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Relationship between Partial and Total Responses to Advertising with Application to U.S. Meats

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- Facilitate the development of new theory and research methodology.

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Abstract

Buse's concept of total response is extended to advertising effects. Results suggest that partial advertising elasticities overstate advertising's ability to increase market demand. One implication is that advertising bans (e.g., for alcohol and tobacco) are apt to be less effective than indicated by partial advertising elasticities estimated from econometric models. Extending the concept of total response to price effects, the total advertising "flexibility" sets the lower bound on the optimal advertising-sales ratio and subsumes the Dorfman-Steiner and Nerlove-Waugh theorems as special cases. Applying the total flexibility concept to U.S. meats, results suggest the beef, pork and poultry industries are under-investing in advertising. However, in the case of beef this conclusion hinges on the assumption that retaliation by pork brand advertisers is minimal, which needs to be tested.

Key words: advertising bans, Dorfman-Steiner theorem, generic advertising, total elasticities

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In a classic paper, Buse introduced the concept of the “total demand response curve” and showed that in general it is less elastic than the Marshallian demand curve of neo-classical theory. He argued that the total concept is important because it gives theory greater predictive content. Specifically, Marshallian demand elasticities are of limited use for prediction purposes because they assume that the prices of all commodities except the one in question are constant, which in general is not true in a free-market situation. The total demand elasticity, by relaxing this aspect of the *ceteris paribus* assumption, moves demand theory closer to reality by providing a more accurate basis for prediction.

The purpose of this research is to extend to advertising Buse’s idea of total elasticity. Specifically, we determine whether the partial advertising elasticity of neo-classical theory (e.g., Basmann) is larger or smaller than the total advertising elasticity, which relaxes the assumption that all prices are fixed. This relationship is important because advertising elasticities are used to predict how advertising bans might achieve certain policy goals such as reduced consumption of alcohol or tobacco. Since advertising-ban studies base their predictions on partial advertising elasticities (see, e.g., reviews by Duffy and by Saffer), it would be useful to know whether such predictions overstate or understate the actual consumption impact when price effects are taken into account.

In an agricultural context, partial advertising elasticities are often used to gauge the extent to which generic advertising might enhance demand or revenue for the promoted commodity (see, e.g., Brester and Schroeder; Kinnucan *et al*. (1997, 2001); Le, Kaiser, and Tomek; Richards, Van Ispelen, and Kagan). Since generic advertising in general affects price as well as quantity, predictions based on partial advertising elasticities are apt to be misleading. As well, increased advertising by one commodity group (e.g., beef) might invite retaliation by another group (e.g., pork or poultry), which would tend to undercut the original group's advertising impact. Retaliatory responses are taken into account in the total response relationships derived in this study. Although the issues addressed here are not new (Alston, Freebairn and James; Kinnucan (1996); Piggott, Piggott, and Wright), no study to our knowledge provides a clear statement of the relationship between partial and total advertising responses. Knowledge of this relationship provides theoretical insight into actual market responses to advertising, but also has the practical advantage of simplifying partial equilibrium models designed to indicate generic advertising's net effect on farm price (see, e.g., Kinnucan and Myrland).

The analysis begins by considering the two-good case. The analysis is then generalized to *n* goods and applied to meat advertising (beef, pork, and poultry) to highlight principles. The main findings are summarized in the concluding section.

2-Good Case

To fix ideas, we begin with the simple case in which the important substitution effects are limited to two goods, say butter (q_1) and margarine (q_2). Each good is advertised and prices for the two goods are determined under competitive conditions.[1] The goods are substitutes in consumption, i.e., an advertising-induced increase in the price of one good increases the demand for the other good. On the supply side, production is sufficiently specialized that the two goods may be considered independent, i.e., changes in the price of one good have no effect on the supply of the other good. (This assumption, which is a departure from Buse's analysis, is made for analytical convenience: relaxing the assumption complicates the total elasticity expressions with no new economic insight.) With these assumptions, the model expressed in terms of percentage changes in the relevant variables is:

(1) $$q_1^* = \eta_{11}\, p_1^* + \eta_{12}\, p_2^* + \beta_{11}\, a_1^* + \beta_{12}\, a_2^*$$

(2) $$q_2^* = \eta_{21}\, p_1^* + \eta_{22}\, p_2^* + \beta_{21}\, a_1^* + \beta_{22}\, a_2^*$$

(3) $$q_1^* = \epsilon_1\, p_1^*$$

(4) $$q_2^* = \epsilon_2\, p_2^*$$

where the asterisks denote relative change (e.g., $q_1^* = dq_1/q_1$), p_i is price of good i, a_i is advertising expenditure on good i, η_{ij} are price elasticities of demand, β_{ij} are advertising elasticities, and ϵ_i are supply elasticities.

For the remainder of the analysis we will assume that demand is downward sloping (η_{ii} <

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[1] The assumption that prices are determined under competitive conditions is in line with how most commodity markets work. In situations where prices are determined under imperfectly competitive conditions, Baker and Bresnahan's duopoly model represents an excellent point of departure (see also Leeflang and Wittink).

0), supply is non-decreasing ($\epsilon_i \geq 0$), the two goods are substitutes ($\eta_{ij} > 0$, $i \neq j$), and advertising causes the demand curve for the advertised good to shift to the right ($\beta_{ii} > 0$) and the demand curve for the substitute good to shift to the left ($\beta_{ij} < 0$, $i \neq j$). In addition, we will assume that the own-price elasticities of demand are larger in absolute value than the cross-price elasticities, i.e., $|\eta_{11}| > \eta_{12}$ and $|\eta_{22}| > \eta_{21}$, a necessary condition for the multi-market equilibrium to be stable (Hicks, Ch. 5 and pp. 315-19).

