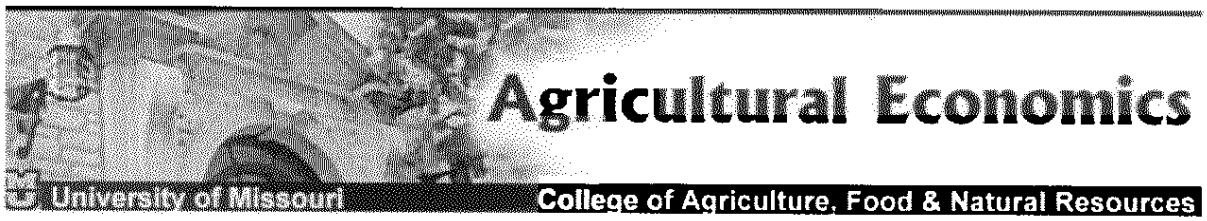

Why a Well Functioning Market Generates Asymmetry of Farm and Wholesale Prices For Hogs and Pork

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Department of Agricultural Economics Working Paper No. AEWP 2001-5

November 2001

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Abstract

Conventional wisdom suggests that weekly prices at farm, wholesale, and retail levels should exhibit symmetry. Observation of asymmetrical price movements is submitted as evidence of the existence and use of "market power" at one or more levels of the market.

However, application of economic theory of the market clearing process in a well functioning, competitive livestock market shows that weekly prices will move asymmetrically. Studies that confirm asymmetric weekly price movements in farm, wholesale, and retail prices of pork demonstrate that these markets are performing as we would expect well functioning, competitive markets to operate. Claims that evidence of asymmetric weekly (or even monthly and quarterly average prices) is not evidence of market power as claimed by the authors of the studies documenting the asymmetry.

Why a Well Functioning Market Generates Asymmetry of Farm and Wholesale Prices for Hogs and Pork*

J. Bruce Bullock**

The recent AJAE paper by Miller and Hayenga is the latest of many papers using a sophisticated mathematical/statistical model to show that farm, wholesale, and retail prices of pork (and other meats) do not comply with the presumption/assertion by the authors that these prices should move in symmetry with each other. Unfortunately these papers are extra long on sophisticated data manipulation/analysis and extra short on developing the economic foundation/justification for their analysis. Indeed in some cases the papers seem to be void of economic reasoning.

As part of the justification for their study Miller and Hayenga (MH) quote an unnamed hog producer who wrote a letter to the editor of Iowa Farmer Today. This eminent economic authority has concluded that since prices of live hogs and the prices of wholesale pork were observed to move asymmetrically in 1998-1999 he has provided evidence that meat packers are "filling their pockets" at the expense of hog producers and pork consumers. MH further justify their presumptions that farm and wholesale prices should exhibit symmetry by pointing out that "concerns about rate and symmetry of price response are commonly raised if one or more sectors in the marketing channel are highly concentrated and dominated by a few firms."

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*Agricultural Economics Working Paper AEWP 2001-5, Department of Agricultural Economics, University of Missouri-Columbia. Working papers generally have not been reviewed by anyone other than the author. They are a part of the process of obtaining from readers comments and suggestions for the author to use in subsequent revisions of the paper and to inform colleagues of work in progress. Working papers should not be quoted or cited as a reference without approval of the author.

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Miller and Hayenga proceed to use a quite sophisticated and impressive data manipulation procedure using weekly hog and pork prices to conclude that "the farm-wholesale margin is asymmetric at all frequencies . . . As a result, subsequent studies of the U.S. pork market may be focused on a narrower set of plausible reasons for asymmetric price transmission." (p. 561).

WHERE IS THE ECONOMICS?

