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Relative Effectiveness of USDA's Nonprice Export Promotion Instruments

Henry W. Kinnucan, Hui Xiao, and Shixue Yu

The USDA's Foreign Agricultural Service funds three types of activities to promote agricultural exports: consumer promotion, technical assistance, and trade servicing. These "instruments" are analyzed using an adaptation of Muth's model. Results indicate that consumer promotion always increases the derived demand for the U.S. agricultural commodity, but that under certain conditions technical assistance and trade servicing can have a perverse effect. Applying the model to cotton promotion in Japan, the results suggest that, owing to cotton's modest share of retail value, the current emphasis on consumer promotion may be misplaced. Specifically, it appears that producer returns can be enhanced by emphasizing technical assistance projects that save on the marketing input.

Key words: agricultural trade, cotton, Market Access Program, nonprice promotion, technical change

Introduction

The U.S. Department of Agriculture (USDA) funds three types of nonprice export promotion activities: consumer promotion, technical assistance, and trade servicing (refer to table 1; see also Henneberry, Ackerman, and Eshleman). Consumer promotion differs fundamentally from trade servicing and technical assistance in that the former affects the demand curve for the finished product, while the latter affect, respectively, the supply curve for marketing services and the foreign industry's farm-retail (or marketers') production function. Although these distinctions are critical to a proper assessment of the relative effectiveness of the three promotional activities (hereafter referred to as "instruments"), they have been largely ignored in the scholarly literature. Accordingly, the purpose of this research is to determine the relative effectiveness of consumer promotion, trade servicing, and technical assistance, taking into account the precise way in which each instrument affects supply and demand in a multistage production system. Specifically, using a model adapted from Muth's analysis, and methods similar to those used by Wohlgenant (1993), we rank the instruments in terms of their ability to increase the derived demand for the U.S.-origin agricultural input in export markets.

Kinnucan is professor and Yu is graduate research assistant, both in the Department of Agricultural Economics and Rural Sociology, Auburn University; Xiao is senior econometrician with American Express, Phoenix, Arizona.

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Table 1. USDA's Nonprice Export Promotion Instruments

Instrument	Purpose/Description
Consumer Promotion (CP)	Increase final product demand through brand and generic advertising, point-of-sale promotions, and public relations. These activities are directed at the final consumer in importing countries to promote product awareness and to influence consumer attitudes toward U.S. products.
Technical Assistance (TA)	Increase U.S. exports by improving productivity and lowering cost in intermediate sectors that use U.S. commodity exports as inputs. Activities include technical and organization training and transfer of techniques used in U.S. production processes.
Trade Servicing (TS)	Provide market and technical information designed to improve customer relations, maintain current customers in importing countries, and create interactions between buyers and sellers. Activities (e.g., trade teams, consultants, exhibits) are aimed at the market rather than individual consumers or producers.

Source: Grigsby and Dixit (p. 5).

Interest in the relative effectiveness issue stems in part from a significant expansion in federal funding for nonprice export promotion, from $34 million in 1985 to $234 million in 1992 (Kinnucan and Ackerman, p. 123). Although funding has since declined to about $120 million (Foreign Agricultural Service), interest in the programs remains high. Export market expansion plays a pivotal role in the new market-oriented farm policy (Gardner). McCalla and Valdes argue that the search for new markets for agricultural products has public-good attributes, which implies that government subsidies for nonprice export promotion may be welfare increasing. The "green box" designation of nonprice promotion in the GATT suggests that nonprice promotion may play a more prominent role in trade and agricultural policy (Kinnucan and Myrland). Although numerous studies have analyzed the economic or demand impact of USDA's nonprice export promotion programs (e.g., Halliburton and Henneberry; Richards and Patterson; Solomon and Kinnucan; Williams), the theory underlying these studies is not well developed.

Following specification of the structural model, the foreign industry's derived demand curve for the agricultural input is calculated to determine how each instrument might affect the demand for agricultural commodities from the United States. The model is then applied to U.S. cotton promotion in Japan in order to highlight principles and to demonstrate the model's empirical utility. Results suggest that the current emphasis on consumer promotion in Japan may be misplaced in that technical assistance projects that cause biased technical change appear to yield much higher returns for U.S. cotton producers.

The Model

Consider a competitive industry in a foreign country that combines a farm product x with a bundle of marketing inputs m to produce a retail product q under conditions of constant returns to scale. Assume that the foreign industry relies on supplies from the

United States for a portion of x. Specifically, let $x = x_{US} + x_F$, where x_{US} is the U.S.-origin quantity, and x_F is the non-U.S. or "foreign" quantity.[1] The United States can influence the demand for x_{US} in three ways: through consumer promotions (CP) that increase the demand for q, through trade servicing (TS) that lowers the cost of m, and through technical assistance (TA) that reduces the cost of producing q. The foreign market for x is assumed to be integrated with the U.S. market so that the law of one price holds. Specifically, the price of x net of transfer costs is the same in both markets.

With the foregoing assumptions, initial equilibrium in this industry can be described as follows:

(1)	$q = f(p, a)$	retail demand,
(2)	$q = q(x, m, t)$	farm-retail production,
(3)	$p_x = pq_x(x, m, t)$	demand for factor x,
(4)	$p_m = pq_m(x, m, t)$	demand for factor m,
(5)	$x_{US} = x_{US}(p_x)$	supply of x_{US},
(6)	$x_F = x_F(p_x)$	supply of x_F,
(7)	$m = m(p_m, s)$	supply of m,

and

(8)	$x = x_{US} + x_F$	identity,

where p is the price of q, p_x is the price of x, p_m is the price of m, a denotes expenditures for CP, t denotes expenditures on TA, and s denotes expenditures for TS. The subscripted terms in (3) and (4) denote marginal physical products, i.e., $q_x = \partial q/\partial x$, and $q_m = \partial q/\partial m$. Notice that whereas CP and TS each affect only one equation in the system, TA affects three equations (retail supply and the two input demands) owing to its effect on the marketers' production function.[2]

The model contains eight endogenous variables (p, p_x, p_m, q, x, x_{US}, x_F, and m) and three exogenous variables (a, s, and t). It generalizes Wohlgenant's (1993) model in that the price of marketing services is endogenized through the inclusion of a supply equation for marketing services, and trade is permitted through the inclusion of an import supply equation for the agricultural input. In addition, whereas Wohlgenant models reductions in marketing cost as a shift in the marketing services' supply curve, we extend the analysis to consider improvements in processing efficiency via shifts in the marketers' production function.

[1] With this formulation, we implicitly assume that the agricultural input is homogeneous across supply sources, an assumption that appears to be in line with how the programs operate, at least for the major commodities (Grigsby and Dixit; Spatz). In situations where product differentiation in the farm-based input is deemed important, Alston and Mullen's model for wool provides an excellent point of departure (see also Azzam). For a model involving product differentiation in the finished (or semi-finished) good, see Goddard and Conboy.