Total Price Elasticity

In Buse's analysis the total price elasticities were obtained by treating the own-price as exogenous. Thus, for example, in the above system the total own-price elasticity for good 1 (η_{11}^T) is obtained by dropping (3), setting $a_1^* = a_2^* = 0$ (to isolate the price effect), and solving the remaining equations simultaneously for q_1^*/p_1^* to yield:

(5) $$\eta_{11}^T = \eta_{11} + \eta_{12}\,\zeta_{21}$$

where $\zeta_{21} = \eta_{21}/(\epsilon_2 - \eta_{22})$ is the "price response elasticity" that measures the percent change in the substitute's price per 1% change in own-price.[2] By the stability condition $|\eta_{11}| > \eta_{12}$ and 0 <

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[2]In the industrial organization and marketing literatures (e.g., Baker and Breshahan; Chintagunta, Rao, and Vilcassim; Cotterill and Putsis; Putis and Dhar) ζ_{21} is referred to as a "price *reaction* elasticity" to connote the fact that firms in imperfectly competitive markets have control over price. In the present analysis where strategic price responses are ruled out by the

$\zeta_{21} < 1$ (for normal-sloping supply and demand). Thus, the total price elasticity is negative and smaller in absolute value than the partial elasticity when goods are substitutes, i.e., $\eta_{11} < \eta_{11}^T < 0$, which means the partial elasticity overstates the effect of a price change.

The reason is that with upward-sloping supply for the substitute good, an increase in the price of the own good causes the demand and price of the substitute good to increase, which increases the demand for the own good through second-round or feedback effects. This induced increase in the demand for the own good counterbalances the initial effect of the price rise. Consequently, failure to take into account the feedback effect, which is measured by the compound term $\eta_{12}\,\zeta_{21}$ in (5), causes the own-price effect as measured by η_{11} to be exaggerated.

Total Advertising Elasticity

Equation (5) is instructive since intuitively one would expect a similar result for advertising. Specifically, since an increase in own advertising causes the demand and price of a substitute good to decrease (when its supply is upward sloping), this would tend to erode the demand for the advertised good through second-round or feedback effects. Thus, failure to take into account the feedback effect (as would be true if a partial elasticity was used to measure the effect) should result in the advertising effect being overstated.

To test this, and to provide an analogue to (5), we initially retain the assumption that p_1 is exogenous, set $a_2^* = 0$ (to isolate good 1's advertising effect), and solve (1), (2), and (4) for

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competitive market-clearing assumption, we use the term "price *response* elasticity" to highlight the passive nature of price adjustments when markets are perfectly competitive.

$q_1^*/a_1^*$to yield:

(6) $$\beta_{11}' = \beta_{11} + \zeta_{12}\,\beta_{21}$$

where β_{11}' is good 1's total advertising elasticity when its price is fixed, and $\zeta_{12} = \eta_{12}/(\epsilon_2 - \eta_{22})$ is the "quantity response elasticity" that measures the percent change in the quantity of the advertised good per 1% change in the quantity of the substitute good.[3] Since under the stated assumptions $\zeta_{12} > 0$ and $\beta_{21} < 0$, intuition is confirmed. That is, $\beta_{11} > \beta_{11}'$, which means that the partial elasticity overstates the advertising effect.

A basic difference between (5) and (6) is that under the stated assumptions (6)'s sign is uncertain. The reason is that ζ_{12} is not constrained to be less than one, nor is β_{11} necessarily larger than $|\beta_{21}|$. Thus, the feedback effect $\zeta_{12}\,\beta_{21}$, which is negative in sign, could dominate the direct effect β_{11}, resulting in a negative total elasticity.

To identify conditions necessary to assure a positive sign for (6), we first invoke Basmann's (p. 53) adding-up condition:

$$\sum_i^n R_i\,\beta_{ij} = 0 \qquad (j = 1, 2, ..., n)$$

where $R_i = p_i\,q_i/\sum_i^n p_i\,q_i$ is the ith good's budget share. Thus, if the cross effects of good 1's advertising are confined to good 2, then β_{11} and β_{21} are related as follows:

$$R_1\,\beta_{11} + R_2\,\beta_{21} = 0,$$

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[3]That $\zeta_{12} = \mathrm{dln}q_1/\mathrm{dln}q_2$ whereas $\zeta_{21} = \mathrm{dln}p_2/\mathrm{dln}p_1$ can be seen by replacing the structural elasticities in each expression with their mathematical counterparts (e.g., $\epsilon_i = (\partial q_i/\partial p_i)(p_i/q_i)$) and then manipulating the expressions algebraically.

which implies $\beta_{11} > |\beta_{21}|$ only if $R_1/R_2 < 1$. Imposing this restriction on (6) yields:

(6a) $$\beta_{11}'' = \beta_{11} [1 - (R_1/R_2) \zeta_{12}],$$

which implies $\beta_{11}'' > 0$ only if $\zeta_{12} < R_2/R_1$. That this restriction holds when income effects are small (or similar) can be shown by invoking the Hotelling-Jureen relation $\eta_{12} \approx (R_2/R_1) \eta_{21}$, which implies $\zeta_{12} \approx (R_2/R_1) \zeta_{21}$. Substituting the latter relation into (6a) yields:

(6b) $$\beta_{11}'' \approx \beta_{11} (1 - \zeta_{21}),$$

which, by virtue of the restriction on ζ_{21} noted earlier, implies a positive total elasticity. In general, however, β_{11}'''s sign is uncertain.

