NEW METHODOLOGIES FOR COMMODITY PROMOTION ECONOMICS

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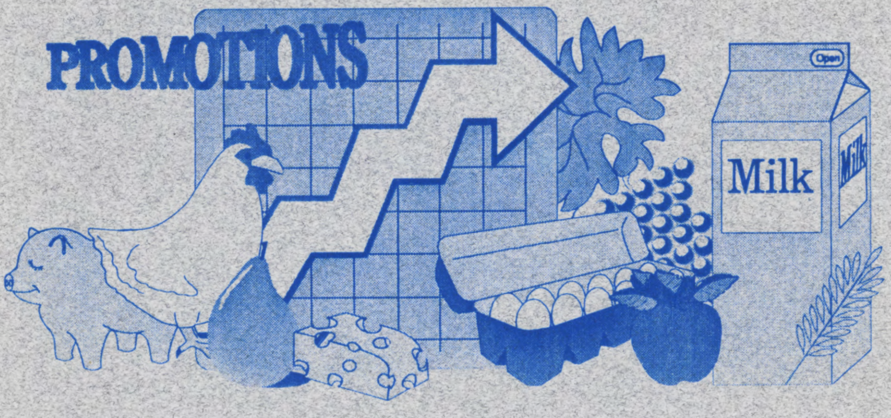

Some Observations on Measuring Returns to Promotion in Vertical Markets

Henry W. Kinnucan

Roley Piggott's paper, along with the related papers appearing in the *American Journal of Agricultural Economics* (Piggott, Piggott, and Wright) and in the recent NEC-63 proceedings volume (Alston, Chalfant, and Piggott), illustrate nicely the usefulness of equilibrium displacement models for commodity promotion evaluation. The papers merit careful reading and study.

I have little to quibble with except noting the models developed by Piggott and collaborators do not take explicit account of the marketing channel. This is evident in the market-clearing conditions, which equate changes in retail and farm quantities without regard to the processes, technological and otherwise, used to convert live animals to products that you or I might find appetizing. Although ignoring the marketing channel is perhaps understandable given the other complexities addressed by the models, the omission of marketing group behavior introduces biases that could vitiate the analyses.

So my remarks will focus on the implications of ignoring the marketing channel when evaluating promotion in a vertical market setting. First, I develop a model that shows farm-level impacts of ignoring the marketing channel when the advertised good is separable from all other goods. I then generalize the model by re-expressing the model in matrix notion incorporating demand interrelationships. A key insight from the analysis is that ignoring the marketing channel is tantamount to assuming a Leontief marketing technology and unitary farm-retail price-transmission elasticities. The assumptions, if false, introduce bias into the reduced form elasticities for farm price with respect to advertising, key parameters from a policy perspective. Fortunately, the direction of the biases are offsetting, so the reduced form elasticities in Piggott's paper might still be accurate.

It would be preferable, however, to start with assumptions that are unassailable, or to have a model with assumptions that can be relaxed to assess effects on inferences. The model developed in this paper relaxes the assumptions of fixed proportions and unitary transmission elasticities, yet reproduces the Piggott model in an elegant and simple fashion. This added flexibility, however, comes at a price: only Leontief and Cobb-Douglas marketing technologies are permissible. The advantage of the reformulated model inheres not so much in its ability to pinpoint the returns to promotion, but to show how assumptions about marketing technology and marketing margin behavior affect benefit-cost ratios.

Basic Model

I begin with a Muth-type equilibrium-displacement model of an isolated vertical market. Advertising is assumed to occur in the retail market and returns are to be measured in the farm market. Following Nerlove and Waugh, I treat advertising as an exogenous lump-sum expenditure. Advertising costs, therefore, are considered separately from benefits. The basic model is

(1) $\mathrm{dln}Q = -N\,\mathrm{dln}P_r + B\,\mathrm{dln}A$ (retail demand)

(2) $\mathrm{dln}X = E\,\mathrm{dln}P_f$ (farm supply)

(3) $\mathrm{dln}P_r = T\,\mathrm{dln}P_f$ (farm-retail price linkage)

(4a) $\mathrm{dln}Q = \mathrm{dln}X$ (Leontief market-clearing)

(4b) $\mathrm{dln}Q = \mathrm{dln}X + \mathrm{dln}P_f - \mathrm{dln}P_r$ (C-D market-clearing)

where $\mathrm{dln}Y = \mathrm{d}Y/Y$ is the relative change in variable Y; Q is quantity demanded at retail; X is the quantity supplied at the farm level; P_r is retail price; P_f is farm price; A is advertising expenditures; N is the absolute value of the retail level demand elasticity; B is the advertising elasticity; E is the farm level supply elasticity; and T is the farm-retail price-transmission elasticity. The model consists of four endogenous variables, Q, P_r, X, P_f, and one exogenous variable, A. Given the negative sign in (1), N, E, T and B are assumed to be positive.

