

Optimal Generic Advertising in an Imperfectly Competitive Food Industry with Variable Proportions*

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Abstract

This paper determines the impact of food industry market power on farmers' incentive to promote in a situation where funds for promotion are raised through a per-unit assessment on farm output and food industry technology is characterized by variable proportions. Specifically, building on earlier studies by Azzam and by Holloway, Muth's model is extended to consider the farm-level impacts of generic advertising when downstream firms possess oligopoly and/or oligopsony power and advertising expenditure is endogenous at the market level. Applying the model to the U.S. beef industry, we find that for plausible parameter values market power reduces farmers' incentive to promote. However, the disincentive is moderated by factor substitution, and effectively vanishes as the factor substitution elasticity approaches the retail demand elasticity. This suggests that the Dorfman-Steiner theorem, suitably modified to account for factor substitution, suffices to indicate optimal advertising intensity in the U.S. beef sector.

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Optimal Generic Advertising in an Imperfectly Competitive Food

Industry with Variable Proportions

Consolidation in food retailing and processing over the past two decades has been dramatic. This is especially true in U.S. beef packing, where the four-firm concentration ratio between 1978 and 1994 increased from 0.30 to 0.86 (Sexton, 2000, p. 1087). An issue of growing concern is the implication of this trend for farmers' incentives to invest in generic advertising and other self-help initiatives. Although substantial research has been done to determine the effect of the funding mechanism, trade, export promotion subsidies, and policy interventions on promotion incentives (see, e.g., Freebairn and Alston and the references cited therein), relatively little is known about imperfect competition's effect. The few studies that have been done are empirical in nature (Suzuki *et al.*), focus on monopoly effects (Goddard and McCutcheon; Kinnucan and Thomas; Kinnucan (1999)), or assume that food industry technology is of a fixed proportions or Leontief type (Cranfield and Goddard; Zhang and Sexton). No systematic analysis exists to indicate how oligopoly and/or oligopsony power affects promotion incentives in a situation where food industry technology is characterized by variable proportions.

The latter issue is important because variable proportions appear to hold in the case of the U.S. beef and pork industries (Wohlgenant (1989); see also Goodwin and Brester) where concerns about non-competitive pricing are particularly acute. In these instances, a fixed-proportions framework would tend to prejudice the analysis in favor of large advertising budgets. Moreover, as is demonstrated in this study, disallowing input substitution may cause market power effects to be exaggerated.

The purpose of this research is to determine the optimal advertising-sales ratio for a situation where food industry technology is characterized by variable proportions, middlemen possess market power, and advertising funds are raised through a per-unit assessment on farm output. A secondary objective is to determine advertising's ability to neutralize the adverse effects of market power on producer welfare. The

analysis is based on a Muth-type model that in essence combines Holloway's model of oligopoly behavior with Azzam's model of oligopsony behavior. An advantage of this formulation is that a derived "demand" curve for farm output can be obtained that shows clearly how advertising shifts this curve when the price of marketing services is endogenous. A key result is that market power tends to reduce promotion incentives, but that the attenuation is moderated by factor substitution.

Model

Consider an industry that combines a farm-based input a with a bundle of marketing inputs b to produce a retail product x under conditions of constant returns to scale (CRTS). Firms in the industry take the price of marketing services P_b as given, but have sufficient market presence to influence the price of the farm-based input P_a , and the price of the retail product P_x . That is, downstream firms exercise oligopoly power in the x market and oligopsony power in the a market, but are individually too small in relation to the total food economy to influence P_b . Consumer demand for the industry's product is separable from other goods such that substitution effects can be ignored, at least as a first approximation. The farm sector raises A dollars for promotion via a tax of T dollars per unit on farm marketings. Thus, advertising expenditures at the industry level is endogenous, dependent on farm output. The economy is closed and prices are determined without government interference.

With these assumptions initial equilibrium in the channel is defined as follows:

$$x = D(P_x, A) \quad (\text{demand for } x) \quad (1)$$

$$x = f(a, b) \quad (\text{CRTS production function}) \quad (2)$$

$$P_a (1 + \Omega) = P_x f_a (1 - \Psi) \quad (\text{demand for } a) \quad (3)$$

$$P_b = P_x f_b (1 - \Psi) \quad (\text{demand for } b) \quad (4)$$

$$P_a = g(a) + T \quad (\text{supply of } a) \quad (5)$$

$$P_b = h(b) \quad (\text{supply of } b) \quad (6)$$

$$A = T a \quad (\text{advertising budget}) \quad (7)$$

where f_i ($i = a, b$) are a 's and b 's marginal products; $\Psi = \xi/\eta$ is the Lerner index that denotes oligopoly power where η is the absolute value of the retail demand elasticity, and $\xi \in [0,1]$ is the output conjectural elasticity ($\xi = 0$ for perfect competition and $\xi = 1$ for pure monopoly); $\Omega = \theta/\varepsilon_a$ is the Lerner index to denote oligopsony power where ε_a is the supply elasticity for a , and $\theta \in [0,1]$ is the input conjectural elasticity ($\theta = 0$ for perfect competition and $\theta = 1$ for pure monopsony).