Intuitively, relaxing the assumption that the advertised good's price is exogenous should reduce the total elasticity further, because then price rationing in the own market becomes a factor. That is, with upward-sloping supply in the own-market, the demand shift will cause the own-good's price to rise, which would tend to reduce consumption relative to the case where the own-good's price is fixed. To check this, good 1's total advertising elasticity with endogenous price (β_{11}^T) is derived by first setting (1) = (3) and (2) = (4) to solve for the reduced-form elasticity p_1^*/a_1^*. Equation (3) is then re-used to obtain:

(8) $$\beta_{11}^T = (\beta_{11} + \zeta_{12} \beta_{21}) \psi_{11} = \beta_{11}' \psi_{11}$$

where $\psi_{11} = \epsilon_1 (\epsilon_2 - \eta_{22})/D$ is an elasticity that indicates the price-rationing effect, and $D = [(\epsilon_1 - \eta_{11}) (\epsilon_2 - \eta_{22}) - \eta_{12} \eta_{21}] > 0$. Since $0 \leq \psi_{11} \leq 1$ under the stated assumptions, $|\beta_{11}^T| \leq |\beta_{11}'|$ and intuition is confirmed. Thus, the simpler expression (6) and its variants place an upper limit on the total advertising elasticity. The extent to which β_{11}' overstates β_{11}^T depends critically on ϵ_1. For example, if $\epsilon_1 = 0$ (implying extreme price rationing), then $\beta_{11}^T = 0$ and β_{11}' would tend to be a poor indicator of the total effect. This highlights the dangers of ignoring the supply side of the market when predicting advertising's effect on consumption.

Price-Increase Equivalence Relation

A critical issue for alcohol and tobacco policy is whether a price increase (through an increase in the excise tax) may be more effective than an advertising restriction as a way to reduce consumption. One way to address this issue is to ask under what conditions price and advertising are equally efficient in the sense that a 1% increase in price would yield the same percentage decrease in consumption as a 1% decrease in advertising expenditure. To determine this, we set:

$$\eta_{11}^{T} = -\beta_{11}^{T},$$

and substitute (5) and (8) to yield:

(9) $$\psi_{11} = -(\eta_{11} + \eta_{12}\,\zeta_{21})/(\beta_{11} + \zeta_{12}\,\beta_{21}) = -\eta_{11}^{T}/\beta_{11}'.$$

The above relation, which we call the "Price-Increase Equivalence" (PIE) relation, indicates that for price and advertising to be equally efficient the advertising response in some sense must be at least as large as the price response (since $\psi_{11} \leq 1$).

To see this relationship more clearly, let $\beta_{11}' = \beta_{11}(1 - \zeta_{21})$, as would be true if cross-effects are confined to good 2 and income effects of the induced price changes are small or similar between the two products. In this case the PIE relation reduces to $-\eta_{11}^{T}/[\beta_{11}(1 - \zeta_{21})] \leq 1$, which, since $(1 - \zeta_{21}) < 1$, implies

(9a) $$-\eta_{11}^{T} < \beta_{11}.$$

Thus, for price policy to be more efficient than advertising policy, it is sufficient that the *total* price elasticity be at least as large as the *partial* advertising elasticity, i.e., $|\eta_{11}^T| \geq \beta_{11}$. Although this result is conditional on the indicated assumptions and thus must be treated with caution, it serves to illustrate that a simple comparison of the partial elasticities can be misleading. In particular, $|\eta_{11}| \geq \beta_{11}$ is no assurance that price policy is more efficient than advertising policy, since this comparison ignores feedback effects, which would tend to blunt the effect of the price increase.

Competitor Reaction

The analysis thus far assumes that a_2 is constant. In reality, firms and industries monitor competitors' advertising and use this information in setting advertising budgets and determining campaign strategy (see, e.g., Leeflang and Wittink). In the present model competitor reaction is analyzed by defining $\delta_{ji} = a_j^*/a_i^*$ (≥ 0) as the "Competitor Response Elasticity" (CRE) that gives the percent change in competitor's advertising per 1% change in own-advertising.[4] Setting a_2^* =

[4] For an explicit analytic expression for CRE in terms of model parameters see Alston, Freebairn and James (p. 893, equation (26)). An interesting aspect of this expression is that CRE's sign is uncertain. That is, an increase in own-advertising may elicit more or less advertising by a competing industry depending in part on the relative magnitude of spillover effects. In this study we assume that CRE is positive in sign, i.e., in Tirole's terminology (see also Seldon, Banerjee, and Boyd and Erickson) advertising messages are viewed by the competing industries as strategic complements.

$\delta_{21}\, a_1^*$ in (1) and (2), and for simplicity treating p_1 as fixed, the total advertising elasticity for good 1 that takes into account competitor response (neglecting income effects) is:

$$\beta_{11}'^{\circ} \approx [\beta_{11} - (R_2/R_1)\, \beta_{22}\, \delta_{21}]\, (1 - \zeta_{21}) \qquad (10)$$

Comparing (6b) and (10), competitor reaction tends to moderate the total elasticity, as expected. The attenuation increases as: (*i*) the competitor's relative market share increases (larger R_2/R_1), (*ii*) the competitor's advertising becomes more effective at shifting demand (larger β_{22}), and (*iii*) the retaliatory response increases (larger δ_{21}).

In fact, unlike (6b), (10)'s sign is uncertain, which means that retaliation can cause a positive total advertising elasticity to turn negative. This tendency is greatest in situations where the rival industry (e.g., beef) dominates the market, as then R_2/R_1 would be large, especially from the perspective of "fringe" competitors (e.g., lamb or fish). (Stated differently, small industries would tend to be damaged more by retaliation than large industries.) The upshot is that competitor responses combine with price effects to reduce advertising impact. Thus, studies that treat either prices or competitor advertising as exogenous are apt to overstate advertising impact, perhaps significantly so.

Total Advertising Flexibility

The emphasis thus far on quantity effects in some sense is misplaced in that it is the price effects of advertising that are important from a welfare standpoint. In particular, for producers in the aggregate to benefit from advertising, the market price must rise.[5] The net effect of good 1's

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[5]With parallel shifts in demand, the change in producer surplus (*PS*) may be measured

advertising on own-price (α_{11}^T), hereafter referred to as good 1's total advertising "flexibility" (to borrow Houck's terminology), is derived by solving (1) - (4) for the reduced-form elasticity p_1^*/a_1^* to yield:

$$\alpha_{11}^T = (\beta_{11} + \zeta_{12}\, \beta_{21})\, \varsigma_{11} = \beta_{11}'\, \varsigma_{11} \qquad (11)$$

where $\varsigma_{11} = (\epsilon_2 - \eta_{22})/D \geq 0$ is an elasticity that indicates the ability of good 1's advertising to raise own price. For example, if $\epsilon_1 = \infty$, then $\varsigma_{11} = \alpha_{11}^T = 0$ and the own-price effect is nil. Conversely, if $\epsilon_1 = 0$ and $\epsilon_2 = \infty$, then $\varsigma_{11} = 1/\text{-}\eta_{11}$ and $\zeta_{12} = 0$, in which case (11) reduces to $\alpha_{11}^T = \beta_{11}/\text{-}\eta_{11}$. This latter expression, as shown below, is identical to the Dorfman-Steiner theorem, and thus represents the largest own-price effect possible.