[2] Holloway develops a model similar to (1)–(8) in which the marketing sector is disaggregated into processing and distribution sectors. However, as noted by Wohlgenant (1993, p. 645, footnote 4), Holloway's model is equivalent to (1)–(8) when the inputs in processing and the inputs in distribution are weakly separable.

The best way to model technical change has been the subject of some debate (e.g., Alston, Norton, and Pardey, p. 264). Here we follow Muth's suggestion and model technical change (induced by TA) as the sum of a "neutral" technical change and an "m-saving" technical change. A neutral technical change is defined by Muth (p. 224) as one that "increases the marginal physical products of both factors proportionally, regardless of the relative proportions employed before the change." Similarly, Muth (p. 224) defines an m-saving technical change as one that "increases the marginal physical product of x relative to that of m, but leaves the total output unchanged for the inputs of the two factors which were used prior to the change."[3] Our modeling approach adheres to these definitions. Shifts in farm supply are not considered in this study because none of the instruments affect this curve.

Changes in prices and quantities can be approximated linearly by totally differentiating (1)–(8) and converting to elasticities and relative changes to yield:

$$q^* = -\eta(p^* - \alpha), \tag{1'}$$

$$q^* = S_x x^* + S_m m^* + \beta, \tag{2'}$$

$$p_x^* = -(S_m/\sigma)x^* + (S_m/\sigma)m^* + p^* + \beta + \gamma, \tag{3'}$$

$$p_m^* = (S_x/\sigma)x^* - (S_x/\sigma)m^* + p^* + \beta - (S_x/S_m)\gamma, \tag{4'}$$

$$x_{US}^* = \varepsilon_{US} p_x^*, \tag{5'}$$

$$x_F^* = \varepsilon_F p_x^*, \tag{6'}$$

$$p_m^* = (1/\varepsilon_m)m^* - \delta, \tag{7'}$$

and

$$x^* = k x_{US}^* + (1 - k)x_F^*, \tag{8'}$$

where the asterisked variables refer to relative changes (e.g., $p^* = dp/p$); η is the absolute value of the retail demand elasticity; S_x ($= p_x x/pq$) and S_m ($= p_m m/pq$) are the cost (revenue) shares for x and m, respectively; σ is the Allen partial elasticity of substitution between x and m; ε_{US} is the supply elasticity for x_{US}; ε_F is the supply elasticity for x_F; ε_m is the supply elasticity for m; k ($= x_{US}/x$) is the U.S. quantity share of x; and α, β, γ, and δ are shift parameters corresponding to CP, neutral TA, m-saving TA, and TS, respectively. [For derivation of β and γ in (2′)–(4′), see Muth, pp. 224–25.]

In the above model, all parameters are defined as positive. Specifically, the retail demand curve is downward sloping ($-\eta < 0$), the supply curves for x_F and x_{US} are upward sloping ($\varepsilon_{US} > 0$, and $\varepsilon_F > 0$), the supply curve for m is nondecreasing ($\varepsilon_m > 0$, or $\varepsilon_m = \infty$), and the production function exhibits variable proportions ($\sigma > 0$). Similarly, the shift parameters are all defined to be positive as follows:

- α = relative *upward* shift in retail demand due to CP, holding q constant at its initial equilibrium level;
- β = relative increase in marginal products of x and m due to neutral TA, holding x and m constant at their initial equilibrium levels;

[3] Muth used A to denote x, and B to denote m. The quote here and later replaces A with x, and B with m.

- γ = relative increase in marginal product of x due to m-saving TA, holding x, m, and q constant at their initial equilibrium levels; and
- δ = relative *downward* shift in m-input supply due to TS, holding m constant at its initial equilibrium level.

Analysis

The key relationship for the purposes of this analysis is the foreign industry's derived demand curve for x_{US}, which, by virtue of the perfect-substitute assumption, is proportional to the industry's derived demand curve for x. The latter curve, following Muth's (p. 225) suggestion, can be derived by treating p_x as exogenous and solving (1′)–(4′) and (7′) for x^* to yield:

$$(9) \qquad x^* = -\left[(\eta\sigma + \lambda\varepsilon_m)/D\right]p_x^* + \left[\eta(\sigma + \varepsilon_m)/D\right]\alpha + \left[(\eta - 1)(\sigma + \varepsilon_m)/D\right]\beta + \left[\sigma(\eta + \varepsilon_m)/D\right]\gamma + \left[S_m(\eta - \sigma)\varepsilon_m/D\right]\delta,$$

where $D = (\varepsilon_m + S_m\eta + S_x\sigma)$, and $\lambda = (S_x\eta + S_m\sigma)$. Since all parameters are defined to be positive, $D > 0$ and $\lambda > 0$. Thus, the coefficient of p_x^* is negative, which means the industry's derived demand curve for x is downward sloping, as expected. In fact, if the supply curve for marketing services is horizontal ($\varepsilon_m = \infty$), the coefficient of p_x^* reduces to $-\lambda$, the Hicks-Allen market elasticity of derived demand (Bronfenbrenner).

The coefficients of α, β, γ, and δ in (9) quantify shifts in the derived demand curve as functions of model parameters. From the standpoint of instrument effectiveness, the coefficients should be positive, i.e., the instruments should cause the derived demand curve for x to shift to the right. As is evident from (9), this is not always the case. In particular, the coefficients of β and δ are ambiguous in sign, which means that neutral TA and TS may be counterproductive. In particular, the USDA would not want to fund neutral TA if the demand for the foreign industry's finished good was price inelastic ($\eta < 1$). Similarly, the USDA would not want to fund TS if middlemen can substitute more easily than consumers such that $\eta < \sigma$. Muth (p. 226) explains the latter result as follows:[4]

> [A]n increase in the supply of factor m not only reduces its price and, hence, leads to a substitution of factor m for factor x, but also leads to a downward shift in the marginal and average cost curves of all firms and an increase in the supply of the product. The latter, of course, leads to a fall in price and to an expansion of industry output. The substitution effect of an increase in the supply of factor m outweighs the output-expansion effect on the demand for factor x if σ exceeds η.

By a similar argument, neutral TA is counterproductive when retail demand is price inelastic because then the expansion in industry output is not sufficient to offset the effect of improved factor productivity, causing the demand for both inputs to fall. The

[4]Technically, Muth's explanation focuses on the effect of an increase in the supply of x on the demand for m. However, since the argument is symmetric, we took the liberty of interchanging x and m in the quote. In particular (as noted by Alston and Scobie), if $\sigma > \eta$, then x and m are gross substitutes, which means that a reduction in the price of *either* factor causes the demand for the other factor to decrease.

upshot is that care must be taken when evaluating TA and TS projects, since these projects under certain conditions can have a perverse effect.

Turning to CP and m-saving TA, the coefficients of α and γ in (9) are always positive under the stated assumptions, which means that these instruments always increase the derived demand for x, and hence for x_{US}. However, since the coefficients of α and γ are not equal, the two instruments in general will have different effects on demand. In particular, if $\alpha = \gamma$, CP and m-saving TA cause identical increases in derived demand only if $\eta = \sigma$. If $\eta > \sigma$ [a situation that holds for beef and veal, pork, and poultry in Wohlgenant's (1989, p. 250) analysis], CP is always more effective than m-saving TA when the two instruments shift the underlying structural relationships by the same relative amount, i.e., $\alpha = \gamma$.