The foregoing model is similar to Zhang and Sexton's in that both oligopsony and oligopoly power are considered within a single framework. However, it is more general in that the assumption of fixed proportions is relaxed, and the price of marketing inputs is treated as endogenous at the industry level. That is, although individual firms in the industry are too small to affect P_b , collectively the firms account for a sufficiently large portion of the total food economy so that industry-wide changes in the demand for b influence P_b . The same distinction applies to A . Specifically, (3) and (4) are based on the assumption that advertising expenditure is endogenous at the industry level, but not at the firm level. That is, downstream firms make input choices without regard to the fact that such choices might affect the level of generic advertising. To the extent that this is not true, the model will tend to *understate* optimal advertising expenditure.¹ (The importance of this potential understatement is analyzed later.) Equations (1) - (6) reduce to Holloway's model when $\Omega = 0$ and to Azzam's model when $\Psi = 0$. Thus, the present model subsumes these earlier models as special cases.²

The model consists of seven endogenous variables (P_x, P_a, P_b, x, a, b , and A), one exogenous variable (T), and four parameters (ξ, θ, η , and ε_a). Following the standard assumption of models of this type (see, e.g., Muth; Gardner), the parameters are treated as fixed constants. Thus, Ψ and Ω are properly interpreted as exogenous variables. In this sense our model is less general than Zhang and Sexton's model in that the latter model permits η to adjust in response to advertising or market-power induced changes in equilibrium quantity. Although endogenizing η is a useful refinement, it should not affect results significantly provided equilibrium displacements are small or the retail demand curve is of the constant-

elasticity type in the relevant range.³

The derived “demand” curve for farm output

The first task is to derive an expression that under certain conditions can properly be interpreted as the derived curve for farm output. For this purpose, and following Muth, we begin by expressing (1) - (7) in percentage changes as follows:

$$x^* = -\eta P_x^* + \beta A^* \quad (1')$$

$$x^* = \kappa_a' a^* + (1 - \kappa_a') b^* \quad (2')$$

$$P_a^* = -[(1 - \kappa_a')/\sigma] a^* + [(1 - \kappa_a')/\sigma] b^* + P_x^* - \eta_\Psi \Psi^* - \varepsilon_\Omega \Omega^* \quad (3')$$

$$P_b^* = (\kappa_a'/\sigma) a^* - (\kappa_a'/\sigma) b^* + P_x^* - \eta_\Psi \Psi^* \quad (4')$$

$$P_a^* = (1/\varepsilon_a) a^* + \tau T^* \quad (5')$$

$$P_b^* = (1/\varepsilon_b) b^* \quad (6')$$

$$A^* = T^* + a^* \quad (7')$$

where the asterisked variables indicate relative change (e.g., $x^* = dx/x$); β is the advertising elasticity; $\kappa_a' = S_a (1 + \Omega)/(1 - \Psi)$ is factor a 's cost share inclusive of oligopsony and oligopoly rent, hereafter referred to as the “value-share” term;⁴ σ is the Hicks-Allen factor substitution elasticity; $\eta_\Psi = \Psi/(1 - \Psi)$ and $\varepsilon_\Omega = \Omega/(1 + \Omega)$ are elasticities that indicate the percent vertical shift in input demand curves (3) and (4) per 1% change in the respective market power indices holding constant output price; $\tau = T/P_a$ is the advertising tax expressed as a fraction of the initial equilibrium farm price; and ε_b is the supply elasticity for marketing services.

In this study all parameters are assumed to be positive, i.e., retail demand is downward sloping ($-\eta < 0$); advertising shifts the retail demand curve to the right ($\beta > 0$); the input supply curves are upward-sloping ($\varepsilon_a > 0$ and $\varepsilon_b > 0$); and food industry technology exhibits variable proportions ($\sigma > 0$). Importantly, the farm-share term $S_a = P_a a/P_x x$ is evaluated at the initial equilibrium point; thus, the value-share term κ_a' in (2') - (4') is properly interpreted as a fixed constant, as is τ in (5').

The derived “demand” curve for farm output is obtained by dropping (5') and (7') (since we want to treat farm price and advertising expenditures as temporarily exogenous) and solving the remaining equations simultaneously for a^* to yield:

$$a^* = - [(\varepsilon_b \lambda + \eta \sigma)/D] P_a^* + [\beta (\varepsilon_b + \sigma)/D] A^* - [\eta_\Psi \eta (\varepsilon_b + \sigma)/D] \Psi^* - [\varepsilon_\Omega (\varepsilon_b \lambda + \eta \sigma)/D] \Omega^* \quad (8)$$

where $\lambda = (\kappa_a' \eta + (1 - \kappa_a') \sigma)$ and $D = (\varepsilon_b + \kappa_a' \sigma + (1 - \kappa_a') \eta) > 0$. Since P_a^* 's coefficient is negative under the stated assumptions, the derived “demand” curve is downward sloping, as might be expected.

