Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: The Case of the U.S. Beef and Pork Industries

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A producer-financed program that leads to either an increase in retail demand from promotion or a decrease in marketing costs from research will generate returns to producers that are generally smaller than returns generated through an equivalent change in producer supply from research. The distribution of gains depends on the degree of substitutibility between farm and nonfarm inputs. Comparative statics of equal absolute changes in demand, supply, and marketing costs in the U.S. beef and pork industries show the significance of input substitutibility for distribution of gains, and sensitivity of the results to beef and pork demand interrelationships.

Key words: competitive marketing system, input substitution, marketing costs, marketing margins, promotion benefits, research benefits.

There is a growing literature on distribution of research benefits among factors of production in multi-stage production systems (Freebairn, Davis, and Edwards; Alston and Scobie; Mullen, Wohlgenant, and Farris; Mullen, Alston, and Wohlgenant; Holloway). While this multi-stage approach is equally applicable to estimating the distribution of gains from generic commodity promotion, little attention has been given to evaluating returns from promotion. The purpose of the present paper is to extend the literature to include distribution of gains from promotion.

The present paper is similar to the work of Lemieux and Wohlgenant and Voon and Edwards, who measure benefits from a research-induced improvement in quality that increases demand for the consumer product. However, the present study is concerned with benefits derived from promotion, which shift the consumer demand curve, compared to benefits derived from research, which shift input supply curves. While research activities may enhance demand through quality improvement, for the present purpose such effects are included with promotion so that attention can focus on the distributional effects of demand shifts versus supply shifts.

Significant policy implications may be drawn by comparing the distribution of gains from research and promotion. Many commodity groups have check-off programs which provide funds for allocation between promotion and research. Indeed, for some commodities (e.g., dairy, beef, pork) the lion’s share of the check-off funds goes for promotion. An understanding of the trade-off between returns from promotion versus research is, therefore, essential to decisions regarding allocation of check-off funds between these activities.

The main finding of this analysis is that producers should not be indifferent between spending funds on promotion and spending funds on research. A producer-financed program that leads to an upward shift in retail demand will generate returns to producers that are generally smaller than returns generated through shifting the producer supply curve downward by the same amount. Moreover, because returns to producers from equal reductions in processing and dis-
tribution costs are generally smaller than returns from an equal reduction in production costs, producers would generally prefer activities that reduce production costs by an equal amount compared to marketing cost reductions and promotional activities. Results hinge crucially on the degree of substitutability between the farm and non-farm inputs in producing the retail product (Alston and Scobie). The model is applied to the U.S. beef and pork industries to show the significance of input substitutability on the distribution of gains from promotion compared to research. Extensions of the basic model to beef and pork market interrelationships, and sensitivity of the results to different parameter values, are also discussed.

Basic Model

Initially, the model of Freebairn, Davis, and Edwards (1982) is extended to include promotion. Then, the assumption of fixed input proportions is relaxed to derive the basic proposition that producers should not be indifferent between spending funds on promotion and research.

Figure 1 shows the impact of promotion and research on prices, quantities, and economic surpluses on a single commodity in a multistage production system under the assumptions of fixed input proportions and a perfectly elastic supply curve of marketing inputs. With these assumptions, derived demand at the farm level \( D_f \) is derived as retail demand \( D_r \) less the constant absolute margin \( M \) at each quantity value. The market is initially in equilibrium at point \( A \) where the farm supply curve \( S_f \) intersects the derived demand curve \( D_f \). Quantity produced at the farm and sold to consumers is \( Q \). Price at the farm level is \( P_f \) and price to consumers is \( P_r \). The difference between \( P_r \) and \( P_f \) is \( M \), the margin representing marketing costs.

Suppose an industry has funds (from a levy on producers) which can be spent on promotion, research on farm production methods, or research on marketing methods (storage, transport, processing, and distribution services). Also, assume equal efficiency on a dollar expended on promotion versus research.\(^1\) That is, suppose that a dollar spent on promotion causes retail demand to increase by the same amount \( IH \) as the reduction in costs attributable to production research \( AE \) or reduction in costs attributable to marketing research \( AG \). How are the gains from these allocation schemes distributed between producers and consumers?

