y_t^* - y_{t-1} \leq 0$) exists between lagged downstream prices and equilibrium downstream prices; ρ_2 – the adjustment coefficient in state 2 which implies the existence of an upward gap ($y_t^* - y_{t-1} > 0$) between lagged downstream prices and equilibrium downstream prices; α – the distribution margins; β – the adjustment coefficient; SD – standard deviation; SE – standard error

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

Table 7. Threshold partial adjustment model results II

	Coefficient	SE	*t*-statistic	Probability
ρ_1	0.2171***	0.0547	3.9694	0.0001
ρ_2	0.1879***	0.0482	3.9004	0.0001
α	3.8179***	0.2975	12.8323	0.0000
β	0.6059***	0.0490	12.3641	0.0000
R-squared	0.2976	mean dependent variable		0.0019
Adjusted *R*-squared	0.2884	SD dependent variable		0.0496
SE of regression	0.0418	Akaike info criterion		–3.4920
Sum squared residuals	0.2658	Schwarz criterion		–2.4331
Log likelihood	273.6330	Hannan-Quinn criterion		–2.4681

***Denote significant at 1%; ρ_1 – the adjustment coefficient in state 1; ρ_2 – the adjustment coefficient in state 2.3.; α – the distribution margins; β – the adjustment coefficient; SD – standard deviation; SE – standard error

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

prices and the extent of price transmission is greater when a downward gap occurs than when an upward gap happens, which indicates the marketing chain for wholesale and retail of pork is not efficiently working. However, the difference between adjustment coefficients in state 1 and 2 are small for two cases. This implies that a relatively low degree of market inefficiency exists for wholesale and two retail markets.

The estimated coefficient is closer to 1 in the case I relative to the case II. This suggests that the retail prices of hypermarkets are relatively more closely linked to wholesale prices than the retail prices of traditional markets.

Asymmetric price transmission before and after policy implementation. Tables 8 and 9 show the results of the analysis based on Equation (6), which extends the linear model to the TPAM that includes the effects of the policy implementation. Compared to the results of asymmetric price transmission for the whole period in Tables 6 and 7, the degree of market inefficiency, which can be measured by the difference of adjustment coefficients, has increased for both cases before and after policy implementation. Before the implementation of policy, faster adjustment for state 1 (ρ_1) takes place when the downward gap ($y_t^* - y_{t-1} \leq 0$) exists between lagged downstream price and the equilibrium price of downstream. In other words, ceteris paribus, downstream prices fall at a faster speed when upstream prices fall for both cases.

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Table 8. Threshold partial adjustment model results I

	Coefficient	SE	*t*-statistic	Probability
ρ_1	0.6075***	0.1305	4.6542	0.0000
ρ_2	0.4742***	0.0829	5.7232	0.0000
δ_1	–0.0501	0.1345	–0.3722	0.7103
δ_2	0.1535	0.1110	1.3822	0.1690
α	3.5921***	0.1852	19.3988	0.0000
β	0.6421***	0.0305	21.0545	0.0000
R-squared	0.5647	mean dependent variable		0.0008
Adjusted *R*-squared	0.5530	SD dependent variable		0.0797
SE of regression	0.0533	Akaike info criterion		–2.9951
Sum squared residuals	0.4257	Schwarz criterion		–2.8970
Log likelihood	237.1228	Hannan-Quinn criterion		–2.9552

***Denote significant at 1%; ρ_1, ρ_2– adjustment coefficients in state 1 and 2 before the implementation of policy; δ_1, δ_2 – adjustment coefficients in state 1 and 2 after the implementation of policy; α – the distribution margins; β – the adjustment coefficient; SD – standard deviation; SE – standard error

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

After the implementation of policy, the adjustment coefficients δ_1 and δ_2 are not estimated to be significant for the case I as shown in Table 8. This implies that the implementation of policy did not have a significant effect on the symmetric structure of the price transmission from wholesale to hypermarket retail prices. Contrary to the hypermarket retailers' concern for a significant decrease in retail sales, the analysis result shows that the policy did not have a direct negative or positive effect on the retail sale of hypermarket. The number of stores in 3 major Korean hypermarket chains was showing an increase in trend up to 2015, however, the number of stores has been stagnant since 2015. This suggests that competition with other retail outlets such as online shopping mall has become stronger (Ahn 2019). Considering the strategy of the hypermarkets to secure market share, the estimation results support the behavior of the fall in retail prices of hypermarkets at a faster rate when wholesale prices fall. In other words, the result of this study implies that hypermarkets are willing to endure the profit loss to maintain market share