The price linkage equation (equation (3)) may be thought of as a quasi-reduced form that reflects the behavior of middlemen (Hildreth and Jarrett). That the equation depicts accurately the relationship between retail and farm price rests on the assumption that forces causing the two prices to change (e.g., shifts in retail demand or farm supply) exert their influences separately rather than in combination (Gardner, p. 404). If this is not the case, a more complicated form of the price-transmission equation may need to be specified (Wohlgenant and Mullen).

The equilibrium mechanism in the model (equations (4a) and (4b)), derived in the appendix, indicates market-clearing under two alternative marketing technologies. One technology is fixed proportions (Leontief). In this case, changes in equilibrium quantities at farm and retail-level are identical and equation (4a) applies. An alternative assumption is Cobb-Douglas (C-D) technology. In this case, changes in equilibrium quantities at the two market levels in general are not equal, and (4b) applies. The technologies appear to cover the range of substitution possibilities observed in food marketing systems. Empirical estimates of the substitution elasticities for major food groups range from $\sigma = 0.11$ (poultry) to $\sigma = 0.96$ (dairy) (Wohlgenant 1989, p. 250).

The first task is to determine the effect of marketing technology on the ability of advertising to raise farm prices. This entails comparing the reduced form equations for farm price under the two technologies. The reduced form under Leontief technology is derived by substituting equations (1) - (3) into (4a) and solving for $d\ln P_f$:

$$d\ln P_f = [B/(E + TN)]\, d\ln A. \tag{5a}$$

Equation (5a) yields the hypothesis that an increase in advertising, under the stated conditions, always increases farm price if marketing technology is Leontief. The equation indicates that the price enhancement ability of advertising is directly related to the advertising elasticity and inversely related to the supply, demand, and price-transmission elasticities. This result is consistent with the Dorfman and Steiner theorem and with the Nerlove and Waugh analysis, provided that the composite term TN in (5a) is interpreted as the *farm level* demand elasticity, a valid interpretation under fixed proportions (Gardner, p. 404).

The reduced form equation for farm price under C-D technology is obtained by substituting equations (1) - (3) into (4b), which yields:

(5b) $$d\ln P_f = \{B/[E + TN + (1 - T)]\}\, d\ln A.$$

Comparing (5a) and (5b), it is evident that marketing technology has an important bearing on the ability of advertising to raise farm price. In particular, relaxing the assumption of fixed proportions weakens advertising's price effect. The price effect, in fact, is indeterminate without information on the magnitudes of the supply, demand, and price-transmission elasticities.

The conditions necessary for advertising to raise farm price under variable proportions can be determined by focusing on the denominator of (5b). Simple inspection yields the hypothesis that $d\ln P_f/d\ln A > 0$ so long as $0 < T \leq 1$. Empirical literature suggests this condition is met for most food items. George and King (p. 62), for example, report transmission elasticities for 32 commodities, only seven of which exceed unity. Of the seven, six (shortening, evaporated milk, sugar, canned corn, canned tomatoes, corn meal) are for minor products that tend not to be promoted by farm groups. The estimated transmission elasticity for the remaining product, cheese, which is heavily promoted, is 2.74 (George and King, p. 62). Recent estimates, however, place the cheese transmission elasticity at 0.58 or less (Kinnucan and Forker, p. 289).

Algebraic manipulation of (5b) yields two additional conditions that insure a positive price effect under variable proportions. One condition is $N \geq 1$. This condition in general is not satisfied because most empirical studies indicate food demands are price inelastic at retail (e.g, Huang). However, farm groups promote a large number of specialty products (e.g., citrus, raisins, prunes, wine, almonds, peaches, grapes, catfish -- see Forker and Ward, pp. 102-03 for a complete listing) whose retail demands may well be elastic.

For these commodities, theory predicts a positive relationship between advertising and farm price--whether or not input substitution occurs.

The second condition derived from algebraic manipulation of (5b) pertains to the situation where $T > 1$ and retail demand is inelastic. In this case, (5b) is positive provided that $T < (1 + E)/(1 - N)$. This condition implies, for example, that if $E = N = 0.5$, $d\ln P_f / d\ln A > 0$ so long as $T < 3.0$. With the exception of canned corn, George and King's estimates of T are all less than 3.0. Thus, even if $T > 1$ and retail demand is inelastic, it would take an unusually large transmission elasticity to cause the price effect of advertising in (5b) to turn negative.