Promotion causes retail demand to increase from \( D_r \) to \( D_r' \) and farm level demand to increase from \( D_f \) to \( D_f' \), since the distance \( AG \) equals the distance \( IH \). Farm price increases from \( P_f \) to \( P_f' \), the retail price increases from \( P_r \) to \( P_r'' \), and quantity produced and consumed increases from \( Q \) to \( Q' \). Producers gain the area \( P_f'CAP_r \) and, assuming a parallel shift upward in retail demand, consumers gain the area \( JIKP'' \). For a research-induced reduction in production costs where the farm supply curve shifts down parallel from \( S_f \) to \( S_f' \), farm price falls to \( P_f' \), retail price falls to \( P_r'' \), and quantity rises to \( Q' \). Returns to producers increase by the area \( P_r'BED \) and consumers' surplus increases by the area \( P_r'HLP' \).

Finally, with a research-induced reduction in marketing costs where the absolute margin declines from \( M \) to \( M' \), derived demand increases from \( D_f \) to \( D_f' \) and we have the same effect on prices, quantity, and economic surplus changes as promotion. Because the farm supply curve shifts down by the same distance \( AE \) as the derived demand curve shifts upward \( AG \), the changes in producers' and consumers' surplus in all three cases are the same. Thus, in this special case of fixed input proportions and parallel shifts in demand and supply, producers would be indifferent as to how funds are expended on promotion and research programs that are equally efficient.\(^2\)

It is straightforward to generalize the results to the case of variable factor proportions. Indeed, the basic relationships have already been derived by Freebairn, Davis, and Edwards (1983). However, it is useful to derive these relationships again to focus on the intuition underlying the basic results. Also, in order to simplify the exposition, duality theory is used to derive the basic comparative static results. This will also be helpful later when the results are extended to multi-market interrelationships.

Diewert (1971, 1981) has shown that output supply and input demand behavior of a com-

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\(^1\) This of course does not mean the various research and promotional activities lead to identical shifts in supply and demand. The annualized benefit from any project, and hence the magnitude of the shift in the supply or demand curve, in the steady state depends on the present discounted value of the investment.

\(^2\) As pointed out by Lindner and Jarrett, gains to producers (and to consumers) are sensitive to the type of supply (and by extension, demand) shift. If the shifts are not parallel then the distribution of gains would not necessarily be affected in the same way. Rose offers persuasive arguments for modeling welfare impacts with parallel shifts.
petitive industry can be characterized by the unit cost function and corresponding input demand functions showing the cost-minimizing input levels needed to produce a given output level (i.e., output-constant input demand functions). Assume the supply curve of marketing inputs to the industry in question is perfectly elastic. Then the change in equilibrium prices and quantities from shifts in retail demand, production costs, or marketing costs can be characterized as

\[ Q^* = \eta(P_r^* - \delta) \]
\[ P_r^* = S_f P_f^* - \gamma \]
\[ Q_f^* = -(1 - S_f) a P_f^* - a \gamma + Q_r^* \]
\[ P_f^* = (1/e)Q_f^* - k \]
where asterisks denote approximate relative changes (i.e., \(X^* = dX/X\)). \(S_f\) is the cost share of the farm input, \(Q_i\) is the retail product, \(P_f\) is retail price, \(Q_j\) is the quantity of the farm product, \(P_j\) is the farm price, \(\eta\) is the own-price elasticity of retail demand, \(\delta\) is the relative increase in retail demand from promotion, \(\gamma\) is the research-induced relative change in marketing costs, \(k\) is the research-induced relative change in farm production costs, \(\alpha\) is the elasticity of substitution between the farm product and bundle of marketing inputs, and \(\varepsilon\) is the elasticity of supply of the farm input. Equation (1) is the specification for change in retail demand, equation (2) is the inverse retail supply function (assuming constant returns to scale), equation (3) is the output-constant industry demand for the farm input (also assuming constant returns to scale), and equation (4) is the inverse farm supply function.

