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Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: Further Results

by

Chanjin Chung
and
Harry M. Kaiser

Department of Agricultural, Resource, and Managerial Economics
College of Agriculture and Life Sciences
Cornell University, Ithaca, New York 14853

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- Enhance both public and private policy maker's understanding of the economics of commodity promotion programs.
- Facilitate the development of new theory and research methodology.

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Abstract

In this study, we examine the distributional effects of research versus consumer promotion. A few years ago, a notable article by Wohlgenant (*AJAE* 75, 1993) investigated this issue and concluded that producers would benefit more from research on farm-level production than from research on marketing services and promotion. His findings have drawn important policy implications for the allocation of checkoff funds, especially for those producer groups (e.g., dairy, beef, and pork) who spend a large share of their funds on consumer promotion. We challenge his conclusions. We contend that his findings are confined to a special case, the parallel shift in demand and supply. To verify our claim, we reexamined his findings with an alternative case, a pivotal shift, and found that consumer promotions benefitted producers more than research activities. Our new findings indicate that the relative profitability of research versus promotion is highly sensitive to the assumption of the nature of shifts in demand and supply.

Chanjin Chung and Harry M. Kaiser are research associate and professor, respectively, in the Department of Agricultural, Resource, and Managerial Economics, Cornell University. Support for this research was provided by the New York State Milk Promotion Board.

Distribution of Gains from Research and Promotion in Multi-Stage Production Systems: Further Results

Agricultural producers in the United States raise approximately $750 million annually in checkoff program designed to increase demand and lower costs (Forker and Ward). This money is used to fund consumer promotion, research, education programs, and other activities. There has been a lot of research conducted on the impacts of the checkoff program, but most of it has focused on either promotion or research, individually. A notable exception to this is recent research by Wohlgenant, who investigated the distribution effects of research versus promotion. He concluded that when the elasticity of substitution between farm and nonfarm inputs is greater than zero and there is equal effectiveness of each checkoff activity (i.e., shifting retail demand and farm supply curves by the same amount vertically), research on farm production generates greater returns to producers than research on marketing service or consumer promotion. Wohlgenant's conclusion is intuitive because given a nonzero substitution elasticity, there should be some loss in transmission of shifts in retail demand (from promotion) back to the farm level.

Wohlgenant's findings have drawn important policy implications for the allocation of checkoff funds. This is of special significance to some producer groups (e.g., dairy, beef, and pork) who spend a large share of the checkoff funds on consumer promotion.[1] Wohlgenant argued, "one reason more resources are not allocated to research is that legislation, enabling spending of producer checkoff 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" (p. 650). Based on his findings, Wholgenant suggested Congress should consider expanding the scope of activities to directly include funding of farm-level research activities.

In this study, we provide some further results on the allocation of checkoff funds between research and promotion. Wohlgenant estimated producer gains from checkoff activities under the assumption of parallel shifts in demand and supply curves. We reexamine his findings with the assumption of pivotal shifts. While the parallel shift in demand function implies that consumer promotion results in a constant increase in sales at each level of price, the pivotal shift in demand function implies that the promotion effects are greater at low prices than at high prices. Similarly, the pivotal shift in supply function implies that research generates greater cost reduction for marginal firms than for inframarginal firms. Several studies in the literature of marketing and agricultural economics have already either discussed or provided evidence of pivotal shifts in demand (e.g., Kuehn; and Prasad and Ring) and supply (e.g., Lindner and Jarrett; Voon and Edwards; and Alston, Sexton, and Zhang) functions caused by consumer promotion and research activities, respectively. Therefore, it is essential to reinvestigate Wohlgenant's findings under the assumption of pivotal shift before making any policy prescriptions.

In contrast to Wohlgenant, we find that consumer promotion benefits producers more than research activities. Our results indicate that the ranking of producer gains from research and promotion activities depends not only on the degree of substitutability between farm and nonfarm inputs, but also on the type of shifts in demand and supply curves. The results, therefore, suggest that erroneous *a priori* generalization about the nature of the demand and supply shifts might lead to incorrect policy recommendations for the allocation of checkoff funds.

Model

Following Wohlgenant, we first provide a graphical illustration for the special case of fixed input proportions and then construct a general model for the cases of both fixed and variable input proportions. Figure 1 shows producer gains from promotion, research on marketing service, and research on farm production for a single commodity market in the case of fixed input proportions. Similar to Wohlgenant, we assume that two inputs, a farm input and a composite marketing input, are used in fixed proportions to produce a retail product. The retail demand curve is D_r, the supply of marketing inputs is S_m, the derived demand curve at the farm-level is $D_f = D_r - S_m$, and the farm supply curve is S_f. With these conditions, the initial market equilibrium price and quantity at point A are P_f and Q, respectively. Suppose the industry has checkoff funds that can be spent on promotion, research on farm production methods, and research on marketing methods, and there is an equal efficiency of each dollar expended on each activity. Then, the question is, which investment option generates the greatest payoffs for checkoff funds expended?