There is a serious problem with their analysis! Where is the economic model that provides MH (and other authors) with the economic theory necessary to presume that weekly prices of live hogs and wholesale pork prices will exhibit symmetry in a well functioning livestock/meat market? What is the theoretical justification for concluding that there is a "problem" with the functioning of the pork market if farm and wholesale prices are not linear or log linear functions of each other? Why should we want to search for "plausible reasons for asymmetric price transmission"? To the contrary, economic theory tells us that we should <u>not</u> expect to observe symmetric price transmission in a well functioning hog and pork market.

In the absence of a valid economic model explaining why symmetry should result, conclusions that "the farm-wholesale margin is asymmetric at all frequencies" are totally meaningless. There simply is no theoretical basis for interpreting the MH results as being inconsistent with the performance of a perfectly functioning livestock/meat market. Indeed as will be shown in the balance of the paper, farm and wholesale prices in a perfectly functioning market will exhibit asymmetric movements for any time interval of less than one year or perhaps longer.

Economic theory indicates that MH and others have tested the wrong hypothesis. Rather than prove that the hog/pork market is not functioning well, the MH results are exactly what economic theory (in contrast to the statements of the Iowa hog producer) predicts will be the performance of a perfectly functioning hog/pork market.

The balance of this paper develops the economic model (conceptual framework) supporting the heresy stated in the preceding paragraphs. The economic model is quite simple: market clearing prices generated in time period t by a well-functioning market are determined by the intersection of the supply and demand for the product. This basic economic principle of how markets work is applicable at all three levels (farm, wholesale, and retail) of the livestock market.

WEEKLY HOG AND PORK SUPPLIES

The production of slaughter hogs is a biological production process. Production of a slaughter hog requires about 10 months from the initiation (breeding) to the termination of the production process (slaughter). Thus the number of hogs slaughtered in week t was determined 10 months prior to that week. The number of animals marketed/slaughtered in week t, A_t, is exogenous to the hog pricing process during week t. That is, the number of animals slaughtered in week t, and hence the amount of pork products injected into the meat market in week t, is not determined by the price of hogs or the price of pork products in week t. To the contrary, the market for hogs and pork (and also beef and poultry markets) is a price-dependent system where weekly average prices at the farm, wholesale and retail level are defined by the predetermined quantity of animals/meat moving through the market that week.

Farm Level

The marketing/slaughter of A_t slaughter hogs in week t inserts $Q_t = r \cdot A_t$ pounds of pork into the wholesale meat market in week t, where r is the pounds of wholesale pork products obtained from each hog slaughtered. This exogenously determined (w.r.t this week's hog price) quantity then moves on to the wholesale level.

Wholesale Level

The quantity of wholesale pork products produced in week t (Q_t) moves through the wholesale market during the following three week period. In week (t+1), a proportion $1 < \lambda_1 < 0$ of the pork slaughtered in week t moves into the wholesale pork market. This portion is primarily fresh pork products. In week t+2, a proportion $1 < \lambda_2 < 0$ of the pork slaughtered in week t moves into the wholesale pork market. This consists of the balance of fresh products and a portion of the cured/ processed products produced from week t slaughter. The remainder of the wholesale products from hogs slaughtered in week t moves through the wholesale meat market in week t+3. This proportion $1 < \lambda_3 < 0$ likely consists almost entirely of cured products produced from the week t slaughter. Thus the amount of pork moving through the wholesale meat market in week t is defined as

(1) $$W_t = \lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}$$

where: $$\sum_{i=1}^{3} \lambda_i = 1$$

Retail Level

The amount of pork products moving through the retail market in week t (R_t) was purchased at the wholesale level in week t-1 as defined by equation (2).

(2) $R_t = k \cdot W_{t-1}$

where: R_t = amount of pork sold to consumers at retail during week t

k = the yield of retail pork products obtained from a pound of wholesale pork products, $1 < k < 0$. As retail packaging at the wholesale level increases, k is approaching a value of 1.0.

In summary, we see below that in week t the farm, wholesale, and retail markets are moving entirely different quantities of meat through the respective market level. In some weeks, quantities may be increasing at one level and decreasing in another level.