Owing to the importance of the price-transmission elasticity in determining the direction and magnitude of advertising's price effect, it is of some interest to know what factors govern the behavior of this key parameter. Gardner (p. 403, equation (18)) derives the following theoretical expression for T that is valid in situations involving isolated shifts in retail demand, the relevant case for advertising:

$$(6) \qquad T = (\sigma + S_x e_m + S_m E) / (\sigma + e_m).$$

In this expression, σ is the elasticity of substitution between farm-based input and the bundle of marketing inputs; S_x and S_m are cost shares for the farm-based and marketing inputs, respectively; e_m is the supply elasticity of marketing inputs; and E is the previously defined supply elasticity for the agricultural input.

Equation (6) is a general expression for the transmission elas-

Table 1. Elasticity of Farm-Retail Price Transmission: Theoretical Values and Implied Restrictions for Isolated Shifts in Retail Demand

Theoretical Value	Restriction
$T = (\sigma + S_x e_m + S_m E) / (\sigma + e_m)$	CRTS marketing technology
$T = (S_x e_m + S_m E) / e_m$	Leontief marketing technology
$T = (1 + S_x e_m + S_m E) / (1 + e_m)$	Cobb-Douglas marketing technology
$T = 1$	$E = e_m$, constant percentage markup
$T < 1$	$E < e_m$
$T = S_x$	$e_m \rightarrow \infty$, constant absolute markup

ticity under conditions of competitive market-clearing and constant returns to scale (CRTS). The present analysis can be specialized by setting $\sigma = 0$ (Leontief technology) or $\sigma = 1$ (C-D technology) as noted in Table 1.

Two special cases of particular interest are $T = 1$ and $T = S_x$. The former obtains when $E = e_m$. This case is of interest because it suggests that retail-level demand elasticities can be used to measure farm-level returns (Piggott, Piggott, and Wright) only in the special case that the supply elasticities for the agricultural and marketing inputs are equal. This equality is a stringent condition. The second case, $T = S_x$, obtains when the supply curve of the marketing inputs is horizontal, a common assumption in vertical market theory (e.g., Wohlgenant, 1989, 1993; Holloway). Employing this assumption, for example, Wohlgenant (1993, p. 645, equation (5)) obtained the following reduced form (in my notation) in his analysis of advertising based on duality concepts:

$$\text{(5c)} \qquad d\ln P_f = [B/(E + S_x N + (1 - S_x)\,\sigma]\, d\ln A$$

Comparing equations (5a), (5b) and (5c), it is evident that the equations are consistent. In particular, equation (5c) reduces to (5b) if $\sigma = 1$ and to (5a) if $\sigma = 0$ and the supply schedule for marketing services is nonhorizontal. This illustrates a key advantage of the model developed in this study: it provides a flexible method of representing the range of input substitution relationships that appear to be relevant to the food system without imposing the assumption that the price of marketing inputs is exogenous.

Incorporating Demand Interrelationships

Demand interrelationships can be incorporated into the analysis with some rather straightforward matrix algebra. For this purpose, the structural model can be rewritten (deleting the Leontief market-clearing condition -- this drops out as a special case of C-D market-clearing) as:

$$\text{(7)} \qquad \mathbf{I}\ d\ln\mathbf{Q} = \mathbf{N}\ d\ln\mathbf{P} + \mathbf{B}\ d\ln\mathbf{A}$$

$$\text{(8)} \qquad \mathbf{I}\ d\ln\mathbf{P} = \mathbf{T}\ d\ln\mathbf{W}$$

$$\text{(9)} \qquad \mathbf{I}\ d\ln\mathbf{X} = \mathbf{E}\ d\ln\mathbf{W}$$

$$\text{(10)} \qquad \mathbf{I}\ d\ln\mathbf{Q} = \mathbf{I}\ d\ln\mathbf{X} + \mathbf{I}\ d\ln\mathbf{W} - \mathbf{I}\ d\ln\mathbf{P}$$

where **I** is an identity matrix; **N** is a square matrix of retail-level demand elasticities; **B** is a square matrix of advertising elasticities; **T** is a square matrix with price-transmission elasticities along the main diagonal and zeroes elsewhere; **E** is a square matrix with farm-level supply elasticities along the main diagonal and zeroes elsewhere; dln**Q** is a vector of retail quantity changes; dln**P** is a vector of retail price changes; dln**X** is a vector of farm-level quantity changes; dln**W** is a vector of farm-level price changes; and dln**A** is a vector of advertising changes. Letting *n* denote the number of commodities in the system, all matrices are *n* x *n* and all vectors are *n* x 1.

