Asymmetric Price Transmission and Demand Characteristics

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Asymmetries in the price transmission from farm markets to wholesale markets, and then to retail markets are detrimental to farmers and consumers interest. Numerous studies have investigated the reasons for this market phenomenon and provide various explanations. A recent survey by Meyer and von Cramon-Taubadel (2004) cites 84 studies on asymmetric price transmission. A partial list of recent studies include Frigon, Doyon, and Romain (1999), Chavas and Mehta (2004), and Carman and Sexton (2005) on dairy products, Richards and Patterson (2003) on fresh fruits, Pick, Karrenbrock, and Carman (1990) on citrus, Zhang, Flectcher, and Carley (1995) on peanuts, and Miller and Hayenga (2001) on pork. Most empirical studies find that farm price increases are transmitted more fully and/or quickly to retail than farm price decreases. However, there is no consensus on the explanations for asymmetries in farm-retail price transmission. This paper provides a new explanation for asymmetries in the speed of price transmission through the effect of a demand characteristic, consumption inertia.

The Model Structure

Food retailers usually enjoy some market power in retail markets because of differentiation among retailers in terms of store locations and other store characteristics, and high concentration in many local retail markets. We consider a model where a retailer is able to set the retail price of an agricultural product as a monopolist in a local retail market due to high differentiation and concentration to facilitate exposition. In the retail market, the demand without consumption inertia, which we call as “regular demand”, for the agricultural product offered by this retailer is specified as

(1) $Q = f(P) = a - bP$, where $a > 0$ and $b > 0$.[1]

This retailer procures the agricultural product from a competitive wholesale market, i.e. the retailer takes the wholesale price W as given. In addition, the retailer incurs a constant average and marginal selling cost, C, per unit of the product. Without losing further generality, we set $C = 0$ to facilitate exposition.

We analyze how the retail price changes in response to equal increments and decrements in the wholesale price to study the price transmission from wholesale to retail. Suppose the wholesale price has been stable at the beginning level W_0 for a relatively long time. The corresponding equilibrium retail prices, quantities, and the retailers' profit with $W = W_0$ in one period are $P_0 = (a + bW_0)/2b$, $Q_0 = (a - bW_0)/2$, and $\pi_0 = (a - bW_0)^2/4b$ respectively.

Now there is a wholesale price change (either an increase or a decrease). Let's denote the time of this wholesale price change as period 1. The wholesale price either increases to $W_1^+ = W_0 + w$ or decrease to $W_1^- = W_0 - w$, where $w \in (0, W_0)$, subscript "$t = 1, 2, \ldots$" to denote the tth period since the wholesale price change, and superscripts "+" and "–" to indicate a wholesale price increase and decrease, respectively. This wholesale price change in period 1 can be either a temporary change with a possibility $\theta \in (0, 1)$ or a permanent one with a possibility $1 - \theta$. If it is a temporary change, the wholesale price will return to the pre-change level in period 2 and stay at that level in all subsequent periods, i.e. $W_t^+ = W_t^- = W_0$ with $t \geq 2$. On the other hand, if the change is permanent, the wholesale price in all subsequent periods will include this change, i.e. $W_t^+ = W_1^+$ or $W_t^- = W_1^-$ with $t \geq 2$.

[1] A linear specification of the demand function allows a focus on the effects of consumption inertia on price transmission. With a concave or convex demand function we would have to deal jointly with the effects of demand curvature, which has been studied by Azzam (1999) and Fousekis (2008), and the special effects of consumption inertia we wish to discuss in this paper.

The retailer chooses an optimal pricing strategy for period 1 and the subsequent periods to maximize the present value of her total profit. The retailer has three types of pricing strategies: (i) a "no-change" strategy, which is to keep her retail price unchanged at P_0 for all periods in spite of the wholesale price change in period 1; (ii) a "waiting" strategy, which is to keep her retail price unchanged at P_0 in period 1, and then change the price in the subsequent periods if the wholesale price change is permanent or still charge P_0 if the wholesale price change is temporary; and (iii) an "immediate-change" strategy, which is to change her retail price immediately in period 1 and make further price changes if necessary in the subsequent periods. Subscripts "*i*", "*ii*", and "*iii*" are used to represent these three types of pricing strategies, respectively. The retailer incurs a repricing cost $S > 0$ for her price changes. The repricing cost is symmetric for the direction of price changes, i.e. the repricing cost of raising prices is equal to that of reducing prices so that the repricing cost itself will not lead to asymmetric price transmission.