The solutions for \(P_f^*, Q_f^*,\) and \(P_j^*,\) and \(Q_j^*\) are

\[
(5) \quad P_f^* = \frac{ek - (\sigma + \eta)(\gamma - \delta)}{(\varepsilon - \lambda)} \\
(6) \quad Q_f^* = \left[ 1 - S_f \right] (\gamma - \eta\delta)/(\varepsilon - \lambda), \\
(7) \quad P_j^* = \frac{-ek - (\varepsilon - 1)(\sigma + \eta)}{(\sigma + \eta)} \gamma - \eta\delta)/(\varepsilon - \lambda), \\
(8) \quad Q_j^* = \frac{-ek - [\varepsilon - 1 - (1 - S_f)] (\sigma + \eta)}{\gamma - (1 + \varepsilon - 1) (\sigma - S_f) \eta\delta)/(\varepsilon - \lambda)}
\]

where

\[
(9) \quad \lambda = -(1 - S_f) \sigma + S_f \eta
\]

is the Hicks-Allen industry derived demand elasticity. Changes in producers’ and consumers’ surplus, assuming parallel shifts in retail demand and farm-level supply, are

\[
(10) \quad \Delta S = P_f Q_f (P_f^* + k)(1 + 0.5 Q_f^*) \\
(11) \quad \Delta C = -P_f Q_f (P_j^* - \delta)(1 + 0.5 Q_j^*).
\]

Finally, if there is equal efficiency in funds spent on promotion and research at each level, then

\[
k \cdot P_f = \gamma \cdot P_r = \delta \cdot P_r
\]

or, when the farm product is initially measured in the same units as the retail product,

\[
(12) \quad k = \gamma / S_f = \delta / S_f.
\]

Equations (5)–(11) can be used to estimate the impacts of shifts in the various demand and supply curves on prices, quantities, and economic welfare. Although not analyzed here, the same set of equations can estimate the impacts due to shifts in the marketing sector production function from technical change. We could also extend the model to include additional stages of marketing as in Holloway, but this model is not analyzed here because it offers few new insights.

The basic proposition that, for equal efficiency in allocation of funds, producers prefer production research to both processing research and promotion can be derived by substituting equations (5) and (6) into equation (10), and imposing condition (12). More simply, because the formula for change in producers’ surplus, equation (10), can be expressed solely as a function of \(P_f^* + k\), it suffices to examine the determinants of this expression. Using equation (5), this expression can be written as

\[
(13) \quad P_f^* + k = \frac{- \lambda k - (\sigma + \eta) \lambda - \eta\delta}{(\varepsilon - \lambda)}.
\]

By (13), it can be observed that when fixed proportions prevail (i.e., \(\sigma = 0\)),

\[
(P_f^* + k)|_{\sigma=0} = \frac{-S_f \eta k - \eta\gamma - \eta\delta}{(\varepsilon - \lambda)}.
\]

Thus, upon imposing the restriction from (12) that \(\gamma = \delta = S_f k\), we obtain the result that producers are indifferent to where funds are spent when there is fixed proportions. However, empirical evidence is compelling that \(\sigma > 0\) (see Wohlgenant) so that producers should not be indifferent to where funds are spent. When \(\sigma > 0\), \(-\lambda > -S_f\eta\) and \(-(\sigma + \eta) < -\eta\), so producers would prefer research-induced reductions in production costs to promotion, and

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1. The impact of farm-input saving technology on producers’ net returns is equivalent to the effect of a decrease in the cost of marketing inputs. The impact of marketing-input saving technology on producers’ net returns is equivalent to the combination of the effect of a decrease in the cost of farm production costs and a decrease in retail demand. The impact of a neutral change is the sum of farm-input saving and marketing-input saving changes.