The reduced form equation for farm price is obtained by substituting equations (7) - (9) into (10) and collecting terms, which yields:

$$\mathbf{C}\ \mathrm{dln}\mathbf{W} = \mathbf{B}\ \mathrm{dln}\mathbf{A}$$

where

$$\mathbf{C} = (\mathbf{E} - \mathbf{T}\,\mathbf{N} + (\mathbf{I} - \mathbf{T})\ \sigma). \tag{11}$$

The σ term in (11) is a scaler to indicate whether marketing technology is Leontief or C-D. In particular, for C-D marketing technology, $\sigma = 1$; for Leontief technology $\sigma = 0$. In the latter case, the (**I** - **T**) term in **C** disappears, because it has to indicate Leontief technology (compare (5a) and (5b)). Premultiplying the above expression by $\mathbf{C}^{-1}$ gives the reduced form for farm price:

$$\mathrm{dln}\mathbf{W} = \mathbf{C}^{-1}\ \mathbf{B}\ \mathrm{dln}\mathbf{A} \tag{12}$$

Equation (12) can be made more intelligible by considering the case in which $n = 2$, and only the first good advertises. In this case, the own-price effect is:

Table 2. Parameter and Baseline (1990) Values for U.S. Beef, Pork, and Poultry Industries

Parameter/Variable	Definition	Value		
		Beef	Pork	Poultry
N_{1j}	Demand elasticity w.r.t. beef price[a]	-0.481	0.594	0.269
N_{2j}	Demand elasticity w.r.t. pork price[a]	0.330	-0.633	-0.082
N_{3j}	Demand elasticity w.r.t. poultry price[a]	0.113	-0.062	-0.136
B_i	Advertising elasticity w.r.t. beef advertising[a]	0.00287	0.0	-0.00360
E_i	Farm-level supply elasticity	0.15[b]	0.40[c]	0.31[d]
S_x^i	Farmers' share of retail dollar[e]	0.60	0.41	0.51
e_m	Elasticity of supply of marketing services[f]	.5, 2,∞	.5, 2,∞	.5, 2,∞
T_i	Elasticity of retail-farm price transmission[g]	?	?	?
A_1	Beef advertising expenditures (mil $)[h]	30.0	--	--
P_i	Retail price ($/lb)[I]	2.81	2.13	0.90
Q_i	Retail quantity (lbs/capita)[j]	67.0	51.1	83.4
$P_i\,Q_i$	Total consumer expenditures (bil. dol.)[k]	46.5	26.9	18.5

Sources:[a] Kinnucan, Xiao, Hsia; [b]Ospina and Shumway; [c]Lemieux and Wohlgenant; [d]Aradhyula and Hollywood; [e]Dunham, p. 5; [f]Assumed values; [g] To be computed from equations given in Table 1; [h] Leading National Advertiser, Inc.; [i]Duewer *et al.*, Table 3, 1990 figure; [j]Duewer *et al.*, Table 2, 1990-92 average; [k] Based on a U.S. 1990 population of 246.9 million.

$$(13)\qquad d\ln W_1 = \{(B_{11}(E_2+L_{22}) + B_{21}T_2N_{12})/ ((E_1 + L_{11})(E_2+L_{22}) - T_2N_{12}T_1N_{21})\}\, d\ln A_1$$

where i indexes the good, Q_i and P_i refer to retail quantities and prices; X_i and W_i refer to farm quantities and prices; and A_1 is advertising for good 1. The parameters E_1 and E_2 are farm-level supply elasticities; N_{12} and N_{21} are cross-price elasticities; B_{11} is the own-advertising elasticity; and B_{21} is the cross-advertising elasticity.

The L_{ii} term in (12) is:

$$L_{ii} = T_i N_{ii} - (1 - T_i)\,\sigma$$

where N_{ii} is the retail-level own-price elasticity for good i and σ equals the previously defined scaler.

Equation (13) highlights the complexity that demand interrelationships bring to the analysis. Even in a relatively simple case with two goods, it is difficult to tell how advertising affects farm price without some simplifying of assumptions. One plausible assumption is that cross-price and cross-advertising effects are small compared to their corresponding direct effects. In this case, and assuming that cross-advertising and cross-price effects are negative, the numerator and denominator of (13) tend to be positive, yielding the hypothesis that own-advertising increases own-price at the farm level.

The key point to note about (13), however, is the ease with which fixed and variable proportions can be analyzed in the model. In particular, to obtain the price effects under fixed and variable proportions, the analyst merely sets σ in (11) to zero and one, respectively. If empirical estimates of the transmission elasticities are unavailable, the appropriate expressions from Table 1 can be substituted for T_i. For example, if the supply schedule for marketing services is horizontal, the T_i in (8) are set to the $S_x^{\,i}$ pertaining to the ith commodity. If this assumption is not acceptable, the diagonal elements of T in (8) are replaced with the appropriate formula from Table 1 and sensitivity analysis is performed using alternative values for e_m. The appropriate formula for T_i when $\sigma = 1$, for example, is the formula in Table 1 corresponding to C-D technology.