Consider first the case of promotion which shifts retail demand from D_r to D_r' and consequently farm-level demand from D_f to D_f' (i.e., $D_f' = D_r' - S_m$). As a result, the farm price increases from P_f to P_f' and quantity increases from Q to Q'. Producer surplus changes from area P_fAR to area $P_f'CR$, resulting in area $P_f'CAP_f$ as a producers' gain. When technology reduces marketing costs, shifting marketing input supply curve from S_m to S_m', the derived farm-level demand shifts from D_f to D_f' (i.e., $D_f' = D_r - S_m'$). Consequently, producers' gain is the same as from promotion. Finally, when research reduces farm production costs, the farm supply curve shifts from S_f to S_f', resulting in a decrease in farm price from production P_f to P_f'' and an increase in production quantity from Q to Q'. Note that because we assume equal efficiency on all activities, the vertical distances between S_f and S_f' at each quantity value are equal to those between D_f to D_f'. The producers' gain from research on the farm-level production methods can be illustrated as area $P_f''BR$ minus $P_f\,AR$. Because area $P_f'CR$ is equal to area $P_f''BS$, which is greater than area $P_f''BR$, it is straightforward that under the assumption of pivotal shifts, producers gain less from production research than from promotion or research on marketing service. In figure 1, D_f^p and S_f^p represent parallel shifts of the initial demand and supply curves, D_f and S_f,

1. Wohlgenant reported that the Beef Board spent $33.5 million on promotion and $2.6 million on research in 1990 (p. 646).

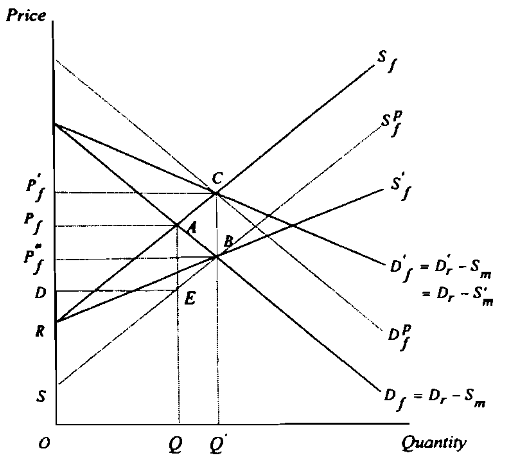

Figure 1. Returns to producers from research and promotion - the case of fixed factor proportions

respectively. The result is clearly different from Wohlgenant, who reported that under the assumptions of fixed input proportions and parallel shifts, producers would be indifferent as to how funds are expended on promotion and research programs that are equally efficient. After generalizing this result to the case of variable factor proportions, Wohlgenant found that producers would benefit more from research on farm-level production than from research on marketing services and promotion.

Following Wohlgenant, we construct a two-input equilibrium displacement model and reexamine his findings for both fixed and variable proportion cases under the assumption of pivotal shifts in demand and supply curves. Unlike Wohlgenant, however, we consider a positively sloped supply curve for marketing inputs. This is necessary since an outward pivotal shift of a perfectly elastic supply curve would result in a negatively sloped curve. Also, this provides for a more general model than Wohlgenant's model.

Consider equations (1), (2), (4), and the first three equations of footnote 5 in Wohlgenant:[2]

(1) $$Q_r^* = \eta(P_r^* - \delta)$$

(2) $$P_r^* = e_f P_f^* + (1 - e_f)P_m^*$$

(3) $$Q_f^* = -(1 - e_f)\sigma P_f^* + (1 - e_f)\sigma P_m^* + Q_r^*$$

(4) $$P_f^* = (1/\varepsilon)Q_f^* - k$$

(5) $$Q_m^* = e_f\sigma P_f^* - e_f\sigma P_m^* + Q_r^*$$

(6) $$P_m^* = (1/\varepsilon_m)Q_m^* - \gamma/(1 - e_f)$$

Here, superscript "*" and subscripts "r", "f", and "m" denote relative changes (i.e., $Y^* = dY/Y$), retail, farm, and marketing sectors, respectively, η is the elasticity of retail demand, δ represents the relative increase in retail demand due to promotion, e_f is the cost share of farm input, γ is the relative decrease in marketing costs, σ is the elasticity of substitution between farm and marketing inputs, ε and ε_m are the elasticities of supply of farm and marketing inputs, respectively, and k is the relative decrease in farm costs due to research on production methods. Equations (1) and (2) represent the relative change in retail demand and supply, equations (3) to (6) are for change in demand and supply of farm and marketing inputs, holding output constant. Constant return to scales is also assumed in this industry.