Comparing (8) and (11), $\varsigma_{11} = \psi_{11}/\epsilon_1$, which implies $\beta_{11}^T = \epsilon_1\, \alpha_{11}^T$. Thus, the total advertising elasticity is less than, equal to, or greater than the total advertising flexibility as own-supply respectively is inelastic, unitary elastic, or elastic. Since β_{11}^T's sign is uncertain, the same is true for α_{11}^T. Consequently, the welfare effects of advertising are *a priori* ambiguous (as noted by Kinnucan 1996).[6]

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using the formula $\Delta PS_i = p_i\, q_i\, p_i^* (1 + ½\, q_i^*)$ (e.g., Wohlgenant). Thus, if $p_i^* = 0$ the welfare gain to industry i is nil. A similar result follows for non-parallel shifts (Chung and Kaiser).

[6]The total flexibility can be easily extended to analyze situations where interest centers on revenue impacts rather than price or quantity impacts *per se* (e.g., Putsis and Dhar). Specifically, let $\upsilon_{11}^T = \alpha_{11}^T + \beta_{11}^T$ where υ_{11}^T is good 1's total revenue elasticity. Substituting (8) and (11) yields $\upsilon_{11}^T = \alpha_{11}^T\, (\epsilon_1 + 1)$, or, more generally, $\upsilon_{ii}^T = \alpha_{ii}^T\, (\epsilon_i + 1)$. Thus, advertising's

Optimal Advertising Intensity

The flexibility's relevance for optimal advertising policy can be seen by considering the special case where the substitute good's supply is perfectly elastic ($\epsilon_2 = \infty$). In this case (11) reduces to:

(11a) $$\alpha_{11}' = \beta_{11}/(\epsilon_1 - \eta_{11}) = \theta_1^{N\text{-}W}$$

where $\theta_1^{N\text{-}W}$ is Nerlove and Waugh's expression for optimal intensity (advertising expenditure divided by industry revenue in producer-surplus maximizing equilibrium) for a competitive industry that raises funds for promotion through a lump-sum tax and where opportunity cost and substitution effects are ignored. From (11a) optimal intensity increases as consumers become more responsive to the advertising, and as demand or supply becomes less price elastic.

If good 1's supply is fixed, as might be true in a short-run situation, (11a) reduces to:

(11b) $$\alpha_{11}'' = \beta_{11}/-\eta_{11} = \theta_1^{D\text{-}S}$$

where $\theta_1^{D\text{-}S}$ is Dorfman and Steiner's condition for optimal intensity for a monopoly (or industry cartel) with fixed output. Since substitution and supply response each lowers advertising's ability to raise price, it follows that $\theta_1^{D\text{-}S} = \alpha_{11}'' > \alpha_{11}' > \alpha_{11}^T$. Thus, the D-S theorem sets the upper limit on the total flexibility.

From the foregoing it may be inferred that optimal intensity and the total flexibility are related. In fact, if opportunity costs are zero, the flexibility sets the lower bound on optimal intensity. In particular, as shown in the appendix:

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ability to enhance industry revenue depends fundamentally on its ability to raise price, and on the resulting supply response.

(12) $$\theta_i^o = \alpha_{ii}^T/(\rho_i + \Omega_i)$$

where θ_i^o is the *i*th industry's optimal intensity, ρ_i is opportunity cost, and Ω_i is the portion of advertising costs borne by producers. In situations where advertising funds are raised via per-unit levies on industry output in a competitive market, a portion of the levy is shifted to consumers unless supply is fixed (Chang and Kinnucan), i.e., $0 < \Omega_i \leq 1$. Thus, $\theta_i^o \geq \alpha_{ii}^T$ when $\rho_i = 0$, as claimed.

Condition (12), which is a new result, generalizes Dorfman and Steiner's and Nerlove and Waugh's theorems in that it takes explicit account of supply response, tax shifting, and substitution effects. It is useful in that it provides a simple metric for determining whether advertising investments are too high or low. In particular, if

(13) $$\alpha_{ii}^T > \theta_i$$

where θ_i is observed intensity, then an expanded advertising budget would be welfare increasing from industry *i*'s perspective (neglecting opportunity cost). Conversely, if $\alpha_{ii}^T < \theta_i$ an expanded budget would be welfare decreasing, unless tax shifting was pronounced, i.e., Ω_i was sufficiently less than one.

Returning to (12), this condition is based on the implicit assumption that an *interior* solution is optimal (see appendix). In reality, the *boundary* solution (no advertising) may yield a higher profit (quasi-rent). This would be true, for example, if the revenue generated by the advertising falls short of variable costs. Whether the latter is true can be determined from the "shut-down" condition (Hadar, p. 128):

(14) $$p_i^o \geq AVC_i^o + a_i^o/q_i^o$$

where p_i^o is equilibrium price consistent with advertising expenditure a_i^o, AVC_i^o is average variable cost consistent with equilibrium quantity q_i^o, and a_i^o/q_i^o is the per-unit advertising costs. Inequalities (13) and (14) taken together constitute the necessary and sufficient conditions for it to be profitable for industry *i* to engage in advertising. In particular, whether $\alpha_{ii}^T > \theta_i$ implies under-investment rests on the assumption that (14) is satisfied.