Application

A key finding from the foregoing analysis is that ignoring the marketing channel in a Muth-type equilibrium displacement model implicitly assumes (i) the (industry) marketing technology is Leontief and (ii) the price-transmission elasticity is unity. Although empirical evidence suggests that assumption (i) might hold in some situations (e.g., poultry in the United States, see Wohlgenant, 1989, p. 250), assumption (ii) appears implausible because it implies input supply elasticities are identical. Because theory suggests the biases introduced by each assumption work in opposite directions, the question becomes: what are the practical consequences of ignoring the marketing channel?

To address this question, I simulated equations (7) - (12) using parameters and baseline data for the U.S. meat industry as indicated in Table 2. The demand and advertising elasticities were estimated from a Rotterdam model using quarterly data for the period 1976.II through 1991.III. The estimates were Hicksian elasticities, which approximated Marshallian elasticities, owing to the small bud-

Table 3. Producer Welfare Impacts of 10 percent ($3 million) Increase in Beef Advertising Under Alternative Assumptions about the Marketing Channel (T_i), Processing/Marketing Technology (σ_l), and the Supply of Marketing Services (e_m), United States, 1990

$T_i = 1.0$ Commodity	$\sigma_1 = \sigma_2 = \sigma_3 = 1$			$\sigma_1 = \sigma_2 = \sigma_3 = 0$			$\sigma_1 = \sigma_2 = 1;\ \sigma_3 = 0$			
	$e_m = .5$	$e_m = 2$	$e_m = \infty$	$e_m = .5$	$e_m = 2$	$e_m = \infty$	$e_m = .5$	$e_m = 2$	$e_m = \infty$	
	---------- Million Dollars ----------									
Simulation 1:										
Beef	7.5	7.8	8.4	8.2	10.7	13.1	13.8	7.5	6.8	5.9
Pork	1.6	1.4	1.0	0.7	1.7	2.1	2.2	1.4	1.0	0.7
Poultry	-7.2	-6.4	-4.7	-3.7	-7.6	-8.0	-8.2	-7.6	-8.3	-8.6
All	1.9	2.8	4.7	5.2	4.8	7.2	7.8	1.3	-0.5	-2.0
Simulation										
Beef	7.9	7.4	7.4	7.2	8.6	10.7	11.6	7.4	7.1	6.4
Pork	1.0	1.0	0.7	0.4	0.8	1.0	1.1	1.0	0.7	0.4
Poultry	-4.2	-4.4	-3.4	-2.8	-4.1	-4.4	-4.6	-4.1	-4.5	-4.7
All	4.7	4.0	4.7	4.9	5.3	7.3	8.1	4.3	3.3	2.1

Note: Simulation 2 uses twice the supply elasticities in Table 2.

get shares for meat items in the U.S. consumer budget. The estimates indicated that the demand for beef, pork, and poultry was price inelastic at retail, a finding consistent with the bulk of the empirical literature on U.S. meat demands. Because the simulations to be performed related to an isolated increase in beef advertising, the advertising elasticities listed in Table 2 pertain only to beef advertising. The elasticities were for generic advertising sponsored by the National Livestock and Meat Board. The own-advertising elasticity was 0.00287, the cross-advertising elasticity with respect to poultry was -0.00360. Apparently, beef advertising had no *direct* effect on pork demand, as the cross-elasticity with respect to pork was zero.

The farm level supply elasticities, which were taken from the published literature as indicated in the footnote to Table 2, were 0.15, 0.40, and 0.31 for beef, pork, and poultry, respectively. To gauge the sensitivity of results to supply response, simulations were performed for two scenarios: a "short-run" scenario based on these supply elasticities, and a "long-run" scenario that doubled the elasticities. The supply elasticities of marketing inputs were set alternatively to 0.5, 2.0, and infinity, as empirical estimates for these elasticities were unavailable. Wohlgenant assumed the supply elasticity for marketing inputs related to meats was infinite; Gardner in his simulations seemed to prefer a value of 2. The value of 0.5 was used to gauge the sensitivity of results to the full range of possible values of e_m, from inelastic to perfectly elastic.

