Notes on Farm-Retail Price Transmission and

Marketing Margin Behavior*

Henry W. Kinnucan

and

Denjun Zhang**

Notes on Farm-Retail Price Transmission and

Marketing Margin Behavior

Abstract

Perfect farm-retail price transmission is sometimes taken to mean an elasticity of price transmission (EPT) equal to 1. We show that this definition is inconsistent with Gardner's (1975) model. We also show that the *absolute* marketing margin (defined as the difference between the retail price and farm price) responds differently to shifts in retail demand, input supply, and technical change in the marketers' production function than does the *relative* marketing margin (defined as the ratio of the retail price to the farm price). The empirical implications of these results are discussed in some detail.

Key words: farm-retail price transmission, marketing margin, market equilibrium, competition

JEL Classification: Q11, Q13

Notes on Farm-Retail Price Transmission and

Marketing Margin Behavior

Despite a large and growing empirical literature on farm-retail price transmission (for reviews see Wohlgenant 2001, Conforti 2004, Meyer and von Cramon-Taubadel 2004, and Frey and Manera 2007), there seems to be little consensus on what theory says about the expected magnitude of such elasticities. Here are three examples, the first from Capps *et al.* (1995, p. 239), the second from Tiffin and Dawson (2000, p. 1282), and the third from Cotterill (2006, p. 28):

Quote 1:

An EPT [elasticity of price transmission] value of one suggests an equal response transmission from the lower to higher level. This type of response would be consistent with perfect competition. An EPT value close to zero suggests virtually no transmission of price signals from the lower to the higher level in the industry. This type of response could be considered a symptom of imperfect competition. Therefore, a value of one is expected for a near-perfect competition segment [farm-wholesale or wholesale-retail]. A value close to zero is expected for a segment where price competition is avoided and non-price competition is the main strategy.

Quote 2:

Therefore, if prices are determined at the producer level, $\ln PR = \alpha_1 + \varepsilon_{RP} \ln PP$ where PR is the retail price, PP is the producer price, and ε_{RP} is the elasticity of price transmission from PP to PR. Perfect price transmission, when $\varepsilon_{RP} = 1$ (Colman, 1985), implies the percentage spread model with a mark-up of $(e^{\alpha_1} - 1)$; imperfect price transmission is where $0 < \varepsilon_{RP} < 1$. Alternatively, if prices are determined at the retail level, $\ln PP = \alpha_2 + \varepsilon_{PR} \ln RP$ where ε_{PR} is the price transmission elasticity from PR to PP. Perfect price transmission,

when $\varepsilon_{PR} = 1$, implies the percentage spread model with mark-down of $(1 - e^{\alpha_2})$; imperfect price transmission is where $\varepsilon_{PR} > 1$.

<u>Quote 3:</u>

In his classic article, Gardner (1975) develops the price transmission model for a competitive food market channel. Gardner demonstrates that even if farm production and the marketing industry are perfectly competitive and if constant returns to scale exist in marketing, there is not a unique and stable relationship between farm and retail prices. In other words, there is no sound economic reason to expect that retail prices should be related to farm prices.

The third quote suggests competitive pressures place no restrictions on the farm-retail elasticity of price transmission (EPT), while the first two suggest a restriction equal to 1. Because both implications of theory cannot be true simultaneously, we revisit the theory to identify which implication, if either, is correct.

The notion that EPT = 1 implies "perfect" price transmission, i.e., competitive markets, is of particular interest as it appears in theoretical as well as empirical studies. For example, in their discussion of George and King's (1971) formula for the farm-level (derived) demand elasticity $\lambda = \eta \cdot \text{EPT}$ (the farm-level elasticity equals the retail-level elasticity multiplied by the EPT), Asche *et al*. (2002, p. 103) state "[the George and King] assumption makes the relationship between the retail demand and derived demand elasticities proportional, but in general they will not be equal. This will only happen when the *price transmission is perfect, i.e., when the elasticity of price transmission is equal to 1*" [emphasis added]. A careful reading of George and King makes this definition suspect. George and King estimate the EPT for 32 food commodities and find that in the majority of cases EPT is less than 1. They explain the implications of this result (*op. cit*., p. 61) by citing Hildreth and Jarrett (1955, p. 111), to wit: "...if producers' price rises while quantity processed and such other factors as prices of inputs used by processors remain fixed, the relative change in consumer price will not exceed the relative change in producers' price. *This would certainly be true if effective competition*

existed in processing, and might be expected to be typical of other instances as well" [emphasis added]. Bronfenbrenner (1961), in his more general discussion of the elasticity of derived demand, shows that the Allen expression $\lambda = (S_a\eta - S_b\sigma)$ holds when the supply of "co-operant services" is perfectly elastic, but makes no reference to price transmission.[1] Thus, the origins of the notion that perfect price transmission implies EPT = 1 are obscure.

Not all empirical studies that draw on Gardner (1975) are confused about the implications of theory for the price transmission elasticity. For example, in their analysis of price transmission in the wheat marketing channel in Ukraine, Brümmer *et al*. (2009, p. 215) posit that competitive market clearing implies EPT = 0.8 for the elasticity that links wheat price to flour price. Also, the empirical studies by Lloyd *et al*. (2004, 2009) explicitly incorporate restrictions implied by Gardner's model. Still, there seems to be enough confusion in the literature to warrant further discussion of theory.

The purpose of this article is to elucidate in some detail the empirical implications of Gardner's model. We make a modest theoretical contribution by extending the analyses of Gardner (1975) and Miedema (1976) to consider the effects of supply and demand shocks and technical change on the *absolute* marketing margin (the difference between the retail and farm price). Gardner, in his analysis of supply and demand shocks, and Miedema in his analysis of technical change, considered only the *relative* marketing margin (the ratio of the retail price to the farm price). As it turns out, the absolute margin responds differently to shifts in retail demand, input supply, and technical change than does the relative margin.

The next section describes the basic model and results. We then analyze the marketing margin and technical change. The paper concludes with a brief summary of the main findings.

---

[1] In the Allen expression, S_a and S_b are cost shares associated with inputs a and b, respectively, and σ is the elasticity of substitution between a and b. Interpreting b as the co-operant input, λ is the derived demand elasticity for input a when the supply of input b is perfectly elastic.