The Market without Consumption Inertia

To provide a benchmark to evaluate the effects of consumption inertia on price transmission, we first study the case when consumption inertia does not exist. In this benchmark case, both consumer demand when there is a retail price change and consumer demand when the price is unchanged, compared to the price in the previous period, are represented by the same function in equation (1). Let's study how retail prices respond to wholesale price changes in this market. If the wholesale price increases to W_1^+ in period 1, by adopting the "no change" strategy, i.e. keeping the retail price at P_0 in all periods, the retailer obtain the profit π_u^+ in period 1, where

$\pi_u^+ = \left(a - bW_0\right)^2 / 4b - \left(a - bW_0\right) w / 2$ and subscript "*u*" indicates that the retail price is unchanged at P_0 in the period. For periods $t \geq 2$, this strategy will yield a per period profit π_0 if the wholesale price change is temporary, and a per period profit π_u^+ if the wholesale price change is permanent. Thus, the present value of the retailer's total profit of choosing the "no change" strategy is

$$\Pi_i^+ = \pi_u^+ + \theta \sum_{t=2}^{\infty} \pi_0 e^{-\gamma(t-1)} + \left(1-\theta\right) \sum_{t=2}^{\infty} \pi_u^+ e^{-\gamma(t-1)},$$

where $\gamma > 0$ is the interest rate.

Similarly, adopting the "waiting" strategy yields π_u^+ in period 1 and a per period profit π_0 for periods $t \geq 2$ if the wholesale price change is temporary. However, if the wholesale price change is permanent, the retailer will increase her price and incur a repricing cost *S* in period 2 to receive a per period profit π_{op}^+ for periods $t \geq 2$, where $\pi_{op}^+ = \left(a - bW_0 - bw\right)^2 / 4b$ is the optimal profit under the regular consumer demand in (1) when the wholesale price increases to W_1^+ and subscript "*op*" denotes optimal. In total, the "waiting" strategy can let the retailer obtain the total profits with a present value

$$\Pi_{ii}^+ = \pi_u^+ + \theta \sum_{t=2}^{\infty} \pi_0 e^{-\gamma(t-1)} + \left(1-\theta\right) \left[\sum_{t=2}^{\infty} \pi_{op}^+ e^{-\gamma(t-1)} - Se^{-\gamma} \right].$$

If the retailer adopts the third strategy, the "immediate change" strategy, she will raise the retail price to $P_{op}^+ = \left(a + bW_0 + bw\right) / 2b$, receive π_{op}^+, and incur a repricing cost *S* in period 1, reduce the price back to P_0 in period 2 and receive a per period profit π_0 for periods $t \geq 2$ if the wholesale price change is temporary, and keep the price at P_{op}^+ and receive a per period profit

π_{op}^{+} for periods $t \geq 2$ if the wholesale price change is permanent. The present value of total profit of adopting the "immediate change" strategy is

$$\Pi_{iii}^{+} = \pi_{rd}^{+} - S + \theta \sum_{t=2}^{\infty} \pi_0 e^{-\gamma(t-1)} + (1-\theta) \sum_{t=2}^{\infty} \pi_{op}^{+} e^{-\gamma(t-1)} .$$

We compare the present values of total profits of the three pricing strategies to find the retailer's choice. When the wholesale price increases by *w*, the retailer will choose

$$(2) \quad \begin{cases} \text{the "no change" strategy} & \text{if } w \in \left(0, \varphi_i^{+}\right], \\ \text{the "waiting" strategy} & \text{if } w \in \left(\varphi_i^{+}, \varphi_{ii}^{+}\right], \text{ and} \\ \text{the "immediate change" strategy} & \text{if } w > \varphi_{ii}^{+}, \end{cases}$$

where $\varphi_i^{+} = 2\sqrt{\left(1-e^{-\gamma}\right) S/b}$ and $\varphi_{ii}^{+} = 2\sqrt{\left(1-e^{-\gamma}+\theta e^{-\gamma}\right) S/b}$.

On the other hand, if the wholesale price decreases to W_1^{-}, we also calculate and compare the present values of total profits of the three pricing strategies. When the wholesale price decreases by *w*, the retailer will choose

$$(3) \quad \begin{cases} \text{the "no change" strategy} & \text{if } w \in \left(0, \varphi_i^{-}\right], \\ \text{the "waiting" strategy} & \text{if } w \in \left(\varphi_i^{-}, \varphi_{ii}^{-}\right], \text{ and} \\ \text{the "immediate change" strategy} & \text{if } w > \varphi_{ii}^{-}, \end{cases}$$

where $\varphi_i^{-} = 2\sqrt{\left(1-e^{-\gamma}\right) S/b} = \varphi_i^{+}$ and $\varphi_{ii}^{-} = 2\sqrt{\left(1-e^{-\gamma}+\theta e^{-\gamma}\right) S/b} = \varphi_{ii}^{+}$. The results of $\varphi_i^{-} = \varphi_i^{+}$, $\varphi_{ii}^{-} = \varphi_{ii}^{+}$, show that the retail price's response does not depend on the direction of a wholesale price change. For any equivalent increments and decrements in the wholesale price, the retail price's responses in terms of whether it will change and, if change, how quickly the retailer price will change are the same. Thus, the wholesale-retail price transmission is symmetric when there is no consumption inertia in this model.