Condition (14) explains why petition drives to eliminate commodity promotion programs tend to appear during periods of economic stress (low commodity prices or high input prices), as is currently the case for beef and pork (Vansickle). From (14) it may be inferred that the producers most likely to mount such drives would be those with high variable costs, typically the under-capitalized or smaller operations.[7]

n-Good Case

Although no new economic insights are gained from the *n*-good case, developing the model is useful since in most instances the advertised good will have more than one substitute. In addition, to add realism to the model, it would be useful to include the marketing channel. Accordingly, we express the relevant behavioral relationships in matrix notation as follows:

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[7]In May 1999 19,000 signatures calling for a referendum on the pork checkoff program were forwarded to the USDA. These signatures were obtained by a group called the Campaign for Family Farms (Vansickle), which may be presumed to represent primarily small- and medium-sized operations. Beef producers have also called for a referendum, with some 126,000 signatures turned into the USDA.

(15) $\boldsymbol{q}^* = \boldsymbol{\eta}\, \boldsymbol{p}^* + \boldsymbol{\beta}\, \boldsymbol{a}^*$,

(16) $\boldsymbol{p}^* = \boldsymbol{\varphi}\, \boldsymbol{w}^*$,

(17) $\boldsymbol{x}^* = \boldsymbol{\epsilon}\, \boldsymbol{w}^*$,

(18) $\boldsymbol{q}^* = \boldsymbol{x}^*$,

where $\boldsymbol{q}^*$ and $\boldsymbol{x}^*$ are n x 1 vectors representing relative changes in quantities at the retail and farm levels of the market, respectively (e.g., the first element of $\boldsymbol{q}^*$ is dq_1/q_1); $\boldsymbol{p}^*$ and $\boldsymbol{w}^*$ are n x1 vectors representing relative changes in prices at retail and farm; $\boldsymbol{a}^*$ is an n x 1 vector representing relative changes in advertising expenditure; $\boldsymbol{\eta}$ and $\boldsymbol{\beta}$ are n x n matrices of demand and advertising elasticities; $\boldsymbol{\epsilon}$ is an n x n matrix of supply elasticities; and $\boldsymbol{\varphi}$ is an n x n diagonal matrix of farm-retail price transmission elasticities.

In this formulation substitution effects are permitted at the farm level, i.e., $\boldsymbol{\epsilon}$ is not necessarily diagonal. However, by virtue of (18) we restrict the aggregate marketing technology to exhibit proportions. (For a discussion of the economic implications of this restriction, see Kinnucan (1997).)

The key relationships are the total (or reduced-form) elasticities for price and quantity at the farm level. The farm-price effects are obtained by substituting (15) - (17) into (18) and solving for $\boldsymbol{w}^*$ to yield:

(19) $\boldsymbol{w}^* = \boldsymbol{\Pi}\, \boldsymbol{a}^*$,

where $\boldsymbol{\Pi} = (\boldsymbol{\epsilon} - \boldsymbol{\eta}\, \boldsymbol{\varphi})^{-1} \boldsymbol{\beta}$ is an n x n matrix of reduced-form elasticities that indicate the net effect of isolated changes in advertising expenditure on farm prices. The total flexibilities corresponding to (11) appear as the diagonal elements of $\boldsymbol{\Pi}$. The farm-quantity effects are obtained by back-substitution of (19) into (17) to yield:

(20) $$\boldsymbol{x}^{*} = \boldsymbol{\epsilon}\,\boldsymbol{\Pi}\,\boldsymbol{a}^{*}.$$

The total advertising elasticities corresponding to (8) appear as the diagonal elements of $\boldsymbol{\epsilon}\,\boldsymbol{\Pi}$.

Application

To demonstrate the model's usefulness and to illustrate principles, (19) and (20) were applied to meat advertising in the United States using parameter values as detailed in table 1. The analysis assumes that substitution effects on the demand side are adequately represented by a four-good system consisting of beef, pork, poultry, and all other goods (n = 4). On the supply side producers are assumed to be sufficiently specialized so that cross-price elasticities of supply can be safely ignored ($\boldsymbol{\epsilon}$ is diagonal). At issue is whether meat advertising is welfare increasing from the producer perspective when cross-commodity substitution effects, supply response, and the marketing channel are taken into account.

Parameterization

The demand and advertising elasticities in table 1 are taken from Brester and Schroeder's study. An advantage of Brester and Schroeder's estimates over others in the literature (e.g., Kinnucan *et al.*) is that separate elasticity estimates are provided for generic and brand advertising, which permits an evaluation of each advertising approach. The elasticities are theoretically consistent in that the price elasticities satisfy the classical restrictions of homogeneity, symmetry, and adding-up; as well, the advertising elasticities satisfy Basmann's adding-up condition. Moreover, all cross-price elasticities are smaller in absolute value than own-price elasticities, as needed to satisfy the multi-market equilibrium condition. The price elasticities, which are

Hicksian, indicate that all four products are net substitutes.

The supply elasticities for beef, pork, and poultry are set respectively to 0.15, 0.40, and 0.90 to be consistent with estimates in the literature (table 1, note b). Since no estimates are available for other goods, ϵ_4 is set to 2, our "best guess" value. However, to determine the sensitivity of results to supply response, and to gauge the extent to which optimal intensity might be affected by length of run, we provide a "short-run" simulation that cuts the supply elasticities in half.

The farm-retail price transmission elasticities are set equal to the farmer's share of the consumer dollar. The justification for this procedure is that the transmission elasticity converges to the farmer's share when the aggregate marketing technology exhibits constant returns to scale and the supply curve for marketing inputs is perfectly elastic (Gardner; see also Kinnucan and Forker, p. 290, table 4, fn. b). Both assumptions are consistent with Wohlgenant's analysis, and the latter has been shown to be innocuous (Kinnucan 1997). The transmission elasticity for other goods is set to unity since the farm-level impact is not relevant.