The farmer's share of the retail dollar and baseline values for prices, quantities and industry revenues was obtained from various USDA publications as reported in the footnotes to Table 2. The baseline year was 1990 because the span falls within the time period of the estimated advertising responses. The transmission elasticities

Table 4. Marginal Benefit-Cost Ratios for Increased Beef Promotion Under Alternative Assumptions about Processing/Marketing Technology (σ) and the Farm-Retail Price Transmission Elasticity (T_i), U.S. Beef Industry, 1990

Length of Run	$T_i = 1$	$T_i = S_x^i$		
		$\sigma_1=\sigma_2=1;\sigma_3=0$	$\sigma_1=\sigma_2=\sigma_3=1$	$\sigma_1=\sigma_2=\sigma_3=0$
Short Run	2.5	2.0	2.7	6.9
Long Run	2.6	2.1	2.4	3.9

Note: $T_i = 1$ implies marketing technology is fixed proportions and demand elasticities at farm and retail are identical. $T_i = S_x^i$ implies that the marketing services supply schedule is horizontal.

were calculated using the foregoing parameter values for S_x^i, e_m, and E (note: $S_x^i = (1 - S_m^i)$ and the equations in Table 1 (row 2 for fixed proportions; row 3 for variable proportions).

To assess bias, I focused on the quasi-rents associated with a 10 percent increase in beef advertising. The quasi-rents generated by the advertising increment were measured using the following equation:

$$(14) \qquad \Delta PS_i = S_x^i P_i Q_i \, d\ln W_i \, (1.0 + 0.5 \, d\ln X_i)$$

where ΔPS_i equals the change in producer surplus in the beef sector associated with a 10 percent increase in beef advertising and S_x^i, P_i, and Q_i are as defined in Table 2. Equation (14) implicitly assumes that advertising generates parallel shifts in linear demand schedules, an assumption deemed innocuous if equilibrium displacements are small (Alston, Norton, and Pardey, 1995, pp. 48-50).

Simulation Results

The simulation exercise proceeded as follows. First, I simulated the model with $T_i = 1$ for all i. This simulation imposed the twin assumptions that marketing technology was Leontief and transmission elasticities were unity. I then simulated the model under three scenarios about marketing technology: (i) all industries were C-D; (ii) all industries were Leontief; and (iii) beef and pork were C-D, poultry was Leontief. (Poultry was assumed to be Leontief because Wohlgenant (1989, p. 250) found the substitution elasticity for poultry to be zero.) For each of these scenarios, I entertained the three hypotheses about the value of e_m as previously indicated. The foregoing simulations were then repeated, only this time doubling the size of the supply elasticities listed in Table 2.

Results confirmed the direction of the biases suggested by theory. That is, when technology was fixed proportions, the advertising effects were more pronounced than when technology was variable proportions (Table 3). If technology was Leontief and transmission elasticities were less than unity, imposing $T_i = 1$ will cause advertising effects to be downward biased (compare column 1 with columns 5-7 in Table 3). The biases were smallest when the supply elasticities for the farm-based and marketing inputs were similar (e.g., $E_2 = 0.40$ and e_m 0.50 for pork), as expected given that $T_i = 1$ if $E_i = e_m$. Biases tended to be reduced as the length of run was increased (compare top and bottom halves of Table 3).

The supply elasticity for marketing services had an important effect on the measured welfare impacts. The general pattern for the "pure technology" cases, i.e., $\sigma_i = 0$ or $\sigma_i = 1$ for i, was for the *direct* (internal to the beef industry) welfare impacts to decrease with increases in the supply elasticity of marketing inputs. The economic interpretation of this result was that the relative scarcity of the farm-based input increased as the supply elasticity for marketing inputs became larger. This caused the farm price of the advertised good to rise by more than the marketing inputs' price because advertising increased retail demand.

If technology was mixed ($\sigma_1 = \sigma_2 = 1$, $\sigma_3 = 0$) and marketing inputs' supply was inelastic, the welfare impacts of increased beef advertising were positive and were close to the measured impacts when $T_i = 1$. This latter result determined whether farm supply was relatively inelastic or relatively elastic. However, if marketing inputs were elastically supplied--the usual assumption--the collective welfare impacts of increased beef advertising were positive only in the "long-run." In the "short-run," owing to the magnified negative effects of beef advertising on poultry when poultry technology was Leontief, returns to the meat industry as a whole were negative. The $T_i = 1$ simulation, by contrast, showed collective impacts to be positive regardless of length of run.

The overall conclusion was that the $T = 1$ assumption is probably not a bad one if the "truth" lies between the Cobb-Douglas and "mixed" technology simulations presented in Table 3. If, however, industry technology was Leontief, the Piggott model was likely to produce severely downward biased estimates of returns to advertising.

Benefit-cost ratios are commonly reported in empirical advertising literature. For example, Ward and Lambert (p. 462) estimated the benefit-cost ratio for beef advertising in the United States to be 5.7:1. Benefit-cost ratios for this study were computed by dividing the numbers in Table 3 by $3 million, the incremental cost of increased beef advertising. Table 4 contained B-C ratios for beef assuming (i) $T_i = 1$ and (ii) $T_i = S_x^i$. The latter scenario implied that the supply schedule for marketing inputs was horizontal, a maintained hypothesis in Wohlgenant's (1993) analysis of beef and pork advertising. For each case, both the "short-run" and the "long-run" B-C ratios were computed, where the lengths of run were as previously defined.