The Consumption Inertia Model

Now consider the case when consumption inertia exists. In a short time (one period in this model) after a retail price change, consumer demand may exhibit the phenomenon of consumption inertia, which means consumers are reluctant to deviate too much from their previous consumption levels in spite of the retail price change. The demand with consumption inertia for the agricultural product is specified as

$$(4)\quad \begin{cases} Q_t = ka + (1-k)(Q_{t-1} - \delta) - kbP_t & \text{if } Q_t \in [0, Q_{t-1} - \delta) \\ Q_t = a - bP_t & \text{if } Q_t \in [Q_{t-1} - \delta, Q_{t-1} + \delta] \\ Q_t = ka + (1-k)(Q_{t-1} + \delta) - kbP_t & \text{if } Q_t > Q_{t-1} + \delta. \end{cases}$$

The demand with consumption inertia was illustrated in figure 1. Equation (4) and figure 1 show that if the retail price change is large enough to cause the new consumption level to deviate more than δ units from the consumption experience of the previous period, consumers are only willing to reduce (raise) their consumption level beyond this experience range, which we defined as $[Q_{t-1} - \delta, Q_{t-1} + \delta]$, by a smaller amount for one-unit additional retail price increase (decrease) than in the case of regular demand. Thus, a consumption inertia effect is triggered if a retail price change causes a new consumption level to deviates more than δ units from the previous level. To focus on the case that a consumption inertia effect can be triggered by retail price changes in response to a wholesale price change, two conditions, $\delta < bw/2$ and $(a-2\delta)^2 / (a+2\delta)^2 < k < 1$, are assumed to hold.

We investigate how the retail price responds to wholesale price changes in this market with consumption inertia. If the wholesale price increases to $W_1^+ = W_0 + w$ in period 1, adopting the "no change" pricing strategy will not trigger the consumption inertia effect in demand because

the retail price remains unchanged in all periods. Thus, the present value Ω_i^+ of total profit of this strategy is that same as that Π_i^+ for the benchmark case.

With the "waiting" strategy, the retailer receives π_u^+ in period 1 and a per period profit π_0 for periods $t \geq 2$ if the wholesale price change is temporary. However, if the wholesale price change is permanent, the retailer will incur a repricing cost to raise her price in period 2 and this price change triggers a consumption inertia effect in period 2. Using the demand function in (4), we obtain the equilibrium in the market with a consumption inertia effect in period 2 as follows,

$Q_{ci}^+ = k\left(a - bW_0 - bw\right)/2 + \left(1-k\right)\left(a - bW_0 - 2\delta\right)/4$,

$P_{ci}^+ = \left(a + bW_0 + bw\right)/2b + \left(1-k\right)\left(a - bW_0 - 2\delta\right)/4bk$,

and $\pi_{ci}^+ = bk\left[\left(a - bW_0 - bw\right)/2b + \left(1-k\right)\left(a - bW_0 - 2\delta\right)/4bk\right]^2$,

where the subscript "ci" denotes consumption inertia. In the next period (period 3), consumers are able to make all necessary adjustments so that the consumption inertia effect disappears. Thus, the retailer will set her price to P_{op}^+ in period 3 and keep this price level for all subsequent periods. The retailer receives a per period profit π_{op}^+ for periods $t \geq 3$. The present value of total profit of the "waiting" strategy is

$$\Omega_{ii}^+ = \pi_u^+ + \theta\sum_{t=2}^{\infty}\pi_0 e^{-\gamma(t-1)} + \left(1-\theta\right)\left[\pi_{ci}^+ e^{-\gamma} + \sum_{t=3}^{\infty}\pi_{op}^+ e^{-\gamma(t-1)} - Se^{-\gamma}\right].$$

If the retailer adopts the "immediate change" strategy, she incurs a repricing cost S to raise her price in period 1 and this change triggers a consumption inertia effect. The retailer receives π_{ci}^+ in period 1. Again, the consumption inertia effect disappears in the next period (period 2). Thus, the retailer reduces her price back to P_0 and receive a per period profit π_0 for periods

$t \geq 2$ if the wholesale price change is temporary, or sets the price at P_{op}^{+} and receive a per period profit π_{op}^{+} for periods $t \geq 2$ if the wholesale price change is permanent. The present value of total profit of the "immediate change" strategy is

$$\Omega_{iii}^{+} = \pi_{ci}^{+} - S + \theta \sum_{t=2}^{\infty} \pi_0 e^{-\gamma(t-1)} + (1-\theta) \sum_{t=2}^{\infty} \pi_{op}^{+} e^{-\gamma(t-1)} .$$