Observed advertising intensities, which correspond to 1993, the last year of Brester and Schroeder's analysis, indicate that pork is the most intensively advertised meat (θ_2 = 0.68% for combined generic and brand advertising) and beef the least (θ_1 = 0.09%). By way of comparison, the median intensity for the 34 California commodities listed in Alston, Carman and Chalfant's study (p. 161) is 1.13%.

Results

All total elasticities are smaller than their corresponding partial elasticities, as expected (table 2).

The greatest difference occurs in the short run when supply is less elastic, in which case the total elasticities range from 17% (generic beef) to 87% (poultry) of their partial counterparts. Although the long-run elasticities show less difference, with the exception of poultry the differences remain non-trivial (e.g., 30% for generic beef and 57% for brand pork). This suggests that in most cases partial advertising elasticities do indeed provide a poor basis for prediction.

Owing to inelastic supplies, the total flexibilities are larger than the total elasticities. Still, the long-run total flexibilities are minute, less than 0.05. Thus, meat advertising has little scope for enhancing product value. For example, the short-run total flexibility for brand pork advertising is 0.067 and the total elasticity is 0.013, which means that a 10% increase in brand expenditure would raise pork value at the farm gate a mere 0.80% in the short run. (The long-run effect is 0.65%.) Thus, calls for increased pork advertising (Runningen) are not likely to have much effect in boosting depressed hog prices or farm revenue. This does not mean, however, that meat advertising is necessarily unprofitable. The reason is that advertising outlays are tiny in relation to product value (e.g., a_2 = \$69 million versus w_2x_2 = \$10.1 billion). Thus, it does not take much of a demand shift to recoup the investment.

In terms of optimizing behavior, with the maintained hypothesis that (14) is satisfied, it appears that the industries are under-investing in advertising, as the flexibility-intensity ratios are greater than one. The one exception is pork's generic campaign, which, owing to its negative (effectively zero) total flexibility, is ineffectual.[8] The Flexibility-Intensity Ratios (FIRs) decline

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[8]Brester and Schroeder reach a similar conclusion based on the statistical insignificance

as the time horizon lengthens, reflecting the inimical affects of supply response on advertising rents. Since the long-run FIRs are the most relevant for policy purposes, the remaining discussion will focus on these.

The FIR for brand beef advertising (206:1) is substantially larger than for generic advertising (14.5:1), which suggests that profits can be increased by diverting funds from generic to brand advertising. (Brand's large FIR is due primarily to its tiny intensity (θ_1^B = 0.007%), since brand's flexibility is only slightly larger than generic's ($\alpha_{11}^B = 0.014$ versus $\alpha_{11}^G = 0.012$).) Similarly, since pork's generic advertising is ineffectual and its brand advertising has a favorable FIR (8.2:1), it appears that the pork industry would be better off adopting a brand approach.

Overall it appears that to maximize quasi-rent beef producers would need to invest about 2.6% of farm value in advertising and pork and poultry producers about 5%. These estimates, which are based on the long-run total flexibilities in table 2, need to be qualified. First, they implicitly assume that the underlying structural elasticities are invariant to advertising. In

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of the own-advertising effect. However, as emphasized by Piggott, Piggott, and Wright, statistical significance of the own-advertising effect (or lack thereof) can be misleading with respect to economic impact. For example, generic pork advertising has a positive effect on beef demand and a negative effect on poultry demand, the latter being highly statistically significant; the former marginally so (Brester and Schroeder, p. 977). Thus, depending on the relative magnitudes of the feedback effects from these demand shifts into the pork market, it is possible for the advertising to have a positive effect on pork price even though it has no *direct* effect on pork demand.

reality, advertising elasticities in particular are expected to decline as advertising increases due to diminishing returns (Simon and Arndt) and satiation effects (Kinnucan, Chang, and Venkateswaran), which would tend to reduce the optimal intensities. Second, the total flexibilities in table 2 implicitly assume that competitors' advertising remains constant, which is unlikely to be the case.

Competitor Response

To gauge the importance of competitor response, we endogenize competitors' advertising by replacing the $\boldsymbol{a}^*$ in (15) with $\boldsymbol{\delta}_\mathbf{i}\, a_i^*$ where $\boldsymbol{\delta}_\mathbf{i}$ is a 4 x 5 matrix of competitor-response elasticities (CRE) under five scenarios. In analyzing these scenarios we restrict attention to brand advertising of pork and poultry and to generic advertising of beef, since generic advertising of pork is ineffectual, no generic advertising occurs for poultry, and brand expenditures for beef are modest and thus unlikely to provoke a response.

The five scenarios analyzed are: (*i*) no competitor response; (*ii*) an isolated 0.5% increase in competitor *A*'s adverting; (*iii*) an isolated 0.5% increase in competitor *B*'s advertising; (*iv*) a combined 0.5% increase in both competitors' advertising; and (*v*) a combined 1% increase in both competitors' advertising. For beef, scenarios (*i*) - (*v*) are analyzed by setting columns 1 - 5 of $\boldsymbol{\delta}_\mathbf{1}$ equal to respectively (1, 0, 0, 0), (1, 0.5, 0, 0), (1, 0, 0.5,0), (1, 0.5, 0.5, 0) and (1, 1, 1, 0); for pork the column vectors of $\boldsymbol{\delta}_\mathbf{2}$ are (0, 1, 0, 0), (0.5, 1, 0, 0), (0, 1, 0.5, 0), (0.5, 1, 0.5, 0) and (1, 1, 1, 0); and for poultry the column vectors of $\boldsymbol{\delta}_\mathbf{3}$ are (0, 0, 1, 0), (0.5, 0, 1, 0), (0, 0.5, 1, 0), (0.5, 0.5, 1, 0) and (1, 1, 1, 0). Scenarios (*ii*) - (*iv*) indicate "halfway" responses to increases in own-advertising; scenario (*v*) indicates a full, or "in-kind," retaliatory response. These scenarios are not meant to be exhaustive, but rather to provide insight into the potential importance of competitor reaction (real or perceived) to advertising budgeting decisions. For brevity, only the long-run total flexibilities are presented, since the total elasticities are derivative, and shortening the time horizon merely intensifies the measured price impacts without altering signs. Cross flexibilities are provided along with the direct flexibilities to permit evaluation of spillover effects.[9]