Further insight into instrument effectiveness can be gained by considering the special case where the supply of marketing services is perfectly elastic—Wohlgenant's (1993) maintained hypothesis. In this case, (9) simplifies to:

$$x^* = -\lambda p_x^* + \eta\alpha + (\eta - 1)\beta + \sigma\gamma + S_m(\eta - \sigma)\delta. \tag{10}$$

Comparing (9) and (10), it is apparent that the $\varepsilon_m = \infty$ restriction affects the *magnitude* of the demand shifts, but not the direction. In particular, the signs of the coefficients of β and δ remain ambiguous. That σ plays a pivotal role in instrument choice is evident from (10). For example, m-saving TA becomes relatively less effective as $\sigma \to 0$, and will have no impact on demand if the (aggregate) marketing technology exhibits fixed proportions ($\sigma = 0$). [An example of a fixed-proportions situation may be poultry, since Wohlgenant's (1989, p. 250) estimate of σ for this industry is not significant.] Conversely, in situations where middlemen can substitute more easily than consumers such that $\sigma > \eta$ [e.g., eggs, dairy, and fresh vegetables in Wohlgenant's (1989, p. 250) analysis], m-saving TA is apt to be more effective than CP, provided the instruments cause equal percentage shifts in the underlying structural relationships.

In addition to guiding instrument choice, (10), or (9), can be useful for econometric analysis. For example, in regressions of x_{US} on p_x, export promotion expenditures, and other shift variables (as in, inter alia, Halliburton and Henneberry), care must be taken in interpreting the regression coefficients for t and s (expenditures on TA and TS, respectively), since they may be positive or negative depending on the absolute and relative values of η and σ. Also, aggregating expenditures across instruments—a common practice in the empirical literature—is ill-advised, since the aggregation implicitly assumes that the coefficients of a, t, and s are identical, which in general is not the case, as is clear from (9) and (10).

Wohlgenant's (1993, p. 645) analysis indicated that producers would be indifferent between CP and TS if $\sigma = 0$, and the instruments are equally efficient in the sense that an incremental expenditure on each instrument causes the relevant structural relationship to shift by the same *absolute* vertical distance so that:

$$\alpha = \beta = S_x\gamma = S_m\delta.$$

This result can be checked by imposing the above restriction on (10) to yield:

$$x^* = -\lambda p_x^* + S_x\eta\alpha' + S_x(\eta - 1)\beta' + \sigma\gamma + S_x(\eta - \sigma)\delta',$$

where $\alpha' = \beta' = \delta' = \gamma$. Comparing the coefficients of α' and δ', it can be seen that they are equal when $\sigma = 0$. Thus, our model reproduces Wohlgenant's result. The result, however, does not extend to TA, which is clearly inferior when $\sigma = 0$.

Application

To highlight the theoretical findings and to demonstrate the model's empirical utility, we applied it to cotton promotion in Japan using the baseline data and parameter values given in table 2. Cotton promotion in Japan represents a useful case study since the assumptions underlying the model (integrated world market and homogeneous product across supply sources) are approximated in this instance. Moreover, cotton has been a major recipient of USDA funds for nonprice export promotion, and a significant portion of those monies (41% between 1993 and 1995) has been invested in Japan. The promotion intensity in this market (promotion expenditure divided by export revenue) is 4%, which is three times higher than the corresponding intensity for the U.S. market.[5]

Historically, TS and TA activities, funded through USDA's Foreign Market Development Program, have been the mainstay of the industry's export promotion efforts. However, with the introduction of the Targeted Export Assistance Program in 1987 (renamed the Market Promotion Program in 1990, and currently called the Market Access Program) and the attendant increase in funding, emphasis shifted to CP. Cotton, Incorporated (CI), the industry's marketing agency, estimates that about 75% of funds were invested in "demand-pull" activities and 25% in "supply-push" activities over the evaluation period (1993–95). In Japan, the demand-pull (or CP) activities focused on increasing consumer awareness of the *Cotton USA Mark* logo, and on reminding consumers of cotton's benefits as a natural fiber. The supply-push activities are defined as activities (e.g., consultancy services, trade fairs, training programs) aimed at middlemen rather than final consumers. To the extent that such activities lower the acquisition cost of U.S. cotton, or improve technical efficiency in Japan's spinning and weaving operations, they potentially increase the derived demand for U.S. cotton by increasing the supply of m or decreasing the cost of q. Accordingly, in this study, supply-push activities are defined as either TS or TA (a precise delineation is not possible from the available information). At issue is whether the 75/25 allocation can be rationalized in terms of the present model.

Reduced Form

Since we are interested in the *net* quantity effects, i.e., the effects that take into account any price changes for x that might be caused by the instruments, we first solved for the reduced-form equation for p_x^*. This was done by setting the derived demand relationship (9) equal to the following supply relationship:

[5] This estimate is based on data from a Texas A&M University study. That report indicated that the cotton industry invested $82 million in domestic market promotion and $45 million in research between 1993 and 1995. It also indicated that domestic cotton marketings were valued at approximately $3.2 billion per year. Dividing $127 million (combined research and promotion expenditures) by $9,600 million (cumulative farm revenues from domestic marketings) gives a domestic market "promotion" intensity of 1.32%, which may be compared to the Japanese-market promotion intensity of 4%. The "advertising" intensities—i.e., the intensities that exclude research, TS and TA expenditures—are 0.85% for the domestic market and 3% for Japan.

Table 2. Baseline Data and Parameter Values, 1993–95

Item	Definition	Value
x	Japan's total mill consumption of raw cotton fiber (mil. lbs.)	2,524[a]
x_{US}	U.S. exports of raw cotton fiber to Japan (mil. lbs.)	1,358[a]
k	U.S. quantity share (x_{US}/x)	0.54
p_x	Average U.S. farm price of cotton ($/lb.)	0.69[a]
$p_x x_{US}$	Export revenue from Japan ($ mil.)	937
$A + T + S$	Expenditures for cotton promotion in all export markets ($ mil.)	90.7[b]
$a + t + s$	Expenditures for cotton promotion in Japan ($ mil.)	37.1[b]
$a_G + t_G + s_G$	USDA's expenditures for cotton promotion in Japan ($ mil.)	13.0[b]
ϕ	Promotion intensity ($(a + t + s)/p_x x_{US}$)	0.040
ω	CP's share of total promotion expenditure in Japan ($a/(a + t + s)$)	0.75[b]
η	Demand elasticity for cotton products in Japan (absolute value)	0.5, 1.0[c], or 2.0
σ	Elasticity of factor substitution in Japanese textile mills	0.1[c], 0.25[d], or 0.49
S_x	Cotton farmers' share of retail dollar	0.05[e] or 0.10
S_m	Marketing input suppliers' share of retail dollar	0.95 or 0.90
ε_m	Supply elasticity for marketing inputs in Japan	20.0[c] or 10.0
ε_F	Supply elasticity for non-U.S. cotton to Japan	1.6[f] or 0.6[f]
ε_{US}	Supply elasticity for U.S. cotton to Japan	1.1[f] or 0.3[f]
α	Increase in retail price due to CP (%/100)	0.05[d]
β	Reduction in marketing cost due to neutral TA	0.05
γ	Reduction in marketing cost due to m-saving TA	α/S_x or 0.05
δ	Reduction in marketing cost due to TS	α/S_m or 0.05