Week t Market Clearing Quantity of Pork

(3) Farm Level $Q_t = r \cdot A_t$

(4) Wholesale Level $W_t = [\lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}]$

(5) Retail Level $R_t = kW_{t-1} = k[\lambda_1 Q_{t-2} + \lambda_2 Q_{t-3} + \lambda_3 Q_{t-4}]$

WEEKLY DEMAND FOR MEAT AND HOGS

The farm level demand for hogs is a derived demand. The farm level demand for hogs is derived from the wholesale demand for pork products which is in turn derived from the retail (consumer) demand for pork.

As noted earlier, the quantity of pork moving through each level of the market in week t was predetermined several months previously. Thus the demand curves at all three levels of the marketing system are price-dependent demand curves that define the market clearing prices at each level given the exogenously determined quantities moving through the respective markets in week t.

Retail Demand

The retail level demand curve for week t defines the maximum price that consumers are willing to pay for alternative quantities of pork products moving through the market in week t. The market clearing retail price of pork in week t defined by the price-dependent retail demand curve defined by equation 6.

(6) $P_t^r = d\, R_t^{e_p} R_{tb}^{e_b} R_{tc}^{e_c} I_t^{e_i}$

where: P_t^r = the retail price of pork in week t

R_t = the amount of pork moving through the retail market in week t

R_{tb} = the amount of beef moving through the retail market in week t

R_{tc} = the amount of poultry products moving through the retail market in week t

I_t = per capita disposable income in week t

The values of R_{tb}, R_{tc} and I_t are exogenous to the pork market. Consequently, equation (6) can be rewritten as:

(6.a) $P_t^r = d_t R_t^{e_p}$, given R_{tb}, R_{tc} and I_t

The value of d_t changes weekly. The retail price flexibility of pork, e_p, remains constant from week to week in the absence of a shift in consumer meat preferences.

Substituting equation (2) into equation (6.a) yields

(7) $P_t^r = d_t [kW_{t-1}]^{e_p}$

which expands to the following when equation (5) is substituted into equation (7).

(8) $P_t^r = d_t [k(\lambda_1 Q_{t-2} + \lambda_2 Q_{t-3} + \lambda_3 Q_{t-4})]^{e_p}$

Wholesale Demand

The price-dependent wholesale demand for pork defines the maximum price that retailers are willing to pay for pork in week t for alternative quantities of pork moving through the wholesale market in week t. The market clearing wholesale price of pork in week t is thus defined by equation (9).

(9) $P_t^w = \alpha W_t^{\beta_p} W_{tb}^{\beta_b} W_{tc}^{\beta_c}$

where: P_t^w = the wholesale price of pork in week t

W_t = the amount of wholesale pork products moving through the market in week t

W_{tb} = the amount of wholesale beef products moving through the market in week t

W_{tc} = the amount of wholesale poultry products moving through the market in week t

The magnitudes of W_{tb} and W_{tc} are exogenous to the pork market. Consequently, equation (9) can be rewritten as:

(9.a) $P_t^w = \alpha_t W_t^{\beta_p}$ given W_{tb} and W_{tc}

The value of α_t changes weekly. The wholesale price flexibility for pork β_p remains constant from week to week in the absence of a shift in consumer preferences. The pricing (wholesale-retail mark-up) strategy of retailers is reflected in the values of α_t and β_p. Note that the wholesale price of pork in week t is not a function of the retail price of pork that week. Rather P_t^w is a function of the quantity of pork in the wholesale market during week t. If the wholesale market for pork is to clear

in week t, retailers cannot impose some arbitrary price mark-up (mark-down from retail) on the wholesale price. The wholesale price of pork will be determined by the quantity of pork moving through the market in week t, not by some fixed amount or fixed percent price mark-up strategy of retailers. **There is no "transmission" of farm prices to the wholesale level. The wholesale price is not determined by what packers paid for the live animal. Rather, the wholesale price is whatever price that clears the market given W_t.**

As Gardner indicated, the retail price and the wholesale price in week t are the prices required to clear the market in that week. The retail to wholesale price spread $(P_t^r - P_t^w)$ in week t is therefore the residual difference between the two prices rather than the result of a retail price mark-up formula.