Results affirm that competitor responses have important effects on advertising's ability to raise producer welfare (table 3). For example, a 0.5% increase in either beef or pork advertising reduces poultry's total flexibility from 0.050 to 0.045; if beef and pork respond simultaneously with a 1% increase in advertising, poultry's flexibility is reduced further to 0.031. However, competitor response is not always detrimental. In particular, poultry advertising has a "halo" effect with respect to the meat group, which means that increases in poultry advertising tend to enlarge the total flexibilities for beef and pork. Thus, the inference from the two-good case that competitor response reduces the total flexibility tends to break down when substitution possibilities are enlarged. The basic reason is that when the analysis is extended beyond two goods, the adding-up condition permits some cross-advertising elasticities to be positive, as

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[9]Technically, the model does not take explicit account of tax shifting so the spillover effects will tend to be overstated in the case of negative spillovers and understated in the case of positive spillovers (since, for example, the beef levy raises the price of pork and vice versa). However, Kinnucan and Miao's analysis suggests that levy cross effects are modest, so the bias should be minimal.

Brester and Schroeder's estimates reveal. Depending on the relative magnitudes of the positive cross-advertising elasticities, it is possible for competitor responses to be reinforcing rather than antagonistic.

Overall, the negative cross effects of beef and pork advertising tend to be outweighed by the positive cross effect of poultry advertising. As a consequence, if poultry joins pork or beef in retaliation, the net effect tends to be positive (for equal increases in advertising expenditure). Conversely, if poultry fails to respond, retaliation by either pork or beef tends to be welfare decreasing. Although the negative spillovers from pork and beef advertising are about equal in size, owing to beef's relatively small "no response" total flexibility (0.012), the beef industry tends to be more adversely affected by pork advertising than vice versa. In particular, whereas an isolated 0.5% increase in beef advertising reduces pork's total flexibility from 0.047 to 0.040, an isolated 0.5% increase in pork advertising reduces beef's total flexibility to -0.0009.[10] That a retaliatory response from pork can render beef advertising unprofitable at the margin highlights the potential importance of this issue for advertising benefit-cost analysis. Clearly, as the cross flexibilities in table 3 indicate, advertising has distributional consequences, which may affect the desirability of advertising as a policy instrument.

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[10] With the maintained hypothesis that advertising messages are strategic substitutes, i.e., the CREs are negative in sign, Alston, Freebairn, and James come to similar conclusions. That is, in the non-cooperative case where the meat industries optimize individually, beef industry ad expenditures are too low. An opposite result obtains in the cooperative case where meat industries choose advertising levels to maximize joint producer surplus.

Concluding Comments

The basic theme of this research is that Buse's concept of total response can be usefully extended to the analysis of advertising effects. Specifically, we show that just as the total price response tends to be less elastic than the partial price response, so too does the total advertising response tend to be less elastic than the partial advertising response. One implication is that consumption impacts based on partial advertising elasticities will tend to be exaggerated. Since empirical estimates of partial advertising elasticities are minute to begin with (typically less than 0.08, see Ferrero *et al*.), this implies that advertising in general is a blunt instrument for achieving changes in consumption, be it decreases in tobacco or alcohol or increases in fruits and vegetables or fish.

As for the economic impacts of advertising, the total advertising flexibility concept developed in this paper serves two useful purposes. First, it provides a simple metric for determining whether advertising is welfare increasing or decreasing at the margin from the producer perspective. Second, it provides a framework for unifying previous results with respect to optimal intensity. Specifically, we show that the total advertising flexibility sets the lower limit on the optimal advertising-sales ratio (when opportunity cost is zero), and subsumes the Dorfman-Steiner/Nerlove-Waugh theorems as special cases. Applying the total flexibility concept to U.S. meats, it appears that the beef, pork and poultry industries are sub-optimizing with respect to their investments in advertising. However, from the beef industry's perspective this conclusion hinges on the assumption that the retaliatory response from pork brand advertisers is minimal, which needs to be tested.

Table 1. Parameter Values for Beef, Pork, Poultry, and All Other Goods, United States

Item	Definition	Value[a]			
		Beef	Pork	Poultry	Other
η_{1j}	Demand elasticities w.r.t. beef	-0.56	0.10	0.05	0.41
η_{2j}	Demand elasticities w.r.t. pork	0.23	-0.69	0.04	0.43
η_{3j}	Demand elasticities w.r.t. poultry	0.21	0.07	-0.33	0.05
η_{4j}	Demand elasticities w.r.t.other goods	0.009	0.004	0.0002	-0.01
β_{i1}^{B}	Brand adv. elasticities for beef	0.006	0.006	0.001	-0.0002
β_{i1}^{G}	Generic adv. elasticities for beef	0.006	-0.009	-0.011	0.00002
β_{i2}^{B}	Brand adv. elasticities for pork	-0.013	0.033	-0.008	-0.00001
β_{i2}^{G}	Generic adv elasticities for pork	0.002	-.0005	-0.010	0.00001
β_{i3}^{B}	Brand adv. elasticities for poultry	0.017	0.004	0.047	-0.0006
ϵ_i	Supply elasticity[b]	0.15	0.40	0.90	2.0
φ_i	Farm-retail price transmission elast.[c]	0.53	0.34	0.43	1.0
$w_i x_i$	Farm value (billion dollars) [d]	30.0	10.1	6.3	--
θ_i^{B}	Brand advertising intensity (%) [d]	0.007	0.57	0.48	--
θ_i^{G}	Generic advertising intensity (%) [d]	0.083	0.11	0	--

[a] Unless indicated otherwise, values are taken from Brester and Schroeder. Note: cross-advertising elasticities in

each row refer to spillover (not spill-in) effects (e.g., β_{31}^{B} = 0.001 is beef advertising's effect on poultry demand, not poultry advertising's effect on beef demand).