Table 9. Threshold partial adjustment model results II

	Coefficient	SE	*t*-statistic	Probability
ρ_1	0.6857***	0.2609	2.6286	0.0095
ρ_2	0.1645***	0.0460	3.5771	0.0005
δ_1	–0.5004*	0.2576	–1.9424	0.0540
δ_2	0.4264***	0.1096	3.8905	0.0001
α	3.8179***	0.2975	12.8323	0.0000
β	0.6059***	0.0490	12.3641	0.0000
R-squared	0.3770	mean dependent variable		0.0019
Adjusted *R*-squared	0.3604	SD dependent variable		0.0496
SE of regression	0.0396	Akaike info criterion		–3.5862
Sum squared residuals	0.2357	Schwarz criterion		–3.4880
Log likelihood	282.9310	Hannan-Quinn criterion		–3.5463

***Denote significant at 1%; ρ_1, ρ_2– adjustment coefficients in state 1 and 2 before the implementation of policy; δ_1, δ_2 – adjustment coefficients in state 1 and 2 after the implementation of policy; α – the distribution margins; β – the adjustment coefficient; SD – standard deviation; SE – standard error

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

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Table 10. Gap of adjustment coefficient before and after the policy implementation

Case	Whole period[1] $(\rho_1 - \rho_2)$	Before[2] $(\rho_1 - \rho_2)$	After[3] $[\rho_1 + \delta_1 - (\rho_2 + \delta_2)]$
I	0.0512	0.1333	0.1333
II	0.0292	0.5212	–0.4056

[1]Using ρ_1, ρ_2 from the Tables 6 and 7 for the cases I and II, $\rho_1 - \rho_2$ – the gap of adjustment coefficient for the whole period; [2]using ρ_1, ρ_2, δ_1 and δ_2 from the Table 8 and 9 for the case I and II, $\rho_1 - \rho_2$ – the gap of adjustment coefficient before the implementation of policy; [3]using ρ_1, ρ_2, δ_1 and δ_2 from the Table 8 and 9 for the case I and II, $\rho_1 + \delta_1 - (\rho_2 + \delta_2)$ – the gap of adjustment coefficient after the implementation of policy

Source: Estimation results based on data from Korea Institute of Animal Products Quality Evaluation (2020) and Korea Agricultural Marketing Information Service (2020)

when the wholesale price falls. This partially explains why the policy had a little direct impact on the behavior of hypermarkets in setting the prices incurring the changes in wholesale prices. In other words, hypermarkets have been willing to sell at low prices in order to avoid inventories from piling up regardless of the implementation of the policy.

On the other hand, the results in Table 9 indicate that a structural change in the asymmetric price transmission occurred for the cases II due to the policy shock. The adjustment coefficients in state 1 $(\rho_1 + \delta_1)$ and state 2 $(\rho_2 + \delta_2)$ for downward gap $(y_t^* - y_{t-1} \leq 0)$ and upward gap $(y_t^* - y_{t-1} > 0)$ are derived to be 0.1853 and 0.5909 after the policy shock. This result implies that downstream prices rise at a faster speed when upstream prices rise after the policy implementation, ceteris paribus.

Before the policy implementation, the equilibrium price of the traditional market falls faster when the prices of wholesale fall due to the lack of information available at the traditional market. When the price of wholesale falls, consumers know the price fall from the information they get from the news or from the hypermarket prices that respond faster to the wholesale price. Therefore, traditional retailers sell at a lower price to attract customers. After the implementation of the policy, however, some consumers who usually go to hypermarkets to buy goods visit traditional markets to purchase foods during Sundays. As a result, the retailers in the traditional market might gain bargaining power, therefore they can sell at a higher price when the wholesale price rise. Interpreting the same result the other way around, the analytical result for the period after policy implementation can be understood as a slower fall in traditional market price when the wholesale price fall. In other words, it means that the pricing structure of the traditional market has changed in the direction of obtaining excess profit by the retailers in this type of market when the price of the traditional market falls, after implementing the policy.