For the case of pivotal shifts, figure 1 illustrates the change in producer surplus from shifts in farm demand (D_f to D_f') caused by promotion or by research on marketing services. Mathematically, the change in producer surplus in this case is:

(7) $$P_f'Q' - \int_0^{Q'} S_f(Q)dQ - [P_fQ - \int_0^{Q} S_f(Q)dQ].$$

The change in producer surplus from shifts in farm supply (S_f to S_f') due to production research is:

(8) $$P_f''Q' - \int_0^{Q'} S_f'(Q)dQ - [P_fQ - \int_0^{Q} S_f(Q)dQ].$$

Equations (7) and (8) can be approximated with solutions of equations (1) through (6) as:

2 . Equation (2) is slightly different from equation (2) in Wohlgenant because the supply curve of marketing inputs is less than perfectly elastic in our study.

$$(9) \qquad \Delta PS = 0.5P_fQ_f[(P_f^* + 1/\varepsilon)(Q_f^* + 1) - 1/\varepsilon].$$

Because equation (9) indicates that the change in producer surplus depends on the change in P_f^* and Q_f^*, to compare the producer welfare effects of all three checkoff activities, it is sufficient to obtain solutions for P_f^* and Q_f^*. From equations (1) to (6), we have:

where $\Phi = (\varepsilon - \lambda)\varepsilon_m + (e_f\varepsilon - \eta)\sigma - (1 - e_f)\eta\varepsilon$, and $\lambda = -(1 - e_f)\sigma + e_f\eta$. Notice that when $\varepsilon_m = \infty$, equations (10) and (11) reduce to equations (5) and (6) of Wohlgenant.[3]

$$(10) \quad P_f^* = \frac{[-\varepsilon k - \gamma(\sigma + \eta) - \eta\delta]\varepsilon_m + [-e_f\sigma + (1 - e_f)\eta]\varepsilon k - \sigma\eta\delta}{\Phi}$$

$$(11) \quad Q_f^* = \frac{[-\varepsilon\lambda k - \varepsilon\gamma(\sigma + \eta) - \varepsilon\eta\delta]\varepsilon_m - (k + \delta)\sigma\varepsilon\eta}{\Phi}$$

Finally, because equal efficiency is assumed among funds spent on promotion and research at each level of quantity, from equation (12) of Wohlgenant, we have:

$$(12) \qquad \gamma = \delta = e_f k.$$

Using equations (9) through (12), we are now able to estimate returns to producers from each of the three alternatives. When fixed proportions prevail, i.e., $\sigma = 0$, relative changes in farm prices (P_f^*) due to promotion and research on marketing methods are always positive and equal to each other while relative change in farm price (P_f^*) induced by research on farm production methods is always negative. That is,

$$(13) \quad \frac{-\varepsilon_m\eta\delta}{\Omega}\Big|_{promotion} = \frac{-\varepsilon_m\eta\gamma}{\Omega}\Big|_{marketing} > \frac{-[\varepsilon_m - (1 - e_f)\eta]\varepsilon k}{\Omega}\Big|_{production}$$

where $\Omega = (\varepsilon - e_f\eta)\varepsilon_m - (1 - e_f)\eta\varepsilon$. For relative changes in farm production (Q_f^*), each alternative program results in same level of production at new equilibrium. That is,

$$(14) \quad \frac{-\varepsilon_m\varepsilon\eta\delta}{\Omega}\Big|_{promotion} = \frac{-\varepsilon_m\varepsilon\eta\gamma}{\Omega}\Big|_{marketing} = \frac{-\varepsilon_m\varepsilon\eta e_f k}{\Omega}\Big|_{production}$$

Then, based on equations (9), (13), and (14), we can conclude that producers would prefer promotion and marketing research to production research when there are fixed factor proportions. This is consistent with our finding from previous geometric analysis in figure 1.