Sources:
[a] USDA/ERS, *Cotton and Wool Yearbook, 1998* (appendix tables 1 and 18); Leslie Meyer, agricultural economist, Economic Research Service, USDA, Washington DC.
[b] Allen Beach and Allen Terhaar, Cotton Council International, Washington, DC, office.
[c] Alston and Mullen's value for world wool model.
[d] Ding and Kinnucan (see text for details).
[e] Don Ethridge, Department of Agricultural Economics, Texas Tech University, and Sandra Forsythe, Department of Consumer Affairs, Auburn University.
[f] Derived from Duffy, Wohlgenant, and Richardson's estimate of Japan's excess demand elasticity for U.S. cotton (see text for details).

$$x^* = ep_x^*, \tag{11}$$

where $e = k\varepsilon_{US} + (1 - k)\varepsilon_F$ is the "total" supply elasticity for x obtained by substituting (5′) and (6′) into (8′).

Solving the resulting equation for p_x^* yields the reduced form:

$$p_x^* = \left[\eta(\sigma + \varepsilon_m)/D'\right]\alpha + \left[(\eta - 1)(\sigma + \varepsilon_m)/D'\right]\beta + \left[\sigma(\eta + \varepsilon_m)/D'\right]\gamma + \left[S_m(\eta - \sigma)\varepsilon_m/D'\right]\delta, \tag{12}$$

where $D' = [\varepsilon_m(\lambda + e) + e(S_m\eta + S_x\sigma) + \eta\sigma] > 0$. Since the coefficients of (9) and (12) differ only by their common denominators D and D', both of which are positive, the instruments' price effects are in the same direction as the quantity effects. Also, whether an increase in k (the U.S. quantity share) magnifies or attenuates the price effect depends on the relative magnitudes of ε_{US} and ε_F. In particular, if $\varepsilon_{US} > \varepsilon_F$, then an increase in k implies a weaker price effect (since e increases with k when $\varepsilon_{US} > \varepsilon_F$, which implies a larger supply response to the promotion). Alternatively, if $\varepsilon_{US} = \varepsilon_F$, the price effect is invariant to k.

The instruments' net effects on U.S. exports (i.e., the reduced-form equation for x^*_{US}) are obtained by substituting (12) into (5′) to yield:

$$x^*_{US} = \left[\eta(\sigma + \varepsilon_m)/D'\right]\varepsilon_{US}\alpha + \left[(\eta - 1)(\sigma + \varepsilon_m)/D'\right]\varepsilon_{US}\beta + \left[\sigma(\eta + \varepsilon_m)/D'\right]\varepsilon_{US}\gamma + \left[S_m(\eta - \sigma)\varepsilon_m/D'\right]\varepsilon_{US}\delta. \tag{13}$$

Equations (12) and (13) were used to compute the impacts of the instruments on U.S. producer welfare using the formula:

$$\Delta PS_{US} = p_x x_{US} p^*_x(1 + 0.5x^*_{US}), \tag{14}$$

where ΔPS_{US} measures the change in economic surplus to U.S. cotton producers.[6] Equation (14)'s validity rests on the assumption that the instruments cause parallel shifts in linear supply and demand curves, a maintained hypothesis in this analysis. [For a cogent discussion of the validity of this assumption, including drawbacks, see Wohlgenant (1999).]

Parameterization

Numerical values used for the parameters in (12) and (13) are given in table 2. For the baseline analysis, η is set to 1.0, the elasticity used by Alston and Mullen in their wool model. The implicit assumption here is that the demand for cotton products is similar to the demand for wool products and that Japanese demand is similar to worldwide demand. Whether this is true depends, inter alia, on Japanese preferences for natural versus synthetic fibers and how their preferences compare to preferences in other countries. Accordingly, to test the sensitivity of results to this parameter, simulations are also performed with η alternatively set to 0.5 and 2.0, values that appear to represent polar substitution possibilities in this market at the retail level.

In the baseline, σ is set to 0.25. A justification for this value is that m technically includes manmade and other noncotton fibers that may be used in the production process and which would tend to be highly substitutable for cotton. In addition, it is consistent with the implied value for the U.S. market. In particular, Ding and Kinnucan estimate the derived demand elasticity for cotton in the United States to be -0.29, which implies $\lambda = (S_x\eta + S_m\sigma) = 0.29$ when $\varepsilon_m = \infty$. Setting $\eta = 1$ and $S_x = 0.05$ (see below) yields

[6] Technically, (14) abstracts from the farm program, a simplification that is justified since the relevant features of that program (the deficiency payment and acreage controls) were eliminated in the 1996 farm bill. (For an analysis of returns with the farm program, see Ding and Kinnucan.)

$\sigma = 0.25$. If the Japanese and U.S. textile production and retail demand conditions are similar, $\sigma = 0.25$ would appear to represent a reasonable value for this parameter. However, since this is a pivotal parameter in the model, simulations are also performed for $\sigma = 0.1$ (Alston and Mullen's value), and for $\sigma = 0.49$ [the mean value for the six commodities included in Wohlgenant's (1989, p. 250) study].

The cost-share parameter S_x is set to 0.05 in the baseline, since discussions with industry experts indicated this as a "best-guess" value for the United States and there is little reason to expect that Japan's cost share should be any different. However, since there is some uncertainty about this parameter, and Alston and Mullen used a much higher figure in their wool model (0.3), in our sensitivity analysis we set S_x to 0.10, the experts' upper-bound estimate (see table 2, footnote e). The value for S_m accordingly is set to 0.95 in the baseline and 0.90 in the sensitivity analysis.

The supply elasticity for marketing inputs is set to $\varepsilon_m = 20.0$, Alston and Mullen's value. In the sensitivity analysis, this parameter is reduced to 10.0 to determine how tighter supply conditions in the marketing-input sector might affect returns.