2. Holloway shows that the Muth-type model used here is consistent with a model in which distribution and processing stages are disaggregated provided that the elasticities of substitution between inputs in distribution and between inputs in processing are equal. Given the assumption of constant returns to scale, this is equivalent to assuming weak separability with respect to the inputs in distribution (an intermediate product and composite marketing inputs) and the inputs in processing (the raw product and composite marketing inputs in processing).
promotion to research-induced reductions in marketing costs.  

The intuition of the result that a research-induced reduction in production costs is preferred to promotion can be understood by focusing on the determinants of retail-to-farm price transmission of a shift in retail demand from promotion. The effect of a given increase in retail price (from an increase in retail demand) on farm price can be determined by solving equations (11)–(13) for \( P_f^* \) holding the quantity of the farm output constant (i.e., setting \( Q_f^* = 0 \)). This comparative static result is simply equation (5) with \( \epsilon = k = \gamma = 0 \).

\[
P_f^* = \eta \delta / \lambda.
\]

Thus, for a 1% increase in retail price (\( \delta = 1 \)), farm price would increase by \( \eta / \lambda \% \). Note again that under fixed proportions this price transmission in percentage terms would equal \( 1/S_f \) because then \( \lambda = S_f \eta \). A farm price increase of \( 1/S_f \% \) for a 1% increase in retail price is equivalent to saying a 1 cent increase in retail price would lead to exactly a 1 cent increase in farm price. However, when there are variable input proportions (i.e., \( \sigma > 0 \)), \( \eta / \lambda < 1/S_f \), so a 1 cent increase in retail price would lead to less than a 1 cent increase in farm price. Therefore, the intuition of the result that producers generally prefer a reduction in production costs to an equivalent increase in retail demand price from promotion is that the full effect of an increase in retail demand will generally not be passed along to producers. In addition to the crucial role played by \( \sigma \), this result has obvious intuitive appeal on the basis of commonly observed margin behavior showing a narrowing farm to retail price spread as retail price falls. (See, e.g., Buse and Brandow, George and King, Tomek and Robinson, Wohlgenant and Haidacher.)

Application to the U.S. Beef and Pork Industries

The model is applied to the U.S. beef and pork industries to see how distribution of gains is affected by funds allocated between research and promotion. Both industries have producer check-off programs which are used for market development and research activities. The assessment rates are $1.00 per head for beef and 25 cents per $100 valuation of pork (Glaser). Substantial funds are available for disbursement on promotion and research activities. For example, in 1990 the Beef Board spent $33.5 million on promotion and $2.6 million on research (Feedstuffs, January 21, 1991).

Table 1 lists the parameters and data necessary to apply equations (5)–(12) to the beef and pork industries. All results are for an equivalent 10% decrease in production costs. Total consumer expenditures, \( P, Q_a \), are calculated as total farm revenue divided by the respective farmer’s cost share, table 1.

### Table 1. Parameter Values for the U.S. Beef and Pork Industries

<table>
<thead>
<tr>
<th>Parameter or variable</th>
<th>Beef</th>
<th>Pork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own-price elasticity of demand (( \eta ))</td>
<td>-0.78*</td>
<td>-0.65*</td>
</tr>
<tr>
<td>Elasticity of substitution (( \sigma ))</td>
<td>0.72*</td>
<td>0.35*</td>
</tr>
<tr>
<td>Elasticity of farm supply (( \epsilon ))</td>
<td>0.15*</td>
<td>0.40*</td>
</tr>
<tr>
<td>Farmer’s cost share (( S_f ))</td>
<td>0.57*</td>
<td>0.45*</td>
</tr>
<tr>
<td>Decrease in production costs (( k ))</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>Decrease in marketing costs (( \gamma ))</td>
<td>0.057*</td>
<td>0.045*</td>
</tr>
<tr>
<td>Increase in retail demand price (( \delta ))</td>
<td>0.057*</td>
<td>0.045*</td>
</tr>
<tr>
<td>Total farm revenue (( P_f Q_f ))</td>
<td>$35 bil.</td>
<td>$10 bil.</td>
</tr>
</tbody>
</table>