The B-C ratios in Table 4 reinforced the earlier point that if marketing technology was variable proportions, the biases associated with assuming $T_i = 1$ may be sufficiently self-cancelling and leaving no cause for concern (the B-C ratios for $T_i = 1$ and $T_i = S_x^i$ were similar so long as $\sigma_i = 1$ for at least two commodities).

The second point to note was how the B-C ratios in Table 4 (2:1 - 7:1) encompassed Ward and Lambert's estimate of 5.7:1, despite very different methodologies used in the two studies. This increases confidence in the accuracy of the results presented in Tables 3 and 4 and in Ward and Lambert's analysis. That Ward and Lambert's B-C ratio fell on the high side of my estimates can be explained by the fact that the Ward and Lambert analysis assumed fixed supply and did not account for advertising spillover and feedback effects. With these restrictions relaxed, advertising effects are expected to be attenuated.

Concluding Comments

Muth-type equilibrium displacement models (EDMs) permit a more thorough analysis of commodity promotion programs than possible with econometric models used in isolation. However, when specifying EDMs, it is essential to take into account the important market interactions, vertical as well as horizontal. Otherwise, the results might be misleading.

Ignoring the marketing channel as Piggott did gives rise to two biases, one associated with marketing technology and another with marketing group behavior. Fortunately, the biases work in opposite directions, so the "bottom line" results (e.g., reduced form elasticities) may still be "within the ballpark." However, getting the assumptions right to begin with is a preferable approach. The reformulated model presented in this paper appears to hold promise because it relaxes the implicit assumptions of the Piggott model, yet captures the horizontal *and* vertical market interactions that are essential to accurate benefit-cost analyses of commodity promotion programs.

Appendix:

Derivation of Market-Clearing Conditions Under Variable Proportions (Cobb-Douglas Technology)

First, define initial equilibrium as:

$$Q_d = k X_s \quad \text{(A.1)}$$

where Q_d is the quantity demanded at retail; X_s is the quantity supplied at the farm level; and k is the number of units of retail product per unit of the farm product, i.e., $k = Q_s / X_d$, where Q_s is the quantity supplied at retail, and X_d is the quantity demanded at farm. k hereafter is referred to as the "dressing percentage."

Recognizing that in competitive equilibrium $Q_d = Q_s = Q$ and

$X_s = X_d = X$, the logarithmic total differential of (A.1) yields:

$$\text{(A.2)} \qquad d\ln Q = d\ln X + d\ln k$$

where $k = Q/X$ (average product). Equation (A.2) indicates that the relationship between changes in equilibrium quantities at two market levels depends on the behavior of the dressing percentage. Two special cases of interest in this paper are (i) the dressing percentage is a constant and (ii) the dressing percentage varies, but in a manner consistent with Cobb-Douglas processing/marketing technology. A constant dressing percentage implies that $d\ln(Q/X) = 0$, which is consistent with a Leontief processing/marketing technology (Chambers, p.16). In this case, (A.2) reduces to:

$$\text{(A.3)} \qquad d\ln Q = d\ln X \quad \text{(Leontief market-clearing)}$$

To derive the market-clearing condition under Cobb-Douglas marketing technology, consider the production function:

$$\text{(A.4)} \qquad Q = X^c M^{(1-c)}$$

where the as yet undefined variable M is a bundle of market inputs and $0 < c \leq 1$. The implications of (A.4) for the behavior of the dressing percentage is determined by solving the production elasticity c $(= (\partial Q/\partial X)/k)$ for k, which yields $k = (\partial Q/\partial X)/c$. Under the maintained hypothesis of competitive markets, inputs are paid the value of their marginal products. Thus, $k = (P_f/P_r)(1/c)$. The total derivative of this expression is:

$$dk = d(P_f/P_r)(1/c) + d(1/c)(P_f/P_r)$$

Setting d $(1/c) = 0$ (the production elasticity is constant), and dividing both sides of the above expression by k yields:

$$\text{(A.5)}\quad dk/k = [d(P_f/P_r)(1/c)] / [(P_f/P_r)(1/c)]$$

$$d\ln k = d\ln(P_f/P_r) = d\ln P_f - d\ln P_r$$

Substituting (A.5) into (A.2) yields:

$$\text{(A.6)}\quad d\ln Q = d\ln X + d\ln P_f - d\ln P_r \quad \text{(C-D market-clearing)}$$

QED

References

Alston, J. M., J. A. Chalfant, and N. E. Piggott. "Demand Response and Returns to Incremental Advertising in the Australian Meat Industry." *Economic Analysis of Meat Promotion.* H. W. Kinnucan, J. E. Lenz, and C. R. Clary (ed). Ithaca, New York: National Institute for Commodity Promotion Research and Evaluation, 1995.