As for the supply elasticities of cotton into Japan, no estimates exist in the published literature. However, several studies (e.g., Babula; Duffy, Wohlgenant, and Richardson; Solomon and Kinnucan) have estimated Japan's demand elasticity for U.S. cotton, which can be used to derive the supply elasticity for foreign cotton. In particular, Japan's excess demand curve for U.S. cotton is obtained by substituting the foreign supply curve (6′) and the derived demand curve (10) (for simplicity we assume $\varepsilon_m = \infty$) into the market-clearing condition (8′), which yields:

$$x_{US}^* = -\left[\left(\lambda + (1 - k)\varepsilon_F\right)/k\right]p_x^* + Z,$$

where the term in brackets is Japan's excess demand elasticity for U.S. cotton, and Z denotes expressions involving the shift parameters that are of no particular interest here. Letting $\lambda_{US} = [(\lambda + (1 - k)\varepsilon_F)/k]$, and noting that $\lambda = (S_x\eta + S_m\sigma)$, the supply elasticity for foreign cotton can be derived as a function of the U.S. demand elasticity and model parameters as follows:

$$\varepsilon_F = \left(k\lambda_{US} - S_x\eta - S_m\sigma\right)/(1 - k).$$

Thus, for example, if $\lambda_{US} = 1.9$ [Duffy, Wohlgenant, and Richardson's (p. 472) mid-range estimate for Japan], and the remaining parameters are set to baseline values ($\eta = 1.0$, $\sigma = 0.25$, $S_x = 0.05$, and $k = 0.54$), then $\varepsilon_F = 1.6$.

Following a similar procedure, but substituting the supply curve for U.S. cotton (5′) into (8′), yields the corresponding expression for the supply elasticity for U.S. cotton:

$$\varepsilon_{US} = \left((1 - k)\lambda_F - S_x\eta - S_m\sigma\right)/k,$$

where λ_F is Japan's demand elasticity for foreign cotton. Since no known estimates exist for λ_F, and since Japan imports virtually all of its cotton (about half of which comes from the United States), for simplicity we set $\lambda_F = \lambda_{US}$. (An additional justification for this assumption is that cotton is assumed to be homogeneous across import sources.) Thus, if $\lambda_F = \lambda_{US} = 1.9$, and the remaining parameters are set to baseline values, then $\varepsilon_{US} = 1.1$. Accordingly, in the baseline simulation, ε_F and ε_{US} are set respectively to 1.6 and 1.1. However, to gauge the sensitivity of results to the supply elasticities, we alternatively

set $\lambda_F = \lambda_{US} = 1.0$—Duffy, Wohlgenant, and Richardson's estimate of the "total" demand elasticity for U.S. cotton, i.e., the elasticity that takes into account competitors' reactions to changes in the U.S. price. In this case, the supply elasticities are $\varepsilon_F = 0.6$ and $\varepsilon_{US} = 0.3$. Since these latter estimates indicate an inelastic supply response compared to the baseline, the corresponding simulation may be interpreted as representing returns over a shorter time horizon, say one year or less.

The shift parameter α is set to 0.05 under the hypothesis that CP shifts the retail demand curve in the price direction by 5%, a value that is consistent with Ding and Kinnucan's estimate for CP of cotton in the United States when diminishing returns are taken into account.[7] To assign values to the remaining shift parameters, we invoke two alternative hypotheses. One hypothesis is that the instruments are equally efficient in the sense defined by Wohlgenant (1993, p. 645). That is, the instruments cause the underlying supply and demand curves to shift by the same *absolute* amount. For $\alpha = 0.05$, the equal-efficiency hypothesis implies:

$$\text{(15a)} \qquad \beta = 0.05, \quad \gamma = 0.05/S_x, \quad \text{and} \quad \delta = 0.05/S_m.$$

The alternative hypothesis is that the instruments cause equal *relative* shifts in the underlying supply and demand curves. This hypothesis implies that:

$$\text{(15b)} \qquad \alpha = \beta = \gamma = \delta = 0.05.$$

Comparing (15a) and (15b), the farmers' share parameter plays an important role in instrument choice when instruments are assumed equally efficient. For example, when $S_x = 0.05$, a 5% shift in retail demand due to CP implies a 100% shift in the x-factor demand function due to m-saving TA [see (3′)]; under the relative shift hypothesis, both curves shift by 5%. Thus, the equal-efficiency hypothesis tends to favor instruments that directly affect input markets, a fact that will become clear later.

Instrument Effectiveness

Intuitively, given the importance of marketing inputs in the total cost of finished cotton products, one would expect that instruments that reduce the need for m in the production process, or that improve x's relative efficiency, have an edge. Intuition is confirmed in the case of equal absolute shifts (table 3). In particular, results indicate that m-saving TA is the preferred instrument for all considered parameter combinations. For the baseline simulation, m-saving TA generates a gross welfare gain to U.S. cotton producers of $157.6 million, which far exceeds the gains from CP ($28.5 million) and TS ($21 million). [Neutral TA's surplus gain is zero in the baseline since retail demand is unitary elastic, implying no effect on derived demand; see equation (9).]

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[7] This estimate is obtained using the formula $\alpha = \mu S_x \alpha_f$, where μ is the ratio of advertising intensity in Japan to the advertising intensity in the United States, S_x is the cotton farmers' share of the retail dollar, and α_f is the vertical demand shift in the United States measured at the *farm level*. The farm-level demand shift is equal to the farm-level advertising elasticity divided by the farm-level demand elasticity. For cotton, Ding and Kinnucan (p. 361) estimated $\alpha_f = 0.066/0.29 = 0.23$, which implies a *retail-level* demand shift in the United States of 1.72% (= $0.23 \times S_x \times 100$, where $S_x = 0.075$, the midpoint between the baseline and the upper-bound estimate). This shift is based on an advertising intensity of 0.85% (see footnote 5). In Japan, the advertising intensity is 3%, which yields $\mu = 3.5$. Assuming that the demand shift is proportional to advertising intensity (i.e., no diminishing returns), and both markets are equally responsive to CP, the implied retail demand shift for Japan is $\alpha = 0.060$ (= 3.5×0.0172). To take account of diminishing returns (Simon and Arndt), the estimated shift was reduced to $\alpha = 0.050$.

Table 3. Instrument-Specific Returns to Cotton Promotion in Japan for Equal *Absolute* Shifts in Underlying Supply and Demand Curves, 1993–95

	U.S. Producer Return per Instrument ($ mil.)[b]				
Simulation[a]	CP	Neutral TA	m-Saving TA	TS	All[c]
No. 1 Baseline	28.5	0.0	157.6	21.0	66.0
No. 2 ($\eta = 2.0$)	53.7	26.5	153.4	46.2	96.8
No. 3 ($\eta = 0.5$)	14.7	-14.4	159.9	7.2	49.2
No. 4 ($\sigma = 0.10$)	31.1	0.0	66.1	27.8	46.8
No. 5 ($\sigma = 0.49$)	25.2	0.0	285.6	12.4	93.4
No. 6 ($S_x = 0.10$)	27.9	0.0	74.1	20.6	44.6
No. 7 ($\varepsilon_{US} = 0.3$; $\varepsilon_F = 0.6$)	63.1	0.0	340.8	46.6	144.2
No. 8 ($\varepsilon_m = 10.0$)	27.6	0.0	158.0	20.1	65.2
Mean	34.0	1.5	174.4	25.2	75.8
Standard Deviation	16.1	11.3	94.9	14.4	34.2
Benefit-Cost Ratio[d]	0.9:1	0.0:1	4.7:1	0.7:1	2.0:1

[a] Based on text equations (12)–(14). Baseline simulation uses parameter values: $\eta = 1.0$, $\sigma = 0.25$, $S_x = 0.05$, $S_m = 0.95$, $\varepsilon_{US} = 1.1$, $\varepsilon_F = 1.6$, and $\varepsilon_m = 20.0$.
[b] Assumes all instruments are equally efficient (see text for details).
[c] Assumes 75% of funds are spent on CP, and 25% on TA and TS.
[d] Mean return divided by total promotion outlay of $37.1 million.