Substituting equation (4) into equation (9.a) provides us with the equation that defines the wholesale price of pork in week t.

$$(10) \qquad P_t^w = \alpha_t [\lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}]^{\beta_p}$$

Farm Level Derived Demand

The price-dependent farm level derived demand for hogs defines the maximum price that packers are willing to pay for hogs in week t for alternative number of hogs to be slaughtered in week t.

In a competitive market for live hogs, the maximum price that packers are willing to pay for hogs is defined as the wholesale price packers are receiving for pork minus the cost (excluding animal cost) of transforming live hogs into wholesale pork products. Thus, the price-dependent farm level derived demand for hogs in week t is defined by equation (11).

(11) $P_t^f = P_w^f - C_t$

where: P_t^f = farm level price of hogs in week t

C_t = the cost of transforming live hogs into wholesale pork products and the cost of moving pork products through the wholesale market.

The cost of pork slaughter/processing services is defined by equation (12).

(12) $C_t = c - b_1 Q_t + b_2 Q_t^2$

where: C_t = is the per unit cost of providing the slaughter/processing/wholesaling services to move Q_t pounds of pork through the wholesale market

Q_t = the pounds of wholesale pork products produced from A_t animals slaughtered in week t as previously defined

The U-shaped cost curve defined by equation (12) reflects the fact that packer costs are determined by the number of hogs slaughtered in week t. Moreover, there is a designed weekly slaughter capacity (Q^*) of the slaughter industry that minimizes per head slaughter costs (Bullock). Packer costs will increase (perhaps sharply depending on the values of b_1 and b_2) as weekly slaughter rates either increase or decrease from this cost minimizing weekly slaughter rate.

If packers purchase and slaughter all slaughter animals marketed in week t the price-dependent farm level derived demand for hogs is defined by equation (13).

(13) $P_t^f = P_t^w - (c + b_1 Q_t - b_2 Q_t^2)$

Substituting equation (10) into equation (13) generates the following expression of the farm level derived demand for hogs in week t.

(14) $P_t^f = \alpha_t [\lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}]^{\beta_p} - [c - b_1 Q_t + b_2 Q_t^2]$

Thus, the farm price of hogs in week t is determined by the magnitudes of α_t, β_p, Q_t and the amount of pork inserted into the wholesale pork market in each of the previous three weeks.

Recall that α_t reflects the retail and wholesale weekly demand shifters of the quantity of beef and poultry products in the market as well as consumer income.

HOG/PORK PRICE RELATIONSHIPS

The set of price dependent market demand curves for hogs and pork are thus defined by the following set of equations.

Retail

$$P_t^r = d_t R_t^{e_p} \text{ or}$$

$$P_t^r = d_t (kW_t)^{e_p}, \text{ and hence}$$

$$(15) \quad P_t^r = d_t [k(\lambda_1 Q_{t-2} + \lambda_2 Q_{t-3} + \lambda_3 Q_{t-4})]^{e_p}$$

Wholesale

$$P_t^w = \alpha_t W_t^{\beta_p} \text{ or}$$

$$(16) \quad P_t^w = \alpha_t [\lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}]^{\beta_p}$$

Farm

$$P_t^f = P_t^w - C_t \text{ or}$$

$$(17) \quad P_t^f = \alpha_t [\lambda_1 Q_{t-1} + \lambda_2 Q_{t-2} + \lambda_3 Q_{t-3}]^{\beta_p} - [C - b_1 Q_t + b_2 Q_t^2]$$

OBSERVATIONS

Gardner showed that the spread between prices at each level of the market "will be forced to change in different ways depending on whether price movements originate from the retail demand or

farm supply side" (p. 399). This is clearly illustrated in the case of hogs and pork by the retail, wholesale and farm level price equations derived above.