When there are variable factor proportions, i.e., $\sigma > 0$, equations (13) and (14) become:

$$(15) \quad \frac{-\eta\delta(\varepsilon_m + \sigma)}{\Phi}\Big|_{promotion} > \frac{-\eta\gamma(\varepsilon_m + \sigma) + \sigma\gamma(\eta - \varepsilon_m)}{\Phi}\Big|_{marketing}$$

$$? \ \frac{-\varepsilon k[\varepsilon_m - (-e_f\sigma + (1 - e_f)\eta)]}{\Phi}\Big|_{production}$$

$$(16) \quad \frac{-\varepsilon\eta e_f k(\varepsilon_m + \sigma) + \varepsilon\sigma k(1 - e_f)(\varepsilon_m - \eta)}{\Phi}\Big|_{production} > \frac{-\varepsilon\eta\delta(\varepsilon_m + \sigma)}{\Phi}\Big|_{promotion}$$

$$> \frac{-\varepsilon\eta\gamma(\varepsilon_m + \sigma) - \varepsilon\sigma\gamma(\varepsilon_m - \eta)}{\Phi}\Big|_{marketing}$$

Equations (9), (15), and (16) indicate that, when variable factor proportions prevail, producers' gain from promotion is always greater than from marketing research. However, it is not straightforward to compare the returns to producers from production research to ones from promotion and marketing research. Results from pivotal shifts in demand and supply, therefore, may not necessarily support Wohlgenant's previous conclusions. For further investigation of the rank in producer gains, we provide some numeric illustrations of the model in the next section.

Application to the U.S. Beef and Pork Industries

Wohlgenant applied his model to the U.S. beef and pork industries and found that producers should prefer farm production research to consumer promotion. To see whether his conclusions are sensitive to the assumption of parallel shifts, our model is also applied to the U.S. beef and pork industries under the same assumptions as Wohlgenant except that now a pivotal shift is used.

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3 .There are a few typographic errors in equations (5) and (6) on page 645 of Wohlgenant. The correct solutions for P_f^* and Q_f^* are

$$P_f^* = \frac{-\varepsilon k - \gamma(\sigma + \eta) - \eta\delta}{\varepsilon - \lambda}$$

$$Q_f^* = \frac{-\varepsilon[-(1 - e_f)\sigma + e_f\eta]k - \varepsilon\gamma(\sigma + \eta) - \varepsilon\eta\delta}{\varepsilon - \lambda}$$

The notation S_f was used for two purposes in Wohlgenant's article: farm-level supply curve and cost-share of farm input. In the present paper, e_f denotes the cost-share of the farm input.

Table 1 lists parameters used for equations (9) to (11) for the beef and pork industries. Most of these parameters are taken directly from Wohlgenant so that results are comparable. First, using Wohlgenant's data (identified with superscript "a") and $\varepsilon_m = 5.0$, the gains to producers from the three checkoff activities are estimated for both parallel and pivotal shifts. This will provide a clear comparison of the ranks in producer gains between the two cases. Then, sensitivity analysis on key parameters is conducted to ascertain how robust the rankings are to model parameters. The results are reported in tables 2 and 3.

The results in table 2 indicate that Wohlgenant's previous finding on the allocation of checkoff funds is no longer true when equally efficient checkoff activities (e.g., promotion and research) result in pivotal shifts in demand and supply curves. The first two rows represent the case of parallel shifts, where producers gain the most from research on farm cost reductions.[4] However, as shown in the last two rows, promotion benefits producers the most in the case of pivotal shifts.

This new finding is reinforced in table 3 by the sensitivity analysis to alternative elasticities of demand, supply, input substitution, and marketing input supply. Our findings are consistent across a wide range of alternative values of parameters. Simulations 1 and 2 consider alternative demand and supply elasticities, and results indicate that producer gains increase as retail demand becomes more elastic and farm supply becomes more inelastic, which is consistent with Wohlgenant. Results from simulation 3 are consistent with Alston and Scobie. In the case of shifts in marketing input supply or retail demand, returns to producers increase as elasticity of substitution decreases. When research shifts farm supply, however, returns to producers decrease as the elasticity of substitution decreases. Results from the last simulation indicate that producer gains decrease as supply elasticity of marketing inputs becomes more inelastic. Numeric examples in tables 2 and 3 clearly show that findings in Wohlgenant should be limited to the case of parallel shifts.

Conclusions

The main conclusion of Wohlgenant's paper is that when there is equal efficiency on a dollar invested in consumer promotion, farm research, or marketing research that leads to parallel shifts in retail demand or farm supply, producers gain more from farm research than from promotion or marketing research. This is an important finding that has drawn significant attention, particularly from producer groups who impose levies on their members to fund research and promotion programs. Producer groups are concerned with the best allocation of their members' resources.