Basic Model

The main insight from Gardner's (1975) analysis is that the EPT in general will differ depending on the source of the supply or demand shock. To be clear about how he arrived at this conclusion, we re-derive the basic relationships using the following dual form of Gardner's original model:

(1) $P_x^* = \frac{1}{\eta} x^* + \alpha$ (retail demand)

(2) $P_x^* = S_a P_a^* + S_b P_b^*$ (retail supply)

(3) $a^* = - S_b\, \sigma\, P_a^* + S_b\, \sigma\, P_b^* + x^*$ (demand for farm-based input)

(4) $b^* = S_a\, \sigma\, P_a^* - S_a\, \sigma\, P_b^* + x^*$ (demand for marketing input)

(5) $a^* = \varepsilon_a (P_a^* + \beta_a)$ (supply of farm-based input)

(6) $b^* = \varepsilon_b (P_b^* + \beta_b)$ (supply of marketing input)

Because variables are expressed as proportionate changes (e.g., $P_x^* = dP_x/P_x$ represents the proportionate change in retail price), their coefficients represent elasticities or cost shares. Specifically, $\eta\ (< 0)$ is the own-price elasticity of demand for the retail product x; $\sigma\ (\geq 0)$ is the elasticity of substitution between the farm-based input a and the bundle of marketing inputs b; $S_a = P_a a / P_x x$ and $S_b = P_b b / P_x x$ are cost shares that sum to one where P_a is the price of the farm-based input, and P_b is the price of the bundle of marketing inputs; $\varepsilon_a\ (> 0)$ is the own-price elasticity of supply for the farm-based input; and $\varepsilon_b\ (> 0)$ is the own-price elasticity of supply for the marketing inputs.[2] The remaining terms are vertical shift parameters. Specifically, α indicates a proportionate shift in the retail demand curve in the price direction due to an exogenous retail demand shifter, and β_a and β_b indicate proportionate shifts in the input supply curves in the price direction due to exogenous input supply shifters.[3]

---

[2] Gardner did not restrict the sign of ε_b to be positive. We do so to simplify the interpretation of the comparative static results to follow, but also because, as noted by Gardner (1975, p. 402), $\varepsilon_b < 0$ represents an "extreme case" where there are external economies of scale in marketing activities.

[3] The use of shift parameters to indicate the effects of exogenous variables follows Muth (1964). They are derived through algebraic manipulation of Gardner's equations. For example, consider Gardner's retail

The only substantive difference between equations (1) – (6) and Gardner's specification is that the production function in Gardner's model is replaced by equation (2) (see appendix A for derivation). This equation has a dual interpretation: it represents the long-run *inverse* supply function for the retail product, but also the farm-retail price transmission relation. The inverse supply equation does not contain a quantity variable because the marketers' production function $x = f(a, b)$ is assumed to exhibit constant returns to scale, which means the retail supply curve in the long run is perfectly elastic.[4] The equation indicates that an isolated 1% increase in farm price causes the retail price to increase by S_a%. This suggests the EPT is less than 1, a hypothesis to be explored in more depth later.

The first step in developing analytical expressions for EPT is to solve equations (1) – (6) for the reduced-form equations for retail and farm price:[5]

(7) $P_x^* = -\left(\frac{\eta(\sigma + S_a\varepsilon_b + S_b\varepsilon_a)}{D}\right)\alpha - \left(\frac{\varepsilon_a S_a(\sigma + \varepsilon_b)}{D}\right)\beta_a - \left(\frac{\varepsilon_b S_b(\sigma + \varepsilon_a)}{D}\right)\beta_b$

(8) $P_a^* = -\left(\frac{\eta(\sigma + \varepsilon_b)}{D}\right)\alpha - \left(\frac{\varepsilon_a(S_a\sigma + \varepsilon_b - S_b\eta)}{D}\right)\beta_a - \left(\frac{S_b\varepsilon_b(\sigma + \eta)}{D}\right)\beta_b$

where $D = \left(\varepsilon_a\varepsilon_b + \sigma(S_a\varepsilon_a + S_b\varepsilon_b - \eta) - \eta(S_b\varepsilon_a + S_a\varepsilon_b)\right) > 0$. Under the stated parametric assumptions (retail demand is downward-sloping, input supply is upward sloping, and inputs are combined in variable proportions), an isolated increase in retail demand ($\alpha > 0$) causes retail and farm prices to increase, while an isolated increase in the supply of the farm-based input ($\beta_a > 0$) causes the retail and farm prices to decrease. An isolated increase in the supply of marketing inputs ($\beta_b > 0$) causes retail price to decrease, and the farm price either to increase or decrease depending on whether the inputs are gross complements ($\sigma < |\eta|$) or substitutes ($\sigma > |\eta|$). The

---

demand equation $x^* = \eta P_x^* + \eta_N N^*$ where N^* is the proportionate change in population, and η_N is the elasticity of food demand with respect to population growth. Writing this equation in inverse form yields $P_x^* = \frac{1}{\eta}x^* - \frac{\eta_N N^*}{\eta}$, or, more simply $P_x^* = \frac{1}{\eta}x^* + \alpha$, where $\alpha = \frac{\eta_N N^*}{-\eta}$ is the proportionate *vertical* shift in the curve, i.e., the shift in the price direction with quantity held constant.

[4] Equation (2) properly is interpreted as a hicksian or *ceteris paribus* supply curve. The corresponding general equilibrium, or *mutatis mutandis* supply curve, is upward sloping. See equation (19) of Muth's paper.

[5] For the steps involved in deriving equations (7) and (8), see Muth (1964) or Gardner (1975).

latter interpretation is consistent with Alston *et al*. (1995, p. 262), to wit: "When the elasticity of substitution is *less* than the absolute value of the demand elasticity ($\sigma < |\eta|$), the two factors are gross complements (i.e., the cross-price elasticity of factor demand is negative so that a fall in price of either factor will increase the demand for the other factor)… When the elasticity of substitution is *greater* than the absolute value of the demand elasticity ($\sigma > |\eta|$), the two factors are gross substitutes (i.e., the cross-price elasticity of factor demand is positive so that a fall in price of either factor will reduce the demand for the other factor)" [emphasis in original]. Research suggests gross complementarity holds for most, but not all, food commodities (Wohlgenant 1989). In particular, in the United States it appears that $\sigma > |\eta|$ holds for eggs, dairy, and fresh vegetables (Wohlgenant, 1989, p. 250).[6]

Farm-Retail Price Transmission Elasticities

The EPTs may be derived from equations (7) and (8) through division of the appropriate coefficients:

(9) $\qquad \tau^{RD} = \dfrac{P_x^*/\alpha}{P_a^*/\alpha} = \dfrac{\sigma + S_a\varepsilon_b + S_b\varepsilon_a}{\sigma + \varepsilon_b}$

(10) $\qquad \tau^{FS} = \dfrac{P_x^*/\beta_a}{P_a^*/\beta_a} = \dfrac{S_a(\sigma + \varepsilon_b)}{\varepsilon_b + S_a\sigma - S_b\eta}$

(11) $\qquad \tau^{MS} = \dfrac{P_x^*/\beta_b}{P_a^*/\beta_b} = \dfrac{\sigma + \varepsilon_a}{\sigma + \eta}$

These equations indicate the determinants of EPT for isolated shifts in retail demand (RD), farm supply (FS), and marketing inputs supply (MS). Equations (9) and (10) are consistent with equations (18) and (19) of Gardner's (1975) paper; equation (11) is consistent with the equation found in footnote 10 of the same paper.