Price movements originating from the retail (consumer) demand side enter the hog/pork market through weekly changes in d_t. The pricing (profit) strategies of retailers is embodied in the value of α_t. However, a simple price mark-up of x cents/unit or a percent price mark-up is not possible since $W_t \neq R_t$ and both markets regularly clear on a weekly basis. Thus α_t is not likely a linear function of d_t and therefore demand (price) shifts at the retail level are not just "transmitted" from the retail level to the wholesale level. Consequently there is no theoretical basis for suggesting that retail and wholesale pork prices should change symmetrically on a weekly basis in response to a price change generated by the retail demand side. Indeed, in some weeks, retail and wholesale prices pork can be expected to actually move in opposite directions.

The demand side shifter, α_t, also appears in the farm level demand equation. However, it is clear from equation (17) that the farm level price change from week t to week t+1 will equal the corresponding change in the wholesale price of pork only if $Q_{t+1} = Q_t$ (i.e., there is no change in the number of animals slaughter from week t to week t+1). Thus, since substantial changes occur from week t to week t+1 in the number of animals slaughtered, we should not expect wholesale price changes to simply be transmitted from the wholesale to the farm level. As is the case with the retail-wholesale price spread, there is no theoretical basis for suggesting that hog prices and wholesale pork prices should move symmetrically on a weekly basis in response to a demand side change at the wholesale level. Indeed in some weeks farm and wholesale prices for hogs and pork can be expected to actually move in opposite directions.

Price movements originating from the farm supply side are initiated weekly by changes in Q_t. Equations (15), (16) and (17) show that the impacts of a change in Q_t ripple through the pricing system over the subsequent four weeks. Moreover, the nature and size of each "ripple" changes weekly and are not identical at the wholesale and retail level. Furthermore, the week t price at neither the wholesale level nor the retail level are affected by Q_t. However, Q_t can have a substantial impact on the farm price that is never "transmitted" to the wholesale and retail levels. Consequently there are substantial differences between the farm level price flexibility (η_p), the wholesale level price flexibility (β_p), and the retail price flexibility (e_p).

The farm level price flexibility is defined by equation (18).

(18) $$\eta_p = \frac{\delta P^f}{\delta Q_t} \cdot \frac{Q_t}{P^f}$$

η_p obviously is a function of Q_t. In contrast, the wholesale and retail price flexibilities are constant regardless of $Q_t, W_t,$ or R_t. In a price dependent market such as the hog/pork market, there simply is no theoretical basis to suggest that price movements at the farm level should be symmetrical with price movements at the wholesale and retail levels.

Bullock used an empirical example to demonstrate that the farm level price flexibility increases exponentially as Q_t increases and will be large multiples of the wholesale price flexibility in some cases whether the wholesale demand for meat is linear or log linear. Moreover, the Bullock model example ignores the fact that different quantities are moving through the market spreads level of the market. His model assumes that Q_t is moved instantaneously through all three market levels during period t. Therefore, the conclusion that a well functioning hog/pork market will generate

asymmetric farm, wholesale and retail prices holds even if the product moves from farm through retail during the same week.

CONCLUSIONS

Application of simple economic logic to the weekly market for hogs and pork demonstrates that farm, wholesale and retail prices will not exhibit symmetry. Prices at one level are not (indeed cannot) simply be transmitted to the next level. Rather, as Gardner pointed out, the spread between prices at each level of the market "will be forced to change in different ways depending on whether price movements originate from the retail demand or farm supply wide". Economic theory states that farm, wholesale and retail prices will change asymmetrically. Rather than the MH analysis providing the basis for subsequent studies of the U.S. pork market to "focus on a narrower set of plausible reasons for asymmetric price transmissions" they have simply confirmed what economic theory predicts. Weekly prices of hogs and pork should and do exhibit asymmetric price movements.

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