\* Taken from table 4 in Wohlgenant and Haidacher (p. 30).
\* Taken from Ospina and Shumway.
\* Taken from Lemieux and Wohlgenant.
\* Average values computed from USDA for the years 1982–1988.
\* Proportional decrease in marketing costs equivalent in absolute change to a 10% decrease in production costs.
\* Proportional increase in retail demand price equivalent in absolute change to a 10% decrease in production costs.
Table 2. Distribution of Gains from Research and Promotion in the U.S. Beef and Pork Industries, Billion Dollars

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Reduction in production costs</th>
<th>Reduction in marketing costs</th>
<th>Increase in consumer demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Producer (ΔP)</td>
<td>Consumer (ΔC)</td>
<td>Producer (ΔP)</td>
</tr>
<tr>
<td>Beef</td>
<td>2.92</td>
<td>0.60</td>
<td>0.13</td>
</tr>
<tr>
<td>Pork</td>
<td>0.56</td>
<td>0.45</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note: Results are for the same absolute change in production costs, marketing costs, and retail demand price, resulting from a 10% decrease in farm production costs. Parameter values and data used in calculations are presented in Table 1.

Results in table 2 provide overwhelmingly evidence that producers should prefer a research-induced decrease in production costs to an equivalent promotion-induced increase in retail price and to a decrease in marketing costs. Indeed, for these specific market parameters, producers would appear to gain little from research focused solely on reducing marketing costs. Moreover, both beef and pork producers appear to gain about 70% higher returns from a reduction in production costs compared to an equivalent increase in consumer demand from promotion. Total surplus changes (ΔCS + ΔP) are approximately the same across each cost/demand shift. Thus, producer’s share of the total benefits can be viewed as another measure of farmer gains. For beef, the farmer’s share of the benefits is 83.0% for reduced production costs, 3.6% for reduced marketing costs, and 48.9% for increased retail demand. With pork, the farmer’s share is 55.4% for reduced production costs, 14.5% for reduced marketing costs, and 33% for increased retail demand. 6

6 These results ignore the influence of trade. The U.S. beef and pork industries are both net importers. In 1987, for example, net imports were about 7% and 7.5% of total beef and pork production, respectively. The simplest way to model the impact of trade is to assume that the quantity of (net) imports is fixed within the current time period (equivalently, supply is perfectly inelastic). Then the system of equations to solve consists of equations (1)–(3) and the two relationships,

\[ Q_f^* = (Q_d/Q_i) Q_f + (Q_d/Q_i) Q_f + (aX_i/as_j)(s_j/x_i) \]
\[ P_f^* = (1/\alpha) Q_f - k \]

where \(Q_d\) is the quantity of commodity produced domestically and \(Q_f\) is the quantity of net imports of the commodity. The first of these two equations is simply the total log differential of the identity \(Q_f = Q_d + Q_f\); the second of these two equations is the inverse supply relationship for the farm input. The solution to this expanded set of equations is:

\[ P_f^* + k = [\ln\alpha + (\sigma + \eta) + \eta\delta]/(\epsilon k - \lambda) \]

where \(k = Q_d/Q_i\). The only difference between this formula and that found in equation (13) is the denominator. Therefore, the effect of trade is not to alter the rankings of research and promotion, but to only intensify the impacts.

Distribution of Gains with Demand Interrelationships

Results for beef and pork reported in table 2 are derived assuming the two markets are independent. Of course, we know that is not the case because beef and pork are substitutes in consumption. This suggests that we extend the model to allow for feedback effects through market interrelationships in demand.