In summary, the estimation results in this study imply that market inefficiency exists for the wholesale and two retail markets in the Korean pork distribution channel. It is found that government policy plays a significant role in changing the asymmetric structure of price transmission between wholesale and traditional market retail prices, as summarized in Table 10. The regulation on Sunday sales by hypermarkets is not estimated to have significant effects on the price asymmetry between wholesale and retail prices for hypermarkets. This may suggest that the policy has not achieved its goal, at least from the perspective of leading to a different price-setting behavior by the hypermarkets, the target of the policy. However, the policy has achieved other indirect effects on the traditional market. As the comparison result of case II in Table 10 indicates, the policy has decreased the absolute value of the gap between the adjustment coefficients for each state, this implies the policy has increased market efficiency in the price transmission from wholesale to traditional market retail prices.

SUMMARY AND CONCLUSION

Pork is a livestock product that has the largest share in production in Korea. Production of pork not only plays an important role in the domestic market in consideration of high demand from consumers but also it is the product of great importance in the income of farmers. While the result of the analysis may have important consequences for the change in the welfare of consumers and producers, analyzing the price movements along distributional channels also suggests whether resources in the supply chain of the pork market in Korea are allocated efficiently.

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In this paper, we investigate three research questions: (*i*) what is the causality in the distribution channel; (*ii*) is there market inefficiency in the distribution channel; and (*iii*) what is the role of regulatory policy for hypermarkets in changing the structure of asymmetric price transmission and the degree of market inefficiency. For investigating these research questions, we develop an empirical model where a partial adjustment process is embedded.

The causality test results show that the wholesale prices of pork affect the retail prices of hypermarkets and the traditional markets. The result of TPAM for the whole period shows that the asymmetric price transmission exists among wholesale prices and two retail prices. The adjustment coefficients for state 1 are revealed to be higher than the adjustment coefficients for state 2. This implies that the faster price adjustment takes place when the downward gap ($y_t^* - y_{t-1} \leq 0$) exists between lagged downstream prices and the equilibrium prices of downstream that is composed of a linear relationship between upstream and downstream prices. However, the difference between adjustment coefficients in each state is estimated to be small, which indicates that a relatively low degree of market inefficiency exists for wholesale and two retail markets for the whole sample period. It is found that government policy plays a significant role in changing the asymmetric structure of price transmission from wholesale prices to retail prices in the traditional market.

The estimation results in this study imply that market inefficiency exists for the wholesale and two types of retail markets in the distributional channel of pork in Korea. This result is consistent with the findings of the previous studies for the pork and livestock markets. The existence of asymmetric price transmission may be a ground for the policy implementation for enhancing market efficiency. Sunday sale regulation introduced by the Korean government can be understood in the context of lessening market inefficiency and forcing more competition among hypermarkets. Although the policy seems to fail in changing the behavior of price setting by hypermarkets, we can say that its policy goal has been achieved in other areas of the traditional market by leading to a more efficient price forming due to a lessened degree of asymmetric price transmission from wholesale price.

The analysis results of this study show government policies can have an effect on where they are not intended. This suggests that it is necessary to consider the related fields together with the main target of the policy when designing it. The regulation of Sunday Sale by hypermarkets in Korea shows that consumers' reactions were focused on traditional markets rather than hypermarkets which were the main target of the policy. This implies that not only the government but also producers or marketers should remind that the magnitude of the effect of policy depends on how consumers react to it.

At the retail level, the market shares of the convenience stores and online (internet) shopping mall have become greater, especially in Korea. Therefore, the role of hypermarket markets or traditional market has become less considerable. This suggests that price transmission between wholesale and these types of retail outlets would be much more important in the future. In this context, modeling and investigating the more composite nature of competition among retail outlets and its relationship with wholesale price would be worthwhile to be analyzed in further studies.

Although this study contributes to the literature by examining the existence, magnitude, and structure of asymmetric price transmission applying TPAM which has not been applied in the previous studies, it fails to incorporate some deeper issues. Since the focus of this research is to examine the magnitude and the structure of asymmetric price transmission changes in response to the government's policy, the study has a limitation in finding out why the hypermarket regulatory policy did not have a direct effect on hypermarkets or caused structural changes in traditional markets. The study is conducted in a way to determine the magnitude and structure of asymmetric price transmission of wholesale and two retail markets in the short run. However, it neglects to incorporate characteristics of price asymmetry in the long run, which could be more important in evaluating the persistence of policy effects. Lastly, the study uses monthly price data for wholesale and two retail markets; therefore, it has a limitation in capturing the asymmetric price transmission that occurs on a daily basis. Monthly price data are used due to the unavailability of daily price data for hypermarket and traditional markets. Future studies may overcome this sort of data problem since big data and more detailed marketing information are currently being collected privately and publicly.

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