The conclusion of our research is that the relative profitability of research versus promotion is highly sensitive to the assumption of the nature of shifts in demand and supply. Therefore, Wohlgenant's finding should be interpreted with caution. As shown in previous sections, erroneous assumptions can result in seriously misleading implications. When there are pivotal shifts, producers would have better returns from promotion than from research.

Although Lindner and Jarrett discussed several cases where researchers could predict the nature of the supply shifts, we know of no study that actually estimates the types of shift directly from technology transfers and promotion activities. Rose argued that, ".. it is unlikely that any knowledge of the shape of the supply curve, or the position at which the single estimate applies, will be available. The only realistic strategy is to assume that the supply shift is parallel" (p. 837). However, as we have shown in this paper, since the assumption on the type of shift is a key determinant of the optimal allocation of checkoff funds, it may not be appropriate to simply assume parallel shifts without having any knowledge regarding the shifts. Any research results relating to the distribution of gains from checkoff programs, therefore, should be used with caution until researchers are able to identify the nature of the shifts. Further research on identifying the nature of demand and supply shifts will significantly contribute to our understanding of the relative producer gains from research and promotions.

4. Changes in producer surplus for the case of parallel shifts were estimated with equation (10) of Wohlgenant (p. 645), which is

$$\Delta PS = P_f Q_f (P_f^* + k)(1 + 0.5 Q_f^*).$$

Our estimates (on the first two rows in table 2) are slightly different from those of Wohlgenant (in table 2, p. 647) because we assume the supply curve of marketing inputs is less than perfectly elastic. However, our conclusions (for the case of parallel shifts) in table 2 are consistent with Wohlgenant.

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Table 1. Values of Parameters and Variables for the U.S. Beef and Pork Industries

Parameter/Variable	Beef	Pork
η	-0.78[a], -0.98[b], -0.45[c]	-0.65[a], -1.23[d], -0.17[b]
ε	0.15[a], 0.30[e], 0.04[f]	0.40[a], 0.80[e], 0.21[f]
σ	0.72[a], 1.0, 0	0.35[a], 1.0, 0
e_f	0.57	0.45[a]
k	0.10[a]	0.10[a]
γ	0.057[a]	0.045[a]
δ	0.057[a]	0.045[a]
ε_m	5.0[g], ∞, 0.1	5.0[g], ∞, 0.1
P_fQ_f(billion dollars)	35[a]	10[a]

[a]Table 1 in Wohlgenant (p. 646).
[b]Alston and Chalfant.
[c]Brester and Wohlgenant.
[d]Eales and Unnevehr.
[e]Table 4 in Wohlgenant (p. 649).
[f]Chung.
[g]Mullen, Wohlgenant, and Farris.

Table 2. Producer Gains from Research and Promotion in the U.S. Beef and Pork Industries, Billion Dollars

	Research on production method	Research on marketing method	Promotion
Parallel shifts			
Beef	2.94	0.12	1.72
Pork	0.55	0.14	0.32
Pivotal shifts			
Beef	1.16	0.12	1.72
Pork	0.04	0.14	0.32

Table 3. Sensitivity of Producer Gains from Research and Promotion to Demand and Supply Elasticities, Substitution Elasticities, and Marketing Input Supply Elasticities for the Case of Pivotal Shift, Billion Dollars

Simulation	Industry	Change in parameters	Research on production methods	Research on marketing methods	Promotion
1	Beef	$\eta = -0.98$	1.23	0.44	1.90
		$\eta = -0.45$	1.01	-0.67	1.29
	Pork	$\eta = -1.23$	0.14	0.31	0.46
		$\eta = -0.17$	-0.10	-0.11	0.12
2	Beef	$\varepsilon = 0.30$	0.74	0.10	1.48
		$\varepsilon = 0.04$	1.57	0.13	1.95
	Pork	$\varepsilon = 0.80$	-0.13	0.10	0.22
		$\varepsilon = 0.21$	0.19	0.18	0.41
3	Beef	$\sigma = 1.0$	0.84	-0.32	1.36
		$\sigma = 0$	0.82	2.59	2.59
	Pork	$\sigma = 1.0$	0.00	-0.08	0.19
		$\sigma = 0$	-0.10	0.41	0.41
4	Beef	$\varepsilon_m = \infty$	1.17	0.12	1.73
		$\varepsilon_m = 0.1$	1.16	0.02	1.67
	Pork	$\varepsilon_m = \infty$	0.05	0.14	0.33
		$\varepsilon_m = 0.1$	0.02	0.03	0.25

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