[b] Values for beef and pork are the same used by Wohlgenant; value for poultry is taken from Tomek and Robinson (p. 61); value for other goods is a guesstimate.

[c] Estimates for beef, pork, and poultry are based on farmer's cost share computed from Elitzak for 1990-95; estimate for "other goods" is set to one since farm-level elasticity is not defined.

[d] Farm value and intensity (advertising expenditure divided by farm value multiplied by 100) refer to 1993, the last year in Brester and Schroeder's analysis. Farm revenue data were taken from USDC.

Table 2. Farm-Level Total Advertising Elasticities and Flexibilities for U.S. Meats with Comparisons to Partial Elasticities and Observed Advertising Intensities

Item[a]	Beef		Pork		Poultry
	Brand	Generic	Brand	Generic	
Short-run:					
Total Elasticity (β_{ii}^T)	0.0014	0.0010	0.0134	-0.0001	0.0407
Total Flexibility (α_{ii}^T)	0.0181	0.0136	0.0668	-0.0005	0.0905
Total/Partial Elast. Ratio (β_{ii}^T/β_{ii})	0.23	0.17	0.41	0.21	0.87
Flex./Intensity Ratio (α_{ii}^T/θ_i)	258.9	16.4	11.7	-0.5	18.8
Long-run:					
Total Elasticity (β_{ii}^T)	0.0022	0.0018	0.0187	-0.0001	0.0449
Total Flexibility (α_{ii}^T)	0.0144	0.0121	0.0467	-0.0003	0.0499
Total/Partial Elast. Ratio (β_{ii}^T/β_{ii})	0.36	0.30	0.57	0.20	0.96
Flex./Intensity Ratio (α_{ii}^T/θ_i)	206.3	14.5	8.2	-0.2	10.4

[a] Short-run results are based on supply elasticities set to one half the values given in table 1; long-run results are

based on the reported supply elasticities.

Table 3. Total Advertising Flexibilities for U.S. Meats with Competitor Response

Commodity/Scenario[a]	Direct Effect	Spillover Effects			
		Beef	Pork	Poultry	Other
Beef:					
(*i*) No response	0.0121	--	-0.0121	-0.0095	0.000030
(*ii*) Pork responds	-0.0009	--	0.0113	-0.0142	0.000012
(*iii*) Poultry responds	0.0328	--	-0.0044	0.0154	-0.000064
(*iv*) Both respond	0.0198	--	0.0190	0.0107	-0.000082

(*v*) Both respond in kind	0.0275	--	0.0501	0.0309	-0.000193
<u>Pork</u>:					
(*i*) No response	0.0467	-0.0260	--	-0.0094	-0.000036
(*ii*) Beef responds	0.0407	-0.0200	--	-0.0142	-0.000021
(*iii*) Poultry responds	0.0545	-0.0053	--	0.0155	-0.000129
(*iv*) Both respond	0.0484	0.0007	--	0.0108	-0.000114
(*v*) Both respond in kind	0.0501	0.0275	--	0.0309	-0.000193
<u>Poultry</u>:					
(*i*) No response	0.0499	0.0415	0.0155	--	-0.000188

(*ii*) Beef responds	0.0451	0.0475	0.0094	--	-0.000173
(*iii*) Pork responds	0.0452	0.0284	0.0389	--	-0.000205
(*iv*) Both respond	0.0404	0.0345	0.0328	--	-0.000190
(*v*) Both respond in kind	0.0309	0.0275	0.0501	--	-0.000193

[a] Scenarios (*ii*) - (*iv*) refer to a 0.5% increase in competitor advertising per 1% increase in own-advertising; scenario (*v*) refers to a 1% increase in competitors' advertising.

Appendix: Relationship between Total Flexibility and Optimal Intensity

The relationship between total advertising flexibility and optimal advertising intensity may be derived from the *i*th industry's "profit" function:

(A.1) $$\pi_i = p_i^o q_i^o - \int_0^q S(t)\,dt - a_i$$

where π_i is *net* producer surplus, i.e., quasi-rent after subtracting advertising cost, p_i^o and q_i^o are price and quantity in competitive equilibrium, and $S(q_i) = p_i$ is the inverse supply function. Letting ρ_i denote opportunity cost (e.g., marginal return from research (Wohlgenant)), (A.1) yields the first-order condition:

$$p_i^o\, dq_i^o/da_i + q_i^o\, dp_i^o/da_i - S(q_i^o)\, dq_i/da_i - 1 = \rho_i,$$

which, since $p_i^o = S(q_i^o)$, simplifies to:

(A.2) $$q_i^o\, dp_i^o/da_i = \rho_i + 1.$$

Multiplying and dividing the left-hand side of (A.2) by a_i/p_i^o yields:

$$\theta_i^{-1}\, p_i^*/a_i^* = \rho_i + 1,$$

where p_i^*/a_i^* is the reduced-form elasticity of own price with respect to own advertising, herein denoted α_{ii}^T. Replacing p_i^*/a_i^* with α_{ii}^T and solving the above relation for θ_i yields:

(A.3) $$\theta_i^{o'} = \alpha_{ii}^T/(\rho_i + 1).$$

where $\theta_i^{o'}$ is optimal intensity in the absence of tax shifting.

To account for tax shifting, (A.3) may be rewritten as follows (Kinnucan 1999):

(A.4) $$\theta_i^o = \alpha_{ii}^T/(\rho_i + \Omega_i)$$

where $\Omega_i = -\eta_{ii}/(\epsilon_i - \eta_{ii})$ is producer incidence of the advertising levy. If $\epsilon_i = 0$ then $\Omega_i = 1$ and

(A.4) reduces to (A.3). In general $\epsilon_i > 0$, which means $\Omega_i < 1$ and (A.3) understates the incentive to promote. (A.4) corrects for this deficiency.

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