Equations (9) − (11) are predicated on the assumption that the marketers' production function exhibits constant returns to scale (CRTS). This assumption appears

---

[6] Of the eight commodities examined by Wohlgenant (1989), the hypothesis of fixed input proportions, i.e., $\sigma = 0$, was rejected in all cases except poultry. Thus, in studies of price transmission the fixed proportions assumption in general should be avoided. For more discussion of this issue, see Kinnucan (2003) and references therein.

to be consistent with most of the major food marketing channels in the United States (Wohlgenant 1989). Wisecarver (1974, p. 364, fn 7) notes that the CRTS assumption is not critical to the analysis if the industry is in long-run competitive equilibrium (where firms operate at the minimum point on their long run average cost curves), as then "the relevant production parameters are (locally) the same as those of constant returns to scale." Extensions of the model to include non-constant returns to scale as well as imperfect competition are provided by McCorriston *et al.* (2001) and Weldegebriel (2004).

In the context of Gardner's model, does perfect farm-retail price transmission imply EPT = 1? The conditions are not promising:

(12a) $\qquad \tau^{RD} = 1 \quad \Rightarrow \quad \varepsilon_a = \varepsilon_b$

(12b) $\qquad \tau^{FS} = 1 \quad \Rightarrow \quad \varepsilon_b = \eta < 0$

(12c) $\qquad \tau^{MS} = 1 \quad \Rightarrow \quad \varepsilon_a = \eta < 0$

Conditions (12b) and (12c) are particularly unrealistic, as they require the supply curves for a and b to be downward sloping *and* to have elasticities identically equal to the elasticity of retail demand. Thus, for example, if the retail demand elasticity is equal to -0.5, then for EPT = 1 to hold, it must also be true that the supply elasticity for the farm-based input or the marketing input equal -0.5. This leaves condition (12a) as the only plausible scenario in which EPT = 1 could serve as a competitive benchmark. But this condition requires that the supply curves for the farm-based and marketing inputs have identical elasticities. This would be highly unusual, and, moreover, is inconsistent with the conventional wisdom that farm supply is less price elastic than marketing input supply. For example, referring to the marketing channel for bread, Gardner (1975, p. 401) states "Since wheat is a specific factor to the x industry, while the components of b (labor, transportation, packaging, etc.) generally are not, and since a is land intensive, it seems likely that $\varepsilon_a < \varepsilon_b$."

Does EPT $\approx$ 0 imply non-competitive pricing? Not necessarily. To see why, consider a situation where the marketing inputs are perfectly elastic in supply. In this

instance, which Gardner (1975, p. 402) refers to as the "long-run, nonspecific factor case," equations (9) and (10) reduce to:

(13) $$\tau^{RD} = \tau^{FS} = S_a \qquad (\varepsilon_b = \infty).$$

The EPT might be close to zero simply because the product is intensive in the b input. For example, wheat accounts for a tiny fraction of the total cost of producing bread.[7] For this product, an EPT close to zero is compatible with competitive market clearing provided the price of marketing inputs is exogenous to the bread industry, *and observed changes in retail and farm prices are due to shifts in retail demand and farm supply and not to shifts in marketing input supply*.

In an empirical study of farm-retail price transmission for 100 food commodities in the United States based on data for 2000-2009, Kim and Ward (2013, p. 226) conclude that "price linkages are strong but slightly declining over time." This finding is consistent with a gradually falling S_a due to growing demand for convenience and product quality (Reed *et al*. 2002).

Is market theory vacuous with respect to the relationship between retail and farm price? Although the economic forces that govern the relationship between the prices change depending on the source of the supply or demand shock, there is nothing in equations (9) – (11) to indicate *no* relationship (as suggested by quote 3). The one possible exception is when observed changes in retail and farm prices are caused by *simultaneous* shifts in input supply or retail demand. This might be true, for example, if oil prices are changing, which would affect costs both in the marketing sector and in the farm sector. In this instance, because equations (9) and (10) are strictly positive for permissible parameter values, while equation (11) is negative whenever consumers can substitute more easily than intermediaries, i.e., whenever $|\eta| > \sigma$, it is possible for the economic forces that govern the price transmission elasticity to exactly cancel, resulting

---

[7] According to data collected by the National Farmers Union, the average retail price of a one-pound loaf of bread in Safeway stores in the United States in September 2010 was $1.99 and the farmers' share was $0.12. (http://www.thehandthatfeedsus.org/farm2fork_As-Food-Price-Rise.cfm, accessed 15 May 2014). This implies $S_a = 0.06$.

in no relationship between farm and retail price. But this situation would by merely happenstance, and thus is little more than a theoretical curiosum.

Omitted Variable Bias

If the supply of marketing inputs is shifting ($\beta_b \neq 0$), due, say, to changes in oil prices, then omitting marketing costs from an estimated price transmission relation will cause the estimated EPT to be biased. The direction of the bias depends on whether a and b are gross substitutes or complements. For example, if a and b are gross complements ($\sigma < |\eta|$), as is apt to be true for most food products according to Wohlgenant's (1989) analysis, a reduction in the supply of b will cause P_b to rise and P_a to fall. A negative correlation between the input prices implies that, in a model like equation (2), the omission of P_b^* would cause the estimated coefficient of P_a^* (the EPT) to be biased toward zero.

To explore the bias issue further, we simulated equations (9) − (11) for alternative parameter values as shown in table 1. The parameter values in rows 1 − 6 are hypothetical values taken from table 1 of Gardner's (1975) paper; the parameter values in rows 7 and 8 are actual values for the U.S. beef and pork industries taken from table 1 of Wohlgenant's (1993) paper. For the considered parameter values, not only is τ^{MS} negative in sign (or undefined when $\sigma = |\eta|$), it is much larger in absolute value than the corresponding values for τ^{RD} and τ^{FS}. This is especially true for beef where $\tau^{RD} = \tau^{FS} = 0.57$ and $\tau^{MS} = -14.5$. The differences are smaller for pork, but still notable, namely $\tau^{RD} = \tau^{FS} = 0.45$ and $\tau^{MS} = -2.5$. (The huge negative value of τ^{MS} for beef is due to values for $|\eta|$ and σ (0.78 and 0.72) that are closely matched, which makes the denominator of equation (11) close to zero, and thus its numerical value large.) Because the EPT is a hybrid of equations (10) and (11) when both input supply curves are shifting, the potential for attenuation bias in studies that ignore marketing

costs would appear non-negligible. Given that EPT ≈ 0 sometimes is taken to imply non-competitive pricing, this seems an especially important implication of theory.[8]

Kim and Ward (2013, p. 234) state "Theoretically, the [farm-retail price] transmission elasticities should not be negative." As is clear from table 1, this statement is true only if observed price movements are due to shifts in retail demand or farm supply. If they are due to shifts in the supply of marketing services, the EPT is negative whenever a and b are gross complements ($|\eta| > \sigma$). The reason is that, in this instance, an increase in P_b causes P_x and P_a to move in opposite directions. P_x rises because of the higher cost of input b, and P_a falls because of the reduced demand for a induced by the rise in the price of b.