The gain from m-saving TA is insensitive to η and ε_m, but highly sensitive to σ, S_x, and the supply elasticities for x. For example, reducing the supply elasticities to $\varepsilon_{US} = 0.3$ and $\varepsilon_F = 0.6$ causes the gain to more than double to $340.8 million (simulation 7). Increasing σ from 0.25 to 0.49 causes the gain from m-saving TA to increase to $285.6 million (simulation 5), while decreasing σ to 0.10 causes the gain to fall to $66.1 million (simulation 4). Increasing S_x from 0.05 to 0.10 causes a reduction in gain to $74.1 million, still significantly ahead of CP ($27.9 million), the second-best instrument (simulation 6).

Thus, overstating input substitution or understating x's cost share tends to bias the analysis in favor of m-saving TA, but not sufficiently to affect choice. More generally, although rankings are not affected by the considered parameter values, returns are, which suggests that accurate information on η, σ, S_x, ε_{US}, and ε_F is critical for benefit-cost analysis. (Note that η is included in the list since returns to instruments other than m-saving TA are highly sensitive to this parameter—e.g., compare CP's returns in simulations 2 and 3.) For the considered parameter values a distinct hierarchy emerges, with m-saving TA dominant, followed (distantly) by CP, which, in turn, is followed by TS.

Neutral TA is an inferior instrument in the sense that it generates a welfare loss of $14.4 million when retail demand is price inelastic (simulation 3). [The instrument is inferior when $\eta < 1$ because then $(\eta - 1) < 0$ in equation (12), which means that neutral TA causes p_x to fall.] If demand is elastic, a gain of $26.5 million is realized, but it is modest in relation to the gain from m-saving TA ($153.4 million), and is substantially less than the gain from CP and TS (simulation 2). Thus, projects that cause neutral technical change should be avoided altogether.

Mean gross returns for the eight simulations are $174.7 million for m-saving TA, $34 million for CP, and $25.2 million for TS (table 3). Weighting these returns by the budget allocation (75% to CP and 25% to TA and TS) produces a gross gain of $75.8 million and a benefit-cost (B-C) ratio of 2.0:1. Thus, under the maintained hypothesis that $\alpha = 0.05$ and the instruments are equally efficient, it appears that the cotton promotion program in Japan was profitable. However, a different instrument mix would have resulted in a larger net return. In particular, by placing more emphasis on m-saving TA (B-C ratio = 4.7:1), and less on CP (B-C ratio = 0.9:1), it should be possible to improve profitability.

How do the results in table 3 compare with Wohlgenant's (1993) findings? First, they are consistent in that CP always dominates TS (compare our table 3 with Wohlgenant's tables 2–5). Second, although Wohlgenant did not explicitly analyze technical change, his result that farm-level production research dominates CP is consistent with our result that m-saving TA dominates CP.[8] In particular, as noted by Wohlgenant (1993, p. 645, footnote 3), m-saving TA is tantamount to a simultaneous reduction in the cost of the farm input and a decrease in retail demand. Since a reduction in retail demand and an increase in farm supply have opposite effects on producer welfare (assuming parallel shifts in linear curves, the maintained hypothesis), the fact that m-saving TA dominates CP in table 3 simply means that the gain from the (implied) increase in farm supply is large relative to the loss from the (implied) decrease in retail demand.

Both sets of results rely on the assumption that the instruments are equally efficient, i.e., cause equal *absolute* shifts in supply and demand. What if we assume instead that the instruments cause equal *percentage* shifts? As can be seen in table 4, the effect is dramatic. In particular, CP replaces m-saving TA as the dominant instrument. Moreover, TS moves to second place, except when input substitution is relatively elastic ($\sigma = 0.49$), in which case m-saving TA is slightly more effective than TS (simulation 5).

The reason for the preference reversals is not hard to discern. In particular, as noted earlier, the equal-efficiency hypothesis favors instruments that affect input markets by implying larger percentage shifts in these markets than in the output market. This is especially true in instances where the cost share for the affected market is small. For example, in the present case where $S_x = 0.05$, a 5% increase in retail demand implies a 100% increase in x-factor demand under the equal-efficiency hypothesis. This accounts for the some 20-fold difference in returns for m-saving TA reported in tables 3 and 4.

Returning to table 3, the mean overall B-C ratio of 2.0:1 excludes returns to non-U.S. cotton suppliers, and thus understates total producer benefits. "Foreign" producers supplied 46% of Japan's raw cotton fiber needs over the evaluation period, and since cotton is assumed to be fungible across supply sources, it follows that these producers captured benefits in proportion to their market shares.[9] Including free-rider benefits would inflate the B-C ratio by 1.85 (= 1/0.54) to 3.7:1, which is below the B-C ratios of between 5.4:1 and 6.0:1 reported by Capps et al. for domestic market promotion when benefits are measured at the mill level. However, it compares favorably with the estimates reported by Ding and Kinnucan (p. 363) for the total promotion program (domestic and export market promotion) when the benefits of demand shifts accrue to U.S. taxpayers via lower outlays for deficiency payments.

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[8] Wohlgenant's (1993) analysis, like ours, rests on the assumption that the instruments cause *parallel* shifts in the underlying supply and demand curves. If the curve shifts are nonparallel, a different ranking emerges (Chung and Kaiser).

[9] More precisely, this statement is strictly true only if supply response across supply sources is equal. Specifically, foreign producer benefits are measured by $\Delta PS_F = p_x x_F p_x^*(1 + 0.5x_F^*)$. Comparing this equation with (14), the proportionality statement holds only if $x_F^* = x_{US}^*$, which implies $\varepsilon_F = \varepsilon_{US}$. In the present case, since $\varepsilon_F > \varepsilon_{US}$, the adjusted B-C ratio given below is understated.

Table 4. Instrument-Specific Returns to Cotton Promotion in Japan for Equal *Relative* Shifts in Underlying Supply and Demand Curves, 1993–95

	U.S. Producer Return per Instrument ($ mil.)[b]				
Simulation[a]	CP	Neutral TA	*m*-Saving TA	TS	All[c]
No. 1 Baseline	28.5	0.0	7.3	19.9	28.2
No. 2 ($\eta = 2.0$)	53.7	26.5	7.1	43.9	59.7
No. 3 ($\eta = 0.5$)	14.7	-14.4	7.4	6.8	11.0
No. 4 ($\sigma = 0.10$)	31.1	0.0	3.2	26.3	30.7
No. 5 ($\sigma = 0.49$)	25.2	0.0	12.5	11.8	25.0
No. 6 ($S_x = 0.10$)	27.9	0.0	7.1	18.5	27.3
No. 7 ($\varepsilon_{US} = 0.3$; $\varepsilon_F = 0.6$)	63.1	0.0	16.2	44.3	62.5
No. 8 ($\varepsilon_m = 10.0$)	27.6	0.0	7.3	19.1	27.3
Mean	34.0	1.5	8.5	23.8	33.9
Standard Deviation	16.1	11.3	4.0	13.8	17.8
Benefit-Cost Ratio[d]	0.9:1	0.0:1	0.2:1	0.6:1	0.9:1

[a] Based on text equations (12)–(14). Baseline simulation uses parameter values: $\eta = 1.0$, $\sigma = 0.25$, $S_x = 0.05$, $S_m = 0.95$, $\varepsilon_{US} = 1.1$, $\varepsilon_F = 1.6$, and $\varepsilon_m = 20.0$.