Although dealing with cross-price effects is conceptually straightforward, the question of how to model demand interrelationships with promotion is more challenging. The conceptual model underlying this specification is utility maximization of a representative consumer, whose utility function has the form

\[ u = u(x, s) \]

where \(x\) is an \(n\)-vector of commodities consumed and \(s\) is an \(n\)-vector of utility function shift parameters. The impact of these shift parameters on utility maximization and demand behavior can be derived using standard comparative static analysis methods. The result has the form (Philips, p. 189)

\[ \partial x_i/\partial s_j = -(1/\lambda)^j k_{ik} (\partial^2 u/\partial x_k \partial s_j) \]

where \(\lambda\) is the marginal utility of income and \(k_{ik}\) is the partial derivative of the Hicksian demand for the \(i\)th good with respect to price of the \(k\)th good. The second term in parentheses shows the impact on marginal utility of good \(i\) with respect to a change in \(s_j\). If we assume that \(\partial^2 u/\partial x_k \partial s_j = 0\) for \(k \neq j\), the above expression simplifies to (Brown and Lee)

\[ \partial x_i/\partial s_j = -(1/\lambda) k_{ij} (\partial^2 u/\partial x_k \partial s_j) \]

In elasticity form this expression can be written as

\[ (\partial x_i/\partial s_j)(s_j/x_i) = -\eta_i(\partial\ln MU_i/\partial\ln s_j) \]
where \( \eta_i \) is the Hicksian price elasticity of good \( i \) with respect to good \( j \) and \( MU_j = \partial u / \partial x_j \) denotes the marginal utility of good \( j \). This specification implies that if we let \( \delta_j = (\partial \ln MU_j / \partial \ln s_j) d \ln s_j \), then shifts in retail demand from promotion can be modeled as proportional to the own-and cross-price elasticities of demand, assuming that the Hicksian elasticities are close approximations to the Marshallian elasticities, which is the case for beef and pork. The latter is equivalent to specifying that \( \delta_j \) measures the increase in willingness to pay by consumers for quantity \( x_j \), holding quantities of other goods constant.

Using the above specification for demand increase due to promotion, the extended model with demand interrelationships between beef and pork can be written as

\[
\begin{align*}
Q^*_1 &= \eta_{11}(P^*_1 - \delta_1) + \eta_{12}(P^*_2 - \delta_2) \\
Q^*_2 &= \eta_{21}(P^*_1 - \delta_1) + \eta_{22}(P^*_2 - \delta_2) \\
P^*_1 &= S_{11}W^*_1 - \gamma_1 \\
P^*_2 &= S_{12}W^*_2 - \gamma_2 \\
X^*_1 &= -(1 - S_{11}) \sigma_1 P^*_1 - \sigma_1 \gamma_1 + Q^*_1 \\
X^*_2 &= -(1 - S_{12}) \sigma_2 P^*_2 - \sigma_2 \gamma_2 + Q^*_2 \\
W^*_1 &= (1/\epsilon_1) X^*_1 - k_1 \\
W^*_2 &= (1/\epsilon_2) X^*_2 - k_2
\end{align*}
\]

where as before asterisks denote relative changes in the variables, \( Q_1 \) and \( Q_2 \) now represent quantities of the two retail products (say beef and pork), \( P_1 \) and \( P_2 \) are the two retail prices, \( X_1 \) and \( X_2 \) are quantities of the two farm products (say cattle and hogs), \( W_1 \) and \( W_2 \) are the two farm product prices, \( \eta_{ij} \) is the elasticity of demand for the \( i \)th retail product with respect to price of the \( j \)th product, \( \delta_j \) is the relative change in demand price of the \( j \)th retail commodity, \( \gamma_j \) is the relative decrease in marketing costs for the \( j \)th product, \( \sigma_j \) is the elasticity of substitution between the farm product and marketing inputs in producing the \( j \)th product, \( S_{ij} \) is the farmer’s cost share of the \( j \)th retail product, \( \epsilon_j \) is the elasticity of supply of the \( j \)th farm product, and \( k_j \) is the relative decrease in production cost for the \( j \)th farm product.