The EPTs in table 1 are less than 1. The only instance in which this is not true is for τ^{RD} when $\varepsilon_a \geq \varepsilon_b$. But, as we have noted, when the model is applied to narrowly defined products like bread (as opposed to the entire food industry, the major thrust of Gardner's analysis), the general expectation is that $\varepsilon_a < \varepsilon_b$. Indeed, in his analysis of research and promotion in the U.S. beef and pork industries, Wohlgenant (1993) sets ε_b to infinity. The upshot is that when aggregate marketing technology exhibits constant returns to scale, and prices are determined under competitive conditions, for normal parameter values EPT in general is expected to be less than 1.

Slope v. Elasticity

It is useful to distinguish between the *slope* of a price transmission relation and its *elasticity*, as the two sometimes are confused in empirical work. For example, Tiffin and Dawson (2000) cite Colman (1985) in support of their claim that perfect price transmission implies EPT = 1 (see quote 2). The claim perhaps is understandable in that

---

[8] Research interest in the last decade has shifted to the time series properties of data used to estimate price transmission relations, and error-correction representations (e.g., see Hassouneh *et al.* (2012) and the references therein). Our unsystematic review of this literature indicates most of the studies omit marketing costs. Whether the associated attenuation bias is as serious as suggested by the examples for beef and pork is unknown.

Colman's definition of perfect transmission is somewhat vague on whether price movements are to be taken as proportionate or absolute, to wit (Colman, 1985, p. 172): "For the purposes of this paper, perfect transmission is defined as occurring where a change in a policy regulated price, such as an intervention or minimum import price, causes an equal change in the farm-gate price." However, in the regressions presented later in Colman's paper, and in the attendant discussion, it is clear that the definition refers to absolute price changes.

That a unitary slope is compatible with EPT < 1 can be seen by considering the price transmission model:

(14) $\qquad P_x = a + b\,\tilde{P}_a + c\,P_b$

where $\tilde{P}_a = (a/x)P_a$ is farm price expressed on *a retail-equivalent* basis. For example, if the price of live steer is $1.00 per pound, and it takes two pounds of live steer to produce one pound of beef at retail, the retail-equivalent farm price is $2.00 per pound. In equation (14), perfect transmission implies $b = 1$. Specifically, if the marketing channel is perfectly competitive, a one penny per pound increase in the *retail-equivalent* farm price will cause the retail price to increase by exactly one penny per pound, holding constant the cost of marketing inputs. Imposing this restriction, it is easy to see that EPT < 1 (since EPT $\equiv \dfrac{\partial P_x}{\partial \tilde{P}_a}\dfrac{\tilde{P}_a}{P_x} = 1 \cdot \dfrac{(a/x)P_a}{P_x} = S_a$).

If farm price is not expressed on a retail-equivalent basis, competitive market clearing implies the slope (in general) exceeds 1. That is, in the model

(14′) $\qquad P_x = a + b'\,P_a + c\,P_b$

where P_a is the unadjusted farm price (expressed in the same units as the retail price, e.g., pennies per pound), perfect competition implies $b' = S_a\left(\dfrac{P_x}{P_a}\right) = \dfrac{a}{x} \geq 1$. In this instance, an isolated one penny per pound increase in farm price in general will cause the retail price to increase by more than one penny. The extent to which the *absolute* pass-through exceeds 1 is determined by the size of the input-output coefficient (a/x). Pass through, for example, should be less for a product like fresh eggs that undergoes

little physical transformation from farm to fork, than for a product like wheat that undergoes substantial transformation. Rejection of the null hypothesis $b' \geq 1$ in favor of the alternative hypothesis $b' < 1$ would constitute evidence in favor of imperfect competition.

Retail-Farm Price Transmission

If $P_x^*/P_a^* < 1$ is compatible with competitive market clearing, then so is $P_a^*/P_x^* > 1$. Why might this be important? Consider the following quote from Lloyd *et al.* (2004, p. 18):

> This paper has focused on the potential presence of market power in the UK food retailing sector, an issue that has drawn attention from the UK anti-trust authority. Specifically, it was motivated by the public concerns raised about the differential impact of price adjustment on retailers and producers, the concern being that prices at the farm gate fell by more than retail prices in the wake of the BSE [Bovine Spongiform Encephalopathy] crises. In this paper we have shown formally how imperfect competition is likely to result in a differential effect on prices at different stages of vertical chain following a shift in the retail demand function.

But, as is clear from equation (9), a retail demand shock will always cause price adjustment at farm to be larger than at retail provided $\varepsilon_a < \varepsilon_b$. As an example, taking the reciprocal of $\tau^{RD} = 0.57$ (the EPT for the U.S. beef industry based on Wohlgenant's (1993) analysis, see table 1) yields $P_a^*/P_x^* = 1.75$. Applying this value to the UK beef market, a 10% reduction in retail price associated with the BSE crises would be expected to reduce the farm price of beef by 18% *under the maintained hypothesis that the marketing channel is perfectly competitive*.

That retail demand shocks have a larger proportionate effect on farm prices than on retail prices can be understood by considering the general equilibrium supply and demand curves for the retail and farm products implied by Gardner's model:

(15) $$x^* = \left(\frac{\varepsilon_a + S_b \sigma}{S_a}\right) P_x^* + terms\ involving\ exogenous\ supply\ shifters$$

(16) $$P_a^* = \left(\frac{1}{S_a \eta - S_b \sigma}\right) a^* + \alpha$$

These equations are derived from equations (1) − (6) with ε_b set to infinity.[9] An $\alpha \cdot 100$ percent vertical shift in the retail demand curve [equation (1)] causes an identical vertical shift in the demand curve at the farm level [equation (16)]. Also, the farm supply curve [equation (5)] is steeper than the retail supply curve [equation (15)]. The latter, in particular, accounts for the sharper price response at the farm level, as shown in figure 1.[10]

Marketing Margin Behavior

What are the implications of perfect farm-retail price transmission for marketing margin behavior? In addressing this question, it is useful to distinguish between the *relative* marketing margin $M_R = P_x / P_a$, and the *absolute* marketing margin $M_A = P_x - \theta\,P_a$, where $\theta = a/x \geq 1$ is an input-output coefficient that converts the farm price to a retail-equivalent price.[11] Gardner analyzed the relative margin or "price ratio," but not the absolute margin or "price spread." Here, we analyze both to see how results compare.