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

Aradhyula, S. V., and M. T. Hollywood. "Risk Behavior and Rational Expectations in the US Broiler Market." *American Journal of Agricultural Economics* 71(1989):892-902.

Chambers, R. G. Applied Production Analysis: A Dual Approach. Cambridge: Cambridge University Press, 1994.

Dorfman, R., and P. O. Steiner. "Optimal Advertising and Optimal Quality." *American Economic Review* 44(1954):826-836.

Duewer, L. A., K. R. Krause, and K. E. Nelson. *U.S. Poultry and Red Meat Consumption, Prices, Spreads, and Margins.* USDA. ERS. Agri. Info. Bull. No. 684, October 1993.

Dunham, D. *Food Costs...From Farm to Retail in 1990.* USDA. ERS. Agr. Info. Bull. No. 619, March 1991.

Forker, O. D., and R. W. Ward. Commodity Advertising: The Economics and Measurement of Generic Programs. New York: Lexington Books, 1993.

Gardner, B. L. "The Farm-Retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics* 57(1975):399-409.

George, P. A., and G. A. King. *Consumer Demand for Food Products in the United States with Projections for 1980.* Giannini Foundation Monograph No. 26, University of California, 1971.

Hildreth, C., and F. G. Jarrett. *A Statistical Study of Livestock Production and Marketing*. Cowles Commission Monograph 15. New York: John Wiley and Sons, Inc., 1955.

Holloway, G. J. "The Farm-Retail Price Spread in an Imperfectly Competitive Food Industry." *American Journal of Agricultural Economics* 73(1991):979-989.

Huang, K. S. *U.S. Demand for Food: A Complete System of Price and Income Effects*. Washington, D.C.: U.S. Department of Agriculture Technical Bulletin, No. 1714, 1985.

Kinnucan, H. W., and O. D. Forker. "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products." *American Journal of Agricultural Economics* 69(1987):285-292.

Kinnucan, H. W., H. Xiao, and C.-J. Hsia. "Direct and Spillover Effects of Increased U.S. Beef Promotion." *Economic Analysis of Meat Promotion*. H. W. Kinnucan, J. E. Lenz, and C. R. Clary (ed). Ithaca, New York: National Institute for Commodity Promotion Research and Evaluation, Cornell University, 1995.

Leading National Advertisers, Inc. *AD$ SUMMARY*. New York: Various issues, 1975-91.

Lemieux, C.M., and M. K. Wohlgenant. "*Ex Ante* Evaluation of the Economic Impact of Agricultural Biotechnology: The Case of Porcine Somatotropin." *American Journal of Agricultural Economics* 71(1989):903-914.

Muth, R. E. "Derived Demand for a Productive Factor and the Industry Supply Curve." *Oxford Economic Papers* 16(1965):221-234.

Nerlove, M., and F. Waugh. "Advertising Without Supply Control: Some Implications of a Study of the Advertising of Oranges." *Journal of Farm Economics* 43(1961):813-837.

Ospina, E., and C. R. Shumway. *Disaggregated Econometric Analysis of U.S. Beef Supply*. Texas A&M University, Texas Agr. Exp. Stat. Tech. Monograph No. 9, 1979.

Piggott, R. R. "Returns to Incremental Advertising Expenditure in the Presence of Cross-Commodity Impacts and Inseparable Markets: An Equilibrium Displacement Modeling Approach." Paper presented at the NEC-63 conference *Evaluation of Mandated Commodity Promotion Programs*, Sacramento, California, October 5-6, 1995.

Piggott, R. R., N. E. Piggott, and V. E. Wright. "Approximating Farm-Level Returns to Incremental Advertising Expenditure: Methods and Application to the Australian Meat Industry." *American Journal of Agricultural Economics* 77(1995):497-511.

Ward, R. W., and C. Lambert. "Generic Promotion of Beef: Measuring the Impact of the U.S. Beef Checkoff." *Journal of Agricultural Economics* 44(1993):456-465.

Wohlgenant, M. K. "Demand for Farm Output in a Complete System of Demand Functions." *American Journal of Agricultural Economics* 71(1989):241-252.

Wohlgenant, M. K. "Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: The Case of U.S. Beef and Pork Industries." *American Journal of Agricultural Economics* 75(1993):642-651.

Wohlgenant, M. K., and J. D. Mullen. "Modeling the Farm-Retail Price Spread for Beef." *Western Journal of Agricultural Economics* 12(1987):120-125.