[b] Assumes equal percentage shifts of 5% in the underlying supply and demand curves (see text for details).

[c] Assumes 75% of funds are spent on CP, and 25% on TA and TS.

[d] Mean return divided by total promotion outlay of $37.1 million.

Optimal Allocation

The analysis thus far suggests that returns to cotton promotion in Japan could have been increased by investing relatively more in *m*-saving TA and relatively less in CP. To sharpen these results, and to indicate how the framework can be used to identify an optimal set of government policies with respect to cotton promotion in Japan, we invoke the principle that the budget allocation is optimized when the last dollar invested in each instrument increases the market price for cotton by the same amount, so that:

$$\partial p_x/\partial a = \partial p_x/\partial t_N = \partial p_x/\partial t_B = \partial p_x/\partial s,$$

where the as yet undefined variables t_N and t_B are expenditures, respectively, for neutral and *m*-saving (biased) TA.[10] The above condition applies when all instruments are non-inferior, which is true when $\eta \geq 1$ and $\eta \geq \sigma$ (case 1). If $\eta < \sigma$, TS is inferior and the

[10] That quantity effects are irrelevant to the allocation decision can be seen by examining the first-order conditions of the optimization problem

$$\max_{a,t,s} \pi = p_x x_{US} - \int_0^{x_{US}} S^{-1}(x_{US})\, dz - (a + t_N + t_B + s),$$

where π is U.S. producer surplus net of the cost of promotion (or "profit"), and S^{-1} is the excess supply curve for U.S. cotton written in inverse form, i.e., price as a function of quantity in equation (5). Thus, for example, the first-order condition corresponding to CP is $\partial\pi/\partial a = 0$, which implies that $(\partial p_x/\partial a)x_{US} + p_x(\partial x_{US}/\partial a) - S^{-1}(x_{US})(\partial x_{US}/\partial a) - 1 = 0$. Noting that $p_x = S^{-1}(x_{US})$, the second and third terms cancel, leaving $(\partial p_x/\partial a)x_{US} = 1$. Thus, only the price effect matters. In particular, if the budget is unconstrained, investment in CP is optimized when the last dollar invested yields exactly one dollar in additional export revenue, i.e., $\partial(p_x x_{US})/\partial a = 1$. A similar expression obtains for each of the remaining instruments. Equating these expressions yields the text's optimality condition.

Table 5. Optimal Budget Allocations When Instruments Are Equally Efficient (percent)

Instrument	OPTIMAL ALLOCATION WHEN: $\eta \geq 1$ and $\eta \geq \sigma$ (Case 1)	$\eta \geq 1$ and $\eta < \sigma$ (Case 2)	$\eta < 1$ and $\eta \geq \sigma$ (Case 3)	$\eta < 1$ and $\eta < \sigma$ (Case 4)
	Formulas			
CP	$S_x\eta(\sigma + \varepsilon_m)/\Phi$	$S_x\eta(\sigma + \varepsilon_m)/\Phi'$	$S_x\eta(\sigma + \varepsilon_m)/\Phi''$	$S_x\eta(\sigma + \varepsilon_m)/\Phi'''$
Neutral TA	$S_x(\eta - 1)(\sigma + \varepsilon_m)/\Phi$	$S_x(\eta - 1)(\sigma + \varepsilon_m)/\Phi'$	—[a]	—[a]
m-Saving TA	$\sigma(\eta + \varepsilon_m)/\Phi$	$\sigma(\eta + \varepsilon_m)/\Phi'$	$\sigma(\eta + \varepsilon_m)/\Phi''$	$\sigma(\eta + \varepsilon_m)/\Phi'''$
TS	$S_x(\eta - \sigma)\varepsilon_m/\Phi$	—[a]	$S_x(\eta - \sigma)\varepsilon_m/\Phi''$	—[a]
	Results for Cotton Promotion in Japan			
Baseline:[b]				
CP	0.20	NA	0.09	NA
Neutral TA	0.10	NA	0.00	NA
m-Saving TA	0.53	NA	0.87	NA
TS	0.17	NA	0.04	NA
All	1.00	NA	1.00	NA
σ = 0.10:				
CP	0.28	NA	0.17	NA
Neutral TA	0.14	NA	0.00	NA
m-Saving TA	0.31	NA	0.69	NA
TS	0.27	NA	0.14	NA
All	1.00	NA	1.00	NA

Notes: $\Phi = S_x\eta(\sigma + \varepsilon_m) + S_x(\eta - 1)(\sigma + \varepsilon_m) + \sigma(\eta + \varepsilon_m) + S_x(\eta - \sigma)\varepsilon_m$,
$\Phi' = S_x\eta(\sigma + \varepsilon_m) + S_x(\eta - 1)(\sigma + \varepsilon_m) + \sigma(\eta + \varepsilon_m)$,
$\Phi'' = S_x\eta(\sigma + \varepsilon_m) + \sigma(\eta + \varepsilon_m) + S_x(\eta - \sigma)\varepsilon_m$, and
$\Phi''' = S_x\eta(\sigma + \varepsilon_m) + \sigma(\eta + \varepsilon_m)$.

[a] Instrument has perverse effect, and thus is deleted from the choice set.

[b] Based on parameter values: $S_x = 0.05$, $\sigma = 0.25$, $\varepsilon_m = 20.0$, $\eta = 2.0$ (case 1), and $\eta = 0.5$ (case 3).

condition is modified by deleting $\partial p_x/\partial s$ (case 2). Similarly, if $\eta < 1$, neutral TA is inferior and $\partial p_x/\partial t_N$ is deleted (case 3). The final possibility is that $\eta < 1$ and $\eta < \sigma$, in which case both $\partial p_x/\partial t_N$ and $\partial p_x/\partial s$ are deleted (case 4). The optimization rules for each case in terms of model parameters (derived in the appendix) are provided in table 5. These rules assume that instruments are equally efficient, a maintained hypothesis.

From table 5, only four parameters govern the allocation decision: η, σ, S_x, and ε_m. Since $\eta > \sigma$ in the present analysis, TS is never inferior, which means that cases 1 and 3 apply. In the simulations, we set σ, S_x, and ε_m to baseline levels, and η to extreme values (0.5 and 2.0), since these results suffice to indicate the general pattern. However, to assess how allocations might be affected in a short-run situation where input substitution possibilities are limited, an additional simulation is provided with σ set to 0.10.