The first step is to express the margins in proportionate change form:

(17) $$M_R^* = P_x^* - P_a^*$$

(18) $$(1 - S_a) M_A^* = P_x^* - S_a P_a^* - S_a \theta^*$$

Substituting equations (7) and (8) into equations (17) and (18) and simplifying yields:

---

[9] Both derivations are consistent with those found in Muth (1964).

[10] In Lloyd *et al*.'s (2004, p. 17) study, the "pass-back elasticity" was estimated to be 4.4, i.e., a 1% decrease in the retail price associated with BSE causes farm price to decline by 4.4%. With the maintained hypothesis that marketing costs are exogenous to the beef sector, this estimate is consistent with a farmers' share of $S_a = 0.22$ when markets are competitive. The implied value for S_a seems too small, lending credence to Lloyd *et al*.'s inference of non-competitive pricing. Still, caution is warranted, as the 95% confidence interval for the 4.4 point estimate could include implied values for S_a in the plausible range.

[11] For a detailed discussion of the absolute marketing margin, including how it relates to USDA's measurement of the farm-retail price spread, see Reed *et al*. (2002).

(19) $\quad M_R^* = -\left(\frac{S_b\eta(\varepsilon_a-\varepsilon_b)}{D}\right)\alpha + \left(\frac{S_b\varepsilon_a(\varepsilon_b-\eta)}{D}\right)\beta_a - \left(\frac{S_b\varepsilon_b(\varepsilon_a-\eta)}{D}\right)\beta_b$

(20) $\quad \widetilde{M}_A^* = -\left(\frac{S_b\eta(\sigma+\varepsilon_a)}{D}\right)\alpha - \left(\frac{S_aS_b\varepsilon_a(\sigma+\eta)}{D}\right)\beta_a - \left(\frac{S_b\varepsilon_b(\varepsilon_a+S_b\sigma-S_a\eta)}{D}\right)\beta_b$

where $\widetilde{M}_A^* = (P_x^* - S_aP_a^*)$ is the proportionate change in the price spread with the term involving θ^* purged.[12] The price spread responds differently to shifts in retail demand and farm supply than does the price ratio. Specifically, an isolated increase in retail demand ($\alpha > 0$) causes the price spread to increase, while the price ratio may increase or decrease depending on the relative magnitudes of ε_a and ε_b. An isolated increase in the supply of the farm-based input ($\beta_a > 0$) causes the price ratio to increase, while the price spread may increase or decrease depending on the relative magnitudes of σ and $|\eta|$. It is only with an increase in the supply of marketing inputs ($\beta_b > 0$) that the price spread and price ratio move in the same direction, decreasing in both cases.

The potential importance of distinguishing between the absolute and relative margins perhaps can be best appreciated by considering the following quotation from Colman (1985, p. 175):

> Analysis of the behavior of distributive margins in agricultural markets has generally tended to confirm their variability. Theoretical analyses, by Gardner (1975) and Chambers (1983), employ assumptions which lead to the conclusion that such margins vary directly with increases in the quantity of produce processed and distributed. Increased throughput arising from either higher supply, or increased demand, in situations where the supply of marketing inputs is less elastic than the supply of farm produce, may be expected to *increase* farm-retail margins [emphasis added].

This statement is consistent with equation (19), but not with equation (20). Specifically, when the marketing margin is defined as a price spread, an increase in farm supply will increase the margin only if the farm-based and marketing inputs are gross complements

---

[12] The term involving θ^* vanishes due to algebraic cancellation; the assumption of variable factor proportions is unaffected.

$(\sigma < |\eta|)$. If the farm-based and marketing inputs are gross substitutes $(\sigma > |\eta|)$, as appears to be true for eggs, dairy, and fresh vegetables in the United States (Wohlgenant 1989), equation (20) indicates that an increase in farm supply will cause the marketing margin to *decrease*. The reason is that, in this instance, an increase in the supply of a will cause *both* P_a and P_b to fall. With input costs lower, competitive pressures will force the price spread to shrink (although the price ratio still rises by equation (19)). In short, it is possible for the farm-retail price spread $(P_x - \theta P_a)$ and ratio (P_x/P_a) simultaneously to widen and narrow.[13]

Gardner discusses in some detail the economic logic behind the comparative static results based on equation (19). Since the same logic carries over to equation (20), we will confine our attention to the empirical implications of the two specifications. As alluded to in connection with Wohlgenant's (1993) study of research and promotion in the U.S. beef and pork industries, it is not uncommon in empirical work to treat the price of marketing inputs as exogenous $(\varepsilon_b = \infty)$. This is true in econometric as well as simulation studies (e.g., Heien 1980, Kinnucan and Forker 1987, Wohlgenant and Mullen 1987, Marsh and Brester 2004, Acharya *et al*. 2011).[14] The behavioral implications of the exogeneity assumption are quite different depending on how the margin is defined, to wit:

(21) $\quad M_R^* = \left(\dfrac{S_b\eta}{\varepsilon_a + S_b\sigma - S_a\eta}\right)\alpha + \left(\dfrac{S_b\varepsilon_a}{\varepsilon_a + S_b\sigma - S_a\eta}\right)\beta_a - \left(\dfrac{S_b(\varepsilon_a-\eta)}{\varepsilon_a + S_b\sigma - S_a\eta}\right)\beta_b \qquad (\varepsilon_b = \infty)$

(22) $\quad \widetilde{M}_A^* = -S_b\beta_b \qquad\qquad (\varepsilon_b = \infty)$

---

[13] A sufficient condition for $M_A^* > 0$ and $M_R^* < 0$ to hold simultaneously can be derived through algebraic manipulation of equation (18). Setting $\theta^* = 0$, it is easy to see that $M_A^* > 0$ whenever $\frac{P_x^*}{P_a^*} > S_a$. Since $M_R^* < 0$ whenever $P_x^* < P_a^*$, all that is necessary for the spread to widen in the face of a decline in the ratio is for the proportionate change in the retail price to be sufficiently large in relation to the proportionate change in the farm price to satisfy $\frac{P_x^*}{P_a^*} > S_a$. The simulations in table 1 suggest this condition will be satisfied only when observed price movements are due to shifts in retail demand.

[14] Colman, in the quote cited earlier, makes reference to $\varepsilon_b < \varepsilon_a$. This was to account for situations where bottlenecks make marketing inputs relatively fixed in supply. In empirical models of marketing margin behavior, the standard assumption is that the price of marketing inputs is exogenous (Wohlgenant 2001). Still, given the importance of the exogeneity assumption for the inferences to follow, in econometric work it should be verified with a Hausman or other appropriate test.

Simply put, when it is legitimate to treat the price of marketing inputs as exogenous, theory indicates that shifts in retail demand and farm supply have no effect on the price *spread*. This suggests a simple test for market power: estimate the *absolute* marketing margin relation with farm supply and retail demand shifters included, and test whether the latter are significant. If they are not significant, this would constitute evidence in favor of competitive market clearing. Examples of econometric studies that impose zero or other restrictions implied by theory to test for perfect competition include Reed and Clark (1998), Lloyd *et al*. 2009, and Kinnucan and Tadjion (2014).