As indicated previously, the determinants of producers’ net gains can be analyzed by examining how the net price change to producers is affected by cost reductions versus increases in retail demand. That is, it suffices to look at \( W^*_1 + k_1 \) as a function of \( k_1, k_2, \gamma_1, \gamma_2, \delta_1, \) and \( \delta_2 \). This comparative static result, derived from equations (14)-(21), has the form

\[
W^*_1 + k_1 = -[(\epsilon_2 - \lambda_2) (\sigma_1 + \eta_{11}) + \eta_{12}S_{12} \eta_{21}] \gamma_1 -[(\epsilon_2 - \lambda_2) \eta_{12} + \eta_{12}S_{12} \eta_{22}] \gamma_2
- [(\epsilon_2 - \lambda_2) \eta_{11} + \eta_{12}S_{12} \eta_{21}] \delta_1
- [(\epsilon_2 - \lambda_2) \eta_{12} + \eta_{12}S_{12} \eta_{22}] \delta_2
- \lambda [\epsilon_2 - \lambda_2 + (\eta_{12}S_{12})(\eta_{21}S_{11})] k_1
- \eta_{12}S_{12} \epsilon_2 \lambda k_2]/[(\epsilon_1 - \lambda_1) \epsilon_2 - \lambda_2]
- (\eta_{12}S_{12})(\eta_{21}S_{11})]
\]

where \( \lambda_i = -(1 - S_{ij}) \sigma_i + S_{ij} \eta_{ii} \) is the Hicks-Allen own-price elasticity of derived demand for the \( i \)th farm product.

Analytically, it is not hard to see that research-induced decreases in production costs are even more strongly preferred by producers, even when there are simultaneous changes in both markets. This is shown below numerically in the context of the beef and pork examples analyzed in the previous section.

Table 3 presents the impact on producer’s

<table>
<thead>
<tr>
<th>Source of change</th>
<th>Reduction in production costs</th>
<th>Reduction in marketing costs</th>
<th>Increase in consumer demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single market</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>2.92</td>
<td>0.12</td>
<td>1.72</td>
</tr>
<tr>
<td>Pork</td>
<td>0.56</td>
<td>0.15</td>
<td>0.33</td>
</tr>
<tr>
<td>Simultaneous changes in both markets:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>2.85</td>
<td>-0.03</td>
<td>1.58</td>
</tr>
<tr>
<td>Pork</td>
<td>0.54</td>
<td>0.06</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Note: Parameter values and data used in the estimations are in table 1 plus values for the cross-elasticities of demand equal to \( \eta_{12} = 0.10 \) and \( \eta_{21} = 0.14 \).
surplus from research and promotion when feedback effects from demand interrelationships are taken into account. In addition to the parameter values in table 1, we need values for $\eta_{12}$ and $\eta_{21}$, the cross-price elasticities between beef and pork and between pork and beef, respectively. Consistent with the values of the other demand parameters, they are taken from Wohlgenant and Haidacher and are set equal to $\eta_{12} = 0.10$ and $\eta_{21} = 0.14$. Only gains to producers are presented, as formulas to compute welfare gains to consumers are analytically intractable for simultaneous market changes (Alston). The results are for both isolated changes in costs and demand, and for simultaneous changes in costs and demand in both markets. For simultaneous changes, each column refers to the case where costs or demand are changed by an amount equivalent to a 10% decrease in production costs for both beef and pork. For example, the first column in table 3 under simultaneous changes in both markets shows the effect reducing both production costs of beef and pork by 10% (holding all marketing costs and demand shifters constant) has on producers’ net returns.

Overall, results in table 3 reinforce the previous findings—innovations that reduce production costs are preferred by producers to innovations that reduce marketing costs or to increases in retail demand price by the same amount. Perhaps somewhat surprisingly, the results for a single market source of change are the same numerically as for the case when demand interrelationships are ignored (table 2). Also, net returns overall decline when there are simultaneous changes in both markets. However, the opportunity costs of promotion and marketing research are even greater in the simultaneous change case.

Table 4 shows the sensitivity of the results to alternative demand and supply elasticities. Case 1 repeats the baseline results from the bottom half of table 3; case 2 is for an alternative set of retail demand elasticities from Huang; case 3 contains results for farm input supply elasticities which are doubled; case 4 reports results when each elasticity of substitution is halved; and case 5 presents results when there are fixed proportions between the farm and marketing inputs in producing each retail commodity. Although the exact magnitude of the effects change in each case, the results in terms of relative magnitudes generally indicate greatest sensitivity to changes in the elasticities of substitution. Based on these simulations, we expect net returns to producers to decline as retail demand becomes more inelastic, farm supply becomes more elastic, and as input substitutability increases.

