Food Policy 41 (2013) 226–236

Contents lists available at SciVerse ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Price transmission across the U.S. food distribution system

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ARTICLE INFO

Article history:
Received 19 July 2011
Received in revised form 12 May 2013
Accepted 19 May 2013
Available online 5 July 2013

Keywords:
Asymmetry models
Price linkages
Recursive parameters
Transmission speed

ABSTRACT

Price transmission models are estimated using recursive methods across 100 food commodities. From the individual commodities, short- and long-run price transmission coefficients are estimated for rising and falling prices. These coefficients are classified into five commodity categories and expressed as one vector while coding for causality, market levels, rising/falling prices, short and long run, and time period. Then the impact of each variable is estimated and inferences are drawn about the degree of price transmission. Results show that price linkages are strong but slightly declining over time, with some evidence of asymmetric behavior. Long-run rising prices are passed through more than long-run falling prices, except for fruits and vegetables.

Introduction

Reliable price signals are essential to assuring efficiency exchange as food products flow through the distribution channels. Most public and private food policies are predicated on the expectation that price signals reflect the product value up and down the supply chain. One might expect weaker price linkage between the farm-gate and the retail when the raw commodity is only a small part of the final retail product. Price signals may differ with rising versus falling farm-gate prices as well as delayed transmission in price signals. Such potential patterns in the flow of price information may be part of the normal distribution process given the complexities of transforming and moving products through a number supply channels. Any breakdown in the flow of price information can have profound influences on the overall market performance.

Many studies have documented the nature of price transmission and price asymmetry with most focusing on a single or only a few commodities (Bessler and Akleman, 1998; Hahn, 1990; Heien, 1980; Kinnucan and Forker, 1987; v. Cramon-Taubabel, 1998; Ward, 1982; Ward and Stevens, 2000). To gain a broader insight into the pricing process, this analysis focuses on empirically showing the nature of the price transmission across U.S. food classifications. Five food classifications with 100 commodities are used to draw inferences about the overall degree of price transmission within the U.S. agribusiness sectors using the farm gate, wholesale, and retail as the three points of exchange.

A number of models have been advanced the theoretical determinants of the price transmission process (Gardner, 1975; Heien, 1980; Wohlgenant, 1985) and the farm–retail price transmission elasticity (McCorriston et al., 2001; Weldegebriel, 2004). Gardner (1975) set out static equilibrium framework for the farm–retail price spread. Heien (1980) developed Gardner's framework with dynamic price adjustment and Wohlgenant (1985) demonstrated that the time lags of price adjustment between retail and wholesale markets can be explained by inventory-holding on the part of retailers. In particular, Gardner (1975)'s study set forth a theoretical framework linking changes in price spreads according to shifts in retail demand and farm supply. Our study derives a theoretical relationship for vertical price transmission based on demand functions across distribution channels.

Wolffram (1971) and Houck (1977) irreversible model facilitates testing for asymmetric and for measuring dynamics in the price transmission process. Heien (1980) introduced two price variables in to the model representing upward and downward price movements based on Wolffram–Houck specification and then tested asymmetric behavior between wholesale and retail markets. Many studies incorporate asymmetric price adjustments in their specifications (Boyd and Brorsen, 1988; Hahn, 1990; Hansmire and Willett, 1992; Kinnucan and Forker, 1987; Pick et al., 1990; v. Cramon-Taubabel, 1998; Ward, 1982; Ward and Stevens, 2000; Zhang et al., 1995).

Public perception about pricing may be simplistic and incorrect. Similarly, true pricing problems may be less apparent without empirical evidence. Having evidence of the overall performance of the pricing systems is essential to formulating marketing

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http://dx.doi.org/10.1016/j.foodpol.2013.05.006

Table 1
Commodity classifications and the number of commodities.

Com. classifications/MKT channels	Grain and oil crops	Meats	Poultry and eggs	Dairy	Fruits and vegetables	Total
Number of crops						
Farmers/shipping (% of category[a])	5 (88.38)	5 (99.24)	3 (97.03)	2 (100.00)	13 (51.49)	28
Wholesalers	9	6	8	4	0	27
Retailers	9	9	6	5	16	45
Sum	23	20	17	11	29	100
Data points	6817	7553	6515	3004	8716	32,605
Rising prices	3592	3800	3444	1595	4515	16,946
Falling prices	3225	3753	3071	1409	4201	15,659
% Rising[b]	52.69	50.31	52.86	53.10	51.80	51.97
% Falling[b]	47.31	49.69	47.14	46.90	48.20	48.03

[a] Shares of the U.S. farm sector cash receipts of the commodity selected over the total commodity in the food classification.
[b] The percentage indicates the percentages of price changes to increase and to decrease during the sample periods.

strategies and setting public policies relating to markets. Likewise, a reliable pricing system is a major component to reducing value risk associated with the product flow. A failure in establishing the value via prices will eventually permeate the performance of the complete supply chain. The question then is how has the U.S. food pricing system performed?