Technical Change

Empirical research suggests the widening spread between retail and farm prices in the United States is due to substitution possibilities in a competitive industry (Wohlgenant 1989; Reed and Clark 1998). This suggests shifts in the marketers' production function $x = f(a, b)$ are not to be overlooked as a potentially important factor influencing price transmission and marketing margin behavior. Miedema (1976) examines the effect of technical change on the relative margin. Here, we extend Miedema's analysis to consider the absolute margin. For this purpose, we follow Muth (1964) and consider both neutral and biased technical change. Biased technical change is defined as a relative increase in the marginal product of a due to a b-saving improvement in production technique, holding x constant (isoquants pivot). Neutral technical change is defined as a relative increase in x and the marginal products of both inputs (isoquants shift in). Biased technical change is modeled by adding a shift parameter γ to the input demand functions in Gardner's original model; neutral technical change is modeled by adding a shift parameter δ both to the input demand functions, and to the production function (see Muth 1964 for details).

The price transmission elasticities associated with technical change are:

$$(23) \qquad \tau^{TC-N} = \frac{P_x^*/\delta}{P_a^*/\delta} = \frac{\varepsilon_a\varepsilon_b + S_b\varepsilon_a + S_a\varepsilon_b + \sigma(1 + S_a\varepsilon_a + S_b\varepsilon_b)}{(1+\eta)(\varepsilon_b+\sigma)}$$

(24) $\qquad \tau^{TC-B} = \frac{P_x^*/\gamma}{P_a^*/\gamma} = \frac{S_a(\varepsilon_b - \varepsilon_a)}{\varepsilon_b - \eta}$

The EPT corresponding to neutral technical change may be positive or negative depending on whether retail demand is inelastic or elastic. Similarly, the EPT corresponding to biased technical change may be positive or negative depending on whether marketing input supply is more or less elastic than farm supply. If $\varepsilon_a < \varepsilon_b$ and $|\eta| < 1$, the most likely scenario, the EPTs associated with technical change are always positive.

The marketing margin relations associated with technical change are: [15]

(25) $\qquad M_R^* = -\left(\frac{S_b(\varepsilon_a - \varepsilon_b) + \varepsilon_a \varepsilon_b + \sigma(1 + S_a \varepsilon_a + S_b \varepsilon_b) - \eta(\sigma + \varepsilon_b)}{D}\right)\delta - \left(\frac{\sigma(S_a \varepsilon_a + S_b \varepsilon_b - \eta)}{D}\right)\gamma$

(26) $\qquad \widetilde{M}_A^* = -\left(\frac{\varepsilon_a \varepsilon_b + \sigma(S_b + S_a \varepsilon_a + S_b \varepsilon_b) - S_a \eta(\sigma + \varepsilon_b)}{D}\right)\delta - \left(\frac{S_a \sigma(\varepsilon_a - \eta)}{D}\right)\gamma$

Biased technical change that is saving in the marketing input ($\gamma > 0$) always reduces the marketing margin. And this is true whether the marketing margin is defined as a price ratio, or as a price spread. Neutral technical change ($\delta > 0$) always reduces the price spread, but may increase or decrease the price ratio depending *inter alia* on the relative magnitudes of ε_a and ε_b. If $\varepsilon_a < \varepsilon_b$, the most likely scenario for individual food products (Gardner 1975), the effect of neutral technical change on the price ratio is ambiguous.

If the price of marketing is exogenous, equations (25) and (26) reduce to:

(27) $\quad M_R^* = -\left(\frac{\varepsilon_a + S_b(\sigma - 1) - \eta}{\varepsilon_a + S_b \sigma - S_a \eta}\right)\delta - \left(\frac{S_b \sigma}{\varepsilon_a + S_b \sigma - S_a \eta}\right)\gamma \qquad (\varepsilon_b = \infty)$

(28) $\quad \widetilde{M}_A^* = -\delta \qquad (\varepsilon_b = \infty)$.

Unless marketing technology is quiescent over the sample period, failure to account for technical change will result in biased estimates of the EPT. Focusing on equation (28), if technical change is biased, the estimated EPT is not, as the price spread is unaffected. However, if technical change is neutral, the bias could be severe. The reason is that, in

---

[15] The derivation of equations (25) and (26), which requires some rather tedious algebra, is in an appendix available upon request from the authors. The anatomy of equation (25) is analyzed in some depth by Miedema (1976). To our knowledge, no comparable analysis is available for equation (26).

this instance, the proportionate relationship between the margin and technical change is 1-1, i.e., a 1% improvement in technical efficiency translates into an identical 1% reduction in the absolute price spread.

Miedema (1976, p. 750) states "Technical change in the food marketing industry has been causally linked to the secular increase in the marketing margin, i.e., the margin between product prices at retail and prices of the related raw farm products." To the extent the statement is true (no supporting references are provided), the technical change would have to be neutral rather than biased, as the latter always reduces the margin.

In their analysis of the marketing channel for fresh salmon, Guillotreua *et al*. (2005) found a structural break occurring in 1992, with EPT equal to 0.6 before the break, and 0.2 after. This finding hints at the potential importance of bias in studies that ignore technical change.

Concluding Comments

Competitive market clearing does not require that the elasticity of farm-retail price transmission equal 1. In fact, in the context of Gardner's (1975) model, situations in which this would occur appear to be rare to the point of irrelevance. In the same vein, an EPT close to zero might represent non-competitive pricing, or it might simply represent consumers' preference for food products that are intensive in the marketing input. From an econometric perspective, an EPT close to zero in models that exclude marketing costs perhaps is to be expected, as such models are subject to attenuation bias whenever consumers can substitute more easily than intermediaries, i.e., whenever the retail demand elasticity $|\eta|$ exceeds the elasticity of substitution σ between the farm-based input and the marketing input.

A second general conclusion is that the *absolute* marketing margin (defined as the difference between the retail price and the retail-equivalent farm price) responds differently to shifts in retail demand, input supply, and technical change than does the

relative marketing margin (defined as the ratio of the retail price to the farm price). If the cost of marketing services is exogenous to the subsector under investigation, Gardner's (1975) model implies the *absolute* marketing margin is invariant to shifts in retail demand and farm supply. This invariance property implies zero restrictions on the price transmission and marketing margin relations that can be used to test for market power,[16] a fact that has as yet to be fully exploited in the error-correction literature.

---

[16] Thus, for example, in the regression $M_A = b_0 + b_1 P_b + b_2 S + b_3 D + \mu$ where M_A is the absolute margin, P_b is marketing costs, S is a farm supply shifter, D is a retail demand shifter, and μ is a random disturbance term, if P_b is exogenous then competitive market clearing implies $b_2 = b_3 = 0$.