Results show m-saving TA receiving the largest budget share for all considered parameter combinations (table 5). However, allocations are sensitive to the demand elasticity. For example, in the baseline with $\sigma = 0.25$, the allocation to m-saving TA increases from 53% to 87% as η decreases from 2.0 to 0.5. If $\sigma = 0.10$, m-saving TA's share increases from 31% to 69% as η decreases to 0.5. Thus, accurate information about the retail demand elasticity is crucial to allocation decisions.

As $\sigma \to 0$, allocations even out, especially when retail demand is elastic. For example, in the extreme case where $\eta = 2.0$ and $\sigma = 0.10$, the optimal budget shares for CP, m-saving TA, and TS differ by only a few percentage points from 29% (table 5, case 1). In this case, as in the others, neutral TA is the least preferred instrument, garnering at most 14% of the budget. Overall, CP's budget share never exceeds 28%, which suggests the current allocation of 75% to demand-pull promotions and 25% to supply-push promotions is inefficient. [In simulations with $\sigma = 0.49$ (not shown), CP's share is less than 14%.] Specifically, results suggest that a 25/75 allocation is about optimal when instruments are equally efficient, which is opposite the actual allocation.

Concluding Comments

The basic theme of this research is that producers and USDA program managers should not be indifferent about the allocation of funds to consumer promotion, technical assistance, and trade servicing. Our analysis, based on an adaptation of Muth's model, suggests that trade servicing and technical assistance in particular need to be evaluated carefully, since under certain conditions these instruments can have a perverse effect.

Key to instrument selection is knowledge of retail demand and input-substitution elasticities for the promoted commodity in the target market. For example, if retail demand is price inelastic, which might be true for many agricultural commodities, especially when "total" demand elasticities are considered (Buse), technical assistance projects that cause neutral technical change should be avoided altogether, since they may cause the derived demand for the agricultural commodity to decrease. Similarly, if middlemen can substitute more easily than consumers ($\sigma > \eta$), which appears to be true for eggs, dairy, and fresh vegetables in the U.S. market (Wohlgenant 1989, p. 250), trade servicing projects should be avoided, since they would tend to decrease the derived demand for the agricultural input.

Few rules-of-thumb beyond these can be extracted from the analysis except perhaps for the intuitive idea that cost shares can be important to instrument choice. For example, for agricultural commodities like cotton or wheat, where marketing inputs account for the bulk of the cost of the finished good (e.g., jeans and bread), activities that lower the relative cost of the marketing input (e.g., by causing m-saving technical change) may be more effective than direct demand promotion. In the more usual case where agricultural input cost shares are relatively large (say 0.3 or above), and retail demand is more elastic than input substitution ($\eta > \sigma$), our analytical model suggests that the preferred instrument in general will be consumer promotion. Thus, the trend toward emphasizing consumer promotion in USDA's budget allocations (Mackie) has some theoretical support.

The theoretical analysis highlights the need for careful record keeping on the part of program managers. In particular, expenditures on the various instruments should be

kept separate to enable researchers to obtain unbiased estimates of program impact. (Such record keeping does not appear to be standard practice at present.) Since some instruments are supply shifters and others are demand shifters in the underlying structural model, and not all instruments have a clear positive effect on derived demand, aggregating the expenditures in general will lead to specification error. This is a point that researchers need to keep in mind when specifying econometric models and interpreting regression coefficients based on data aggregated over the instruments.

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Appendix: Derivation of Optimality Conditions

Consider first the case where all instruments are non-inferior. In this case, allocations are optimized when the following condition is satisfied:

$$\partial p_x/\partial a = \partial p_x/\partial t_N = \partial p_x/\partial t_B = \partial p_x/\partial s.$$

Rewriting the condition in elasticity form yields:

$$(p_x^*/a^*)/a^{\circledast} = (p_x^*/t_N^*)/t_N^{\circledast} = (p_x^*/t_B^*)/t_B^{\circledast} = (p_x^*/s^*)/s^{\circledast}, \tag{A1}$$

where $j^{\circledast}$ ($j = a, t_N, t_B, s$) denotes the expenditure on the jth instrument that maximizes "profit" (see text footnote 10), and the terms in parentheses are reduced-form elasticities. The reduced-form elasticities from text equation (12) are defined as follows:

$$p_x^*/a^* = [\eta(\sigma + \varepsilon_m)/D']\alpha, \tag{A2a}$$

$$p_x^*/t_N^* = [(\eta - 1)(\sigma + \varepsilon_m)/D']\beta, \tag{A2b}$$

$$p_x^*/t_B^* = [\sigma(\eta + \varepsilon_m)/D']\gamma, \tag{A2c}$$

and

$$p_x^*/s^* = [S_m(\eta - \sigma)\varepsilon_m/D']\delta. \tag{A2d}$$

Substituting (A2) into (A1) and imposing the equal efficiency condition $\{\alpha = \beta = S_x\gamma = S_m\delta\}$ yields the optimality condition in terms of model parameters:

$$\text{(A3)} \qquad S_x\eta(\sigma + \varepsilon_m)/a^{\circledast} = S_x(\eta - 1)(\sigma + \varepsilon_m)/t_N^{\circledast} = \sigma(\eta + \varepsilon_m)/t_B^{\circledast} = S_x(\eta - \sigma)\varepsilon_m/s^{\circledast}.$$

Equation (A3) is expressed in terms of expenditure *ratios*. To express the condition in terms of expenditure (or budget) *shares*, define

$$\kappa_j^{\circledast} = j^{\circledast}/\Sigma j^{\circledast},$$

where $\kappa_j^{\circledast}$ is the jth instrument's share of the total promotion budget in profit-maximizing equilibrium. Thus, for example, CP's optimal budget share is:

$$\kappa_a^{\circledast} = a^{\circledast}/(a^{\circledast} + t_N^{\circledast} + t_B^{\circledast} + s^{\circledast}) \Rightarrow 1/\kappa_a^{\circledast} = 1 + t_N^{\circledast}/a^{\circledast} + t_B^{\circledast}/a^{\circledast} + s^{\circledast}/a^{\circledast}.$$

Making the appropriate substitutions from (A3) into the above expression yields:

$$\text{(A4)} \qquad \kappa_a^{\circledast} = S_x\eta(\sigma + \varepsilon_m)/\Phi,$$

where Φ is the sum of (A3)'s numerators as defined in text table 5. Equation (A4) indicates CP's optimal budget share when all instruments are equally efficient and non-inferior. Corresponding expressions for the remaining instruments are derived in a similar manner and are given in text table 5, column 1.

If an instrument is inferior, as is true for neutral TA when $\eta < 1$, and for TS when $\eta < \sigma$, the optimality condition must be adjusted to take into account the reduced choice set. This is accomplished simply by deleting the expression corresponding to the inferior instrument from (A1) [or, equivalently, (A3)], and recomputing the optimal budget share as just described. Text table 5 provides the complete set of formulas for all possible choice sets.