Food price descriptions and attributes

U.S. foods can be usually classified into five classifications: (1) grain and oil crops, (2) meats, (3) poultry and eggs, (4) dairy, and (5) fruits and vegetables. Monthly price data on 100 commodities were collected from 1970:1 through 2009:6 and classified into one of these five (Appendix)[3]. These data include shipping points and retail prices and, when possible, intermediate wholesale prices. Monthly retail prices are from the U.S. Bureau of Labor Statistics' (BLS) average consumer price series, and farm/shipping point and wholesale prices come from the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), Economics Research Service (ERS), and Agricultural Marketing Service (AMS).

Table 1 includes general information about the series with values in parentheses indicating shares of the U.S. farm sector cash receipts. Given the diversity of products, all prices are expressed in dollars per pound while recognizing difficulties in sometimes expressing a product on a pound basis. The commodities within the five categories account for approximately 76% of all U.S. farm sector cash receipts. Somewhat surprising is the balance between the numbers of rising versus falling prices within categories. While the magnitude of rising and falling prices is not shown, the history of price movements in both directions gives the opportunity for measuring the nature of price transmission across commodity classifications. For some commodities, prices are reported periodically, thus leading to discontinuous price series. Except for apples, lemons, and grapefruit, all fruit products at the farm gate have discontinuous price-data series. Discontinuous series are dealt with in Ward's (1982) method in which dummy variables were used to denote a data gap and, where needed, that procedure has been adopted in this study.

Demand and price transmission

Let q_1 and q_2 be the quantity of a good at two points in the market distribution system with q_1 denoting the lower point (e.g., producer or wholesale) and q_2 a higher point (e.g., wholesale or retail). As specified in Eqs. (1a) and (1b), there is an implied demand for the good at both distribution points with that demand driven by prices and other factors. While the demand form is an empirical question, the form is often expressed assuming a fixed price elasticity as suggested with ξ. For discussion purposes, other factors can be captured in the intercepts. If buyers operate on a different demand response with rising versus falling prices, the elasticities should differ with the inclusion of ASY to reflect asymmetry in the demand curves. For example, ξ_1 is either γ_{11} or $\gamma_{11} + \gamma_{12}$ depending on ASY = 1 or 0 with ASY = 1 implying asymmetry.

Commodities are linked through the transformation of the quantities as they move through the distribution channels. Eq. (2) points to one such linkage where q_{2t} is a transformation of q_{1t} and potentially levels of $q_{1(t-i)}$ from prior periods. That depends on the transformation and distribution process between market points (1) and (2) as well as the degree of transformation needed. Let τ capture that transformation linkage as specified in Eq. (2) with the τ values ranging from zero upward. Note that all τ's equaling zero would imply no measurable linkage between q_2 and q_1.

Since both quantities are expressed in terms of prices in Eqs. (1a) and (1b), one can substitute those relations in the linkage equation giving Eqs. (3a) and (3b). Explicitly, Eq. (3b) shows price p_2 to be linked to current and lagged price p_1 with the linkage conditioned on both price elasticities, the technical transformation τ as well as the values embedded in the intercepts and adjustor (i.e., τ_0). In Eq. (3b), the relationship between p_2 and p_1 may be asymmetric since that relationship depends on both elasticities with the potential for asymmetry in the demands. In Eq. (3a) the linkage between p_2 and p_1 is explicitly tied to the transformation process and the price elasticities. Theoretically, $\tau \geqslant 0$ and $\xi_1 < 0$, and $\xi_2 < 0$, then $\tau(\xi_1/\xi_2) \geqslant 0$ and thus $\partial P_2/\partial P_1 \geqslant 0$ since the product in Eq. (3a) is an exponential (i.e., $\exp^{(\tau_0 - \gamma_{20} + \tau_{1i}\gamma_{10}/\xi_2)} \geqslant 0$) for any of the current or lagged price periods. The properties of the second derivative are of little interest since one can easily argue for situations with either positive or negative signs for changes in the rate of transmission.

The elasticities are defined as γ_{11} or $\gamma_{11} + \gamma_{12}$ depending on if asymmetry exists (i.e., ASY = 1) or not and γ_{21} and $\gamma_{21} + \gamma_{22}$. One can easily express the elasticities relative to the initial terms that must always be negative or $\gamma_{11}(1 + \omega_1) < 0$ and $\gamma_{21}(1 + \omega_2) < 0$ where ω is simply a weighting of the rising (or falling) price elasticity depending on how the asymmetry is defined as will be shown later. Using $\gamma_{11}(1 + \omega_1)$ to illustrate, it must be that $(1 + \omega_1) > 0$ or $\omega_1 > -1$. If $-1 < \omega_1 < 0$, then $(1 + \omega_1)$ is a fraction implying that the demand is less price sensitive with the asymmetry. If $\omega_1 > 0$, $(1 + \omega_1) > 1$ and demand becomes more price sensitive with the asymmetry or $|\gamma_{11} + \gamma_{12}| > |\gamma_{11}|$. Similar arguments follow for ω_2. Finally, asymmetry in the price transmission is tied to $(\xi_1/\xi_2) > 0$ or explicitly the weights ω_1 and ω_2. Many economic

[3] Starting points of prices at shipping points, wholesale, and retail differ depending on commodities. Retail food prices from the U.S. Bureau of Labor Statistics start January 1980. Also, note that fish products are not included.