Table 1. Farm-Retail Price Transmission Elasticities Corresponding to Shifts in Retail Food Demand (τ^{RD}) , Farm Product Supply (τ^{FS}), and Marketing Input Supply (τ^{MS})

Row [a]	σ	ε_a	ε_b	η	S_a	τ^{RD}	τ^{FS}	τ^{MS}
1	0.5	1.0	2.0	-0.5	0.5	0.80	0.50	Undefined
2	0	1.0	2.0	-0.5	0.5	0.75	0.44	-2.0
3	0	1.5	2.0	-0.5	0.5	0.88	0.44	-3.0
4	0	2.0	2.0	-0.5	0.5	1.00	0.44	-4.0
5	0	2.0	1.0	-0.5	0.5	1.50	0.40	-4.0
6	0	1.0	2.0	-1.0	0.5	0.75	0.40	-1.0
7	0.72	0.15	∞	-0.78	0.57	0.57	0.57	-14.5
8	0.35	0.40	∞	-0.65	0.45	0.45	0.45	-2.5

[a]Parameter values in rows 1 – 6 are hypothetical values taken from Gardner (1975, p. 403, table 1); parameter values in rows 7 and 8 are actual values for beef and pork, respectively, taken from Wohlgenant (1993, p. 646, table 1). In this table, σ is the elasticity of substitution between the farm-based input a and the bundle of marketing inputs b; ε_a and ε_b are supply elasticities for inputs a and b; η is the own-price elasticity of demand for the retail product x; and $S_a = P_a a / P_x x$ is the farmers' share of the retail dollar.

Figure 1. Effect of a Retail Demand Shock on Retail and Farm Prices when the Supply of Marketing Inputs is Perfectly Elastic
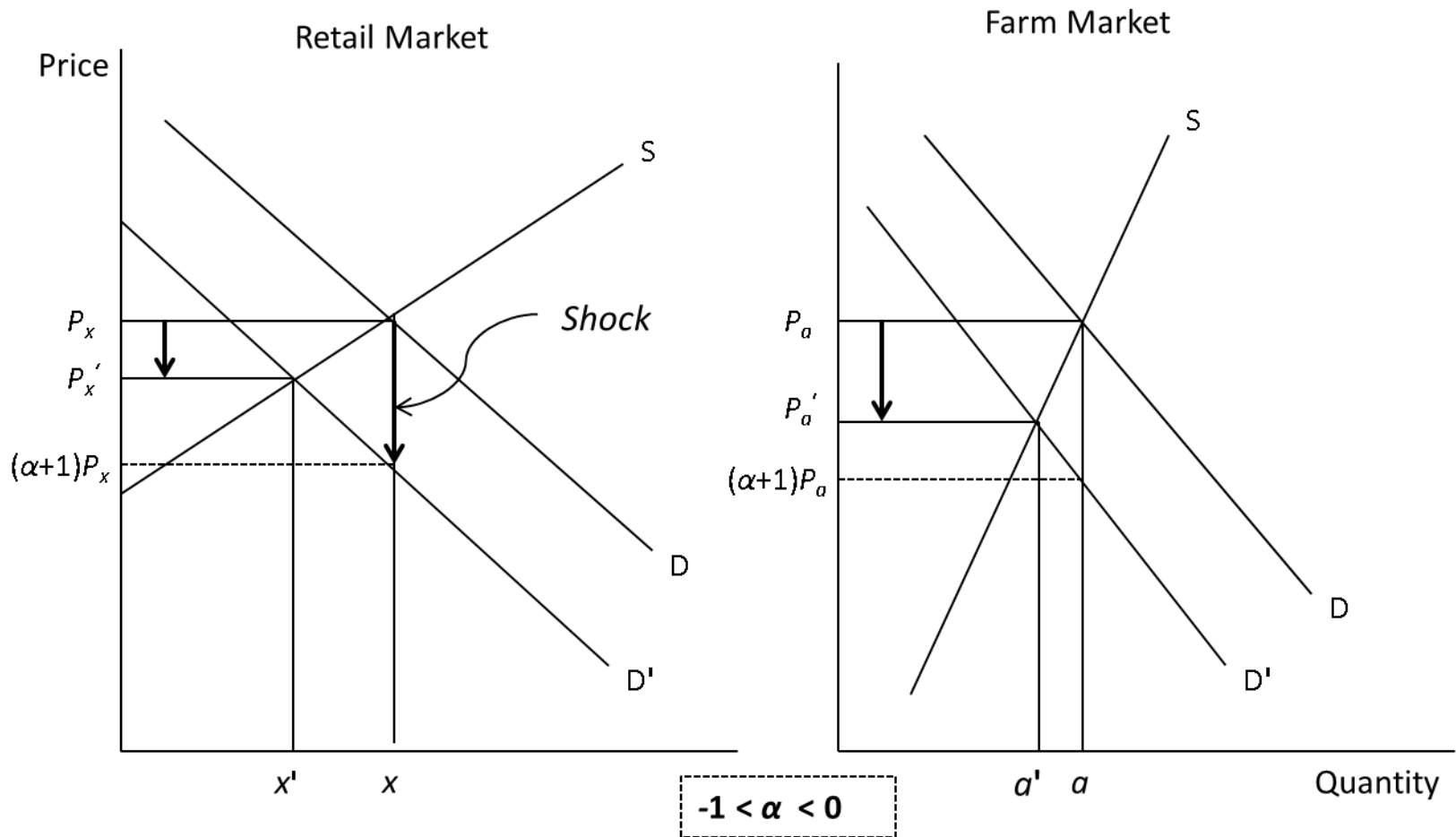
Appendix A: Derivation of the Price Transmission Relation

The price transmission relation (text equation (2)) is derived from the marketers' cost function, which, after imposing constant returns to scale, may be written as

(A1) $\qquad C = c(P_a, P_b) \cdot x$

where $c(P_a, P_b) = C/x$ is the unit, or average, cost function.

The zero profit condition of long-run competitive equilibrium implies price equals average cost

(A2) $\qquad P_x = c(P_a, P_b).$

Taking the total differential of (A2) yields

(A3) $\qquad dP_x = \dfrac{\partial c}{\partial P_a} dP_a + \dfrac{\partial c}{\partial P_b} dP_b.$

The partial derivatives in (A3) can be eliminated by applying Shephard's lemma to (A1)

(A4) $\qquad a \equiv \dfrac{\partial C}{\partial P_a} = \dfrac{\partial c}{\partial P_a} \cdot x \ \Rightarrow \dfrac{\partial c}{\partial P_a} = \dfrac{a}{x}$

(A5) $\qquad b \equiv \dfrac{\partial C}{\partial P_b} = \dfrac{\partial c}{\partial P_b} \cdot x \ \Rightarrow \dfrac{\partial c}{\partial P_b} = \dfrac{b}{x}.$

Substituting (A4) and (A5) into (A3), and converting absolute changes to relative changes, yields

$$\frac{dP_x}{P_x} = \left(\frac{a}{x}\frac{P_a}{P_x}\right)\frac{dP_a}{P_a} + \left(\frac{b}{x}\frac{P_b}{P_x}\right)\frac{dP_b}{P_b}$$

or, more simply,

(A6) $\qquad P_x^* = S_a P_a^* + S_b P_b^*.$

References

Acharya, R. N., H. W. Kinnucan, and S. B. Caudill. 2011. Asymmetric farm-retail price transmission and market power: a new test. *Applied Economics* 43, 4759-4768.