**Conclusions**

The main theme of this paper is that producers should not be indifferent to the allocation of funds between research and promotion. Moreover, theoretical results and empirical applications to U.S. beef and pork indicate producers benefit more from research-induced decreases in production costs and promotion than from research-induced increases.

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Reduction in production costs</th>
<th>Reduction in marketing costs</th>
<th>Increase in consumer demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1 (baseline)</td>
<td>2.86</td>
<td>-0.03</td>
<td>1.60</td>
</tr>
<tr>
<td>Beef</td>
<td>0.54</td>
<td></td>
<td>0.28</td>
</tr>
<tr>
<td>Pork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 2 ($\eta_{11} = -0.62$, $\eta_{12} = 0.11$, $\eta_{21} = 0.19$, $\eta_{22} = -0.73$)</td>
<td>2.77</td>
<td>-0.45</td>
<td>1.37</td>
</tr>
<tr>
<td>Beef</td>
<td>0.55</td>
<td>0.06</td>
<td>0.29</td>
</tr>
<tr>
<td>Pork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 3 ($\epsilon_1 = 0.3$, $\epsilon_2 = 0.8$)</td>
<td>2.43</td>
<td>-0.3</td>
<td>1.36</td>
</tr>
<tr>
<td>Beef</td>
<td>0.36</td>
<td>0.04</td>
<td>0.19</td>
</tr>
<tr>
<td>Pork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 4 ($\sigma_1 = 0.36$, $\sigma_2 = 0.175$)</td>
<td>2.70</td>
<td>0.93</td>
<td>1.96</td>
</tr>
<tr>
<td>Beef</td>
<td>0.47</td>
<td>0.20</td>
<td>0.33</td>
</tr>
<tr>
<td>Pork</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case 5 ($\sigma_1 = 0$, $\sigma_2 = 0$)</td>
<td>2.47</td>
<td>2.47</td>
<td>2.47</td>
</tr>
<tr>
<td>Beef</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
</tr>
<tr>
<td>Pork</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Simulations are all for simultaneous changes in beef and pork markets with demand interrelationships. See table 2 for additional information on parameter specification.
induced decreases in marketing costs. The ranking is insensitive to whether demand interrelationships are accounted for, and whether research and/or promotion occur simultaneously in both markets.

One reason more resources are not allocated to research is that legislation, enabling spending of producer check-off funds, is limited to promotion and certain research activities. For example, the Beef Promotion and Research Act of 1986 limits research to “studies relative to the effectiveness of market development and promotion efforts, studies relating to the nutritional value of beef and beef products, other related food science research, and new product development.” (Federal Register, p. 26139). Legislation limits research to activities beyond the farmgate. Because the marginal effectiveness of research benefits at the farm level appears to be considerably larger than for research activities beyond the farmgate, Congress might consider expanding the scope of activities to directly include funding of farm-level research activities.

Finally, it needs to be stressed that results presented in this paper are for equal shifts in demand and supply. Because of lags between research and adoption of new technology, research at the farm level may not shift supply by as much as the marginal effect of the same amount of funds spent on promotion. Thus, a topic for further research is to extend the present analysis to estimate returns to investment in research and returns to investment in promotion. For research, this could be done along the lines suggested by Scobie, Mullen, and Alston, in which a production function approach is used to estimate productivity growth, and hence magnitudes of the supply shifts. One also needs estimates of the marginal effectiveness of advertising on consumer demand; but such results will have to wait until enough data has been accumulated to accurately measure the marginal effectiveness of generic advertising on beef and pork demand. Nonetheless, the present paper makes clear that consumer demand must increase by more than a decrease in farm-level production costs in order for producers to prefer promotion over on-farm research.

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References