We compare the present values of total profits generated by the three pricing strategies to analyze the optimal choice of the retailer. When consumption inertia exists, if the wholesale price increase by the magnitude of *w*, the retailer will choose

$$(5) \quad \begin{cases} \text{the "no change" strategy} & \text{if } w \in \left(0, \eta_i^{+}\right], \\ \text{the "waiting" strategy} & \text{if } w \in \left(\eta_i^{+}, \eta_{ii}^{+}\right], \text{ and} \\ \text{the "immediate change" strategy} & \text{if } w > \eta_{ii}^{+}, \end{cases}$$

where $\eta_i^{+} = G_i^{-1}(0)$, $\eta_{ii}^{+} = G_{ii}^{-1}(0)$, and $G_i^{-1}(\bullet)$ and $G_{ii}^{-1}(\bullet)$ are the inverse function of

$$G_i(w) = (1-k)(a - bW_0 - bw)(bw - 2\delta)/4b + (1-k)^2 (a - bW_0 - 2\delta)^2 / 16bk + bw^2 / 4\left(1 - e^{-\gamma}\right) - S$$

and $G_{ii}(w) = G_i(w) - \theta e^{-\gamma} bw^2 / 4\left(1 - e^{-\gamma}\right)\left(1 - e^{-\gamma} + \theta e^{-\gamma}\right)$, respectively.

On the other hand, when a wholesale price decrease by the magnitude of *w* to W_1^{-}, the retailer also has the three pricing strategies. We derive and compare the present values of three pricing strategies to find the retailer's optimal choice as follows:

$$(6) \quad \begin{cases} \text{the "no change" strategy} & \text{if } w \in \left(0, \eta_i^{-}\right], \\ \text{the "waiting" strategy} & \text{if } w \in \left(\eta_i^{-}, \eta_{ii}^{-}\right], \text{ and} \\ \text{the "immediate change" strategy} & \text{if } w > \eta_{ii}^{-}, \end{cases}$$

where $\eta_i^- > \eta_i^+$ and $\eta_{ii}^- > \eta_{ii}^+$. The results, $\eta_i^- > \eta_i^+$ and $\eta_{ii}^- > \eta_{ii}^+$, show that, when consumption inertia exists, the wholesale-retail price transmission is asymmetric for some levels of wholesale price changes. If the magnitudes of wholesale price changes belong to $\left(\eta_{ii}^+, \eta_{ii}^-\right)$, the retail price will increase immediately in response to a wholesale price increase, while, for an equivalent wholesale price decrease, the retail price will either remain unchanged all the time or wait for some time before any reduction. If the magnitudes of wholesale price changes belong to $\left(\eta_i^+, \eta_i^-\right)$, for a wholesale price increase, the retail price will increase either immediately or after some time, but the retail price will always remain unchanged in response to an equivalent wholesale price decrease. These asymmetries in wholesale-retail price transmission can only be attributed to consumption inertia based on the comparison of the analysis of this market with consumption inertia and that of the benchmark case. Proposition 1 summarizes the results.

PROPOSITION 1. *Consumption inertia can cause asymmetries in the price transmission from wholesale to retail markets when seller power exists in retail markets. For some medium levels of wholesale price changes* $\left[w \in \left(\eta_i^+, \eta_i^-\right) \cup \left(\eta_{ii}^+, \eta_{ii}^-\right)\right]$*, consumption inertia causes the following asymmetries:*

(i) Retail prices rise immediately in response to a wholesale price increase while their response to an equivalent wholesale price decrease is slower, or

(ii) *retail prices rise in response to a wholesale price increase while retail prices remain unchanged in response to an equivalent wholesale price decrease.*

The range of wholesale price changes that are asymmetrically transmitted to retail is affected by the magnitude of consumption inertia in demand. The result on this relationship is included in the following proposition.

PROPOSITION 2. *A stronger consumption inertia effect, represented by a smaller* δ *and/or* k*, leads to a wider range,* $\left(\eta_i^+, \eta_i^-\right) \cup \left(\eta_{ii}^+, \eta_{ii}^-\right)$*, of wholesale price changes that are asymmetrically transmitted to retail markets*.

Conclusion

This paper uses a simple framework to study asymmetries in the speed of price transmission from farm to retail markets. This paper finds that consumption inertia during price changes can cause retail prices to rise more quickly in response to a wholesale price increase than their response to an equivalent wholesale price decrease. Consumption inertia may also cause retail prices remain unchanged in response to an equivalent wholesale price decrease. A stronger consumption effect will cause asymmetries in the speed of price transmission more likely to happen.

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