Alston, J. M., G. W. Norton, and P. G. Pardey. (1995). *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Cornell University Press, Ithaca, NY.

Asche, F., O. Flaaten, J. R. Isaksen, and R. Vassdal (2002). Derived demand and relationships between prices at different levels in the value chain: A note, *Journal of Agricultural Economics* 53, 101-107.

Bronfenbrenner, M. (1961). Notes on the elasticity of derived demand, *Oxford Economic Papers* 13, 254-261.

Brümmer, B., S. von Cramon-Taubadel, and S. Zorya (2009). The impact of market and policy instability on price transmission between wheat and flour in Ukraine. *European Review of Agricultural Economics* 36. 203-230.

Capps, O. Jr., P. J. Bryne, and G. W. Williams (1995). Analysis of marketing margins in the U.S. lamb industry, *Agricultural and Resource Economics Review* 24, 232-240.

Chambers, R. (1983). International trade, gross substitutability, and the domestic farm-retail margin, *European Review of Agricultural Economics* 10, 33-53.

Colman, D. (1985). Imperfect price transmission, *European Review of Agricultural Economics* 12, 171-186.

Conforti, P. (2004). *Price Transmission in Selected Agricultural Markets*. FAO Commodity and Trade Policy Research Paper No. 7. Rome, Italy.

Cotterill, R. W. (2006). Antitrust analysis of supermarkets: global concerns playing out in local markets, *Australian Journal of Agricultural and Resource Economics* 50, 17-32.

Frey, G. and M. Manera (2007). Econometric models of asymmetric price transmission, *Journal of Economic Surveys* 21, 350-414.

Gardner, B. L. (1975). The farm-retail price spread in a competitive food industry, *American Journal of Agricultural Economics* 57, 399-409.

George, P. S. and G. A. King (1971). *Consumer Demand for Food Commodities in the United States with Projections for 1980.* Giannini Foundation Monograph 26, University of California, Berkeley.

Guillotreau, P., L. Le Grel, and M. Simioni (2005). Price-cost margins and structural change: sub-contracting within the salmon marketing chain, *Review of Development Economics* 9, 581-597.

Hassouneh, I., von Cramon-Taubadel, S., Serra, T., & Gil, J.M. 2012. Recent developments in the econometric analysis of price transmission. Working Paper No. 2. Transparency of food pricing. Seventh Framework Programme. Department of Economics, University of Exeter, Devon, England.

Heien, D. M. (1980). Markup pricing in a dynamic model of the food industry, *American Journal of Agricultural Economics* 62, 10-18.

Hildreth, C. and F. G. Jarrett (1955). *A Statistical Study of Livestock Production and Marketing*. Cowles Commission Monograph No. 15. New York: John Wiley & Sons.

Kim, H. and R. W. Ward (2013). Price transmission across the U.S. food distribution system, *Food Policy*, 41, 226-236.

Kinnucan, H. W. (2003). Optimal generic advertising in an imperfectly competitive food industry with variable proportions, *Agricultural Economics* 29, 143-158.

Kinnucan, H. W. and O. D. Forker (1987). Asymmetry in farm-retail price transmission for major dairy products, *American Journal of Agricultural Economics* 69, 285-292.

Kinnucan, H. W. and O. Tadjion (2014). Theoretical restrictions on farm-retail price transmission elasticities: a note, *Agribusiness: An International Journal* 29, forthcoming.

Lloyd, T., S. McCorriston, W. Morgan, and A. Rayner. (2004). *Price Transmission in Imperfectly Competitive Markets*. Discussion Paper No. 04/09. Discussion Papers in Economics, University of Nottingham.

Lloyd, T., S. McCorriston, W. Morgan, A. Rayner, and H. Weldegebriel. (2009). Buyer power in U.K. food retailing; a 'first-pass' test, *Journal of Agricultural & Food Industrial Organization* 7: article 5.

Marsh, J. M. and G. W. Brester (2004). Wholesale-retail marketing margin behavior in the beef and pork industries, *Journal of Agricultural and Resource Economics* 29, 45-64.

McCorriston, S., C.W. Morgan, and A.J. Rayner. (2001). Price transmission: the interaction between market power and returns to scale, *European Review of Agricultural Economics* 28, 143-59.

Meyer, J., and S. von Cramon-Taubadel (2004). Asymmetric price transmission: a survey, *Journal of Agricultural Economics* 55, 581-611.

Miedema, A. K. (1976). The farm-retail price ratio, the farmer's share, and technical change, *American Journal of Agricultural Economics* 58, 750-756.

Muth, R. F. (1964). The derived demand curve for a productive factor and the industry supply curve, *Oxford Economic Papers* 16, 221-234.

Reed, A. J. and J. S. Clark (1998). The transmission of trends in retail food prices and farm prices, *American Journal of Agricultural Economics* 80, 1139-1143.

Reed, A. J., H. Elitzak, and M. K. Wohlgenant (2002). *Retail-Farm Price Margins and Consumer Product Diversity*. USDA Technical Bulletin Number 1899.

Tiffin, R. and P. J. Dawson (2000). Structural breaks, cointegration, and the farm-retail price spread for lamb, *Applied Economics* 32, 1281-1286.

Weldegebriel, H. T. (2004). Imperfect price transmission: is market power really to blame? *Journal of Agricultural Economics* 55, 101-114.

Wisecarver, D. (1974). The social costs of input-market distortions, *American Economic Review* 64, 359-372.

Wohlgenant, M. K. (1989). Demand for farm output in a complete system of demand functions, *American Journal of Agricultural Economics* 71, 241-252.

Wohlgenant, M. K. (1993). Distribution of gains from research and promotion in multi-stage production systems: the case of the U.S. beef and pork industries, *American Journal of Agricultural Economics* 75, 642-651.

Wohlgenant, M. K. (2001). Marketing margins: empirical analysis. In *Handbook of Agricultural Economics*, B. L. Gardner and G. C. Rausser (editors): Volume 1, Chapter 16, pp. 933-970.

Wohlgenant, M. K. and J. D. Mullen (1987). Modeling the farm-retail price spread for beef, *Western Journal of Agricultural Economics* 12, 119-125.