Also, A^* 's coefficient is positive and Ψ^* 's coefficient is negative, which means that a simultaneous increase in advertising and oligopoly power shifts the derived “demand” curve in opposite directions. This, too, is in accordance with economic logic.

If P_b is exogenous, as is assumed by Zhang and Sexton and by Wohlgenant (1993), equation (8) reduces to:

$$a^* = - \lambda P_a^* + \beta A^* - \eta_\Psi \eta \Psi^* - \varepsilon_\Omega \lambda \Omega^*. \quad (8a)$$

In this case P_a^* 's coefficient is simply $-\lambda$, which is equivalent to Waterson's expression for the market elasticity of derived demand when $\Omega = 0$, and to Allen's expression when $\Psi = \Omega = 0$ (see, e.g., Bronfenbrenner, p. 259). Thus, in these instances (8) and (8a) may be interpreted as the derived demand curve for farm output without qualification. In instances where $\Omega > 0$ the derived demand curve collapses to a single point when $\theta = 1$ (pure monopsony), and thus the curve is ill-defined. Nonetheless, henceforth we will ignore this technicality, since no harm is done provided this qualification is borne in mind (see, e.g., Friedman p. 190). Because previous analysis suggests treating P_b as exogenous has no important effect on promotion incentives (Kinnucan, 1997), the remaining analysis will focus on (8a) unless indicated otherwise.

Interpretation of Coefficients

Ψ^* 's coefficient in (8a) (and (8)) is equal and opposite in sign to A^* 's coefficient when $\eta_\Psi = \beta/\eta$. This

implies that generic advertising's ability to offset oligopoly power hinges on the β/η ratio. What is interesting about this result is that β/η is equivalent to Dorfman and Steiner's rule for optimal advertising. Specifically, the D-S theorem states $\bar{\phi} = \beta/\eta$, where $\bar{\phi}$ is the optimal advertising intensity (advertising expenditure divided by industry revenue) for a monopoly with fixed output. Alston, Carman, and Chalfant [hereafter ACC] show that the same condition applies to a competitive industry that raises funds for promotion through a per unit tax.

This result is useful because it can be used to quantify β/η , which, in turn, provides a basis for assessing advertising's ability to offset oligopoly power. In particular, the observed intensity in the U.S. beef industry is 0.056% (Table 1). Since the beef program is mandatory, i.e., all producers must contribute to the checkoff regardless of their individual support for the program, one might argue that the observed intensity is close to the economic optimum, since the free-rider problem is minimized.⁵ With this in mind, let us generously suppose that the optimal intensity for U.S. beef is twice the observed intensity so that $\bar{\phi} = 0.11\%$. This would imply that β/η for beef has an upper limit of 0.0011. Setting $\eta = 0.56$ (Brester and Schroeder's estimate for beef) and $\xi = 0.10$ (our upper-bound estimate of the output conjectural elasticity for beef, as discussed later) yields $\Psi = 0.18$, which implies that $\eta_\Psi = \Psi/(1 - \Psi) = 0.22$. With these parameter values, (8a) suggests that to neutralize a 1% increase in oligopoly power, U. S. beef producers would need to increase generic advertising expenditures by at least 200%! Although hypothetical, this example hints at the potential importance of market power for producer welfare. It suggests that from the producer perspective generic advertising is a weak offset to oligopoly power.

Turning to oligopsony power, Ω^* 's coefficient in (8a) is proportional to the derived demand elasticity (P_a^* 's coefficient). This implies that things that make retail demand more (less) price elastic tend to magnify (attenuate) oligopsony power's effect at the farm level. Stated differently, as farm supply becomes less elastic in relation to retail demand, the farm-level impact of the oligopsony distortion is accentuated. Thus, for example, in Zhang and Sexton's simulation work where the retail demand curve is

linear, η increases *pari passu* with increases in oligopsony power (since equilibrium quantity is reduced). In this case, a larger reduction in the “demand” for farm output would occur than would be true if the retail demand curve were of the constant elasticity type (as is implicitly assumed here).

What of oligopsony and oligopoly’s power relative impact? To answer this, let $\Psi = \Omega = 0.18$ so that the distortions are equivalent. In this case, $\varepsilon_{\Omega} = \Omega/(1 + \Omega) = 0.15$, which is less than $\eta_{\Psi} = 0.22$. This implies from (8a) that under the stated assumptions oligopoly power always has a *larger* effect on farm-level “demand” than comparable oligopsony power, provided $\eta \geq \lambda$ (sufficient condition). The latter condition always holds when $\eta \geq \sigma$, as appears to be true for the beef, pork, and poultry industries in the United States (Wohlgenant, 1989, p. 250).

Returning to the advertising effect, A^* ’s coefficient in (8a) is simply the advertising elasticity β . This means that if P_b is indeed exogenous, as is commonly assumed (e.g., Wohlgenant 1993), then the advertising-induced demand shift at the farm level is identical to the shift at retail. However, if P_b is endogenous, the demand shifts at the two market levels in general are not identical. In particular, letting $E_{a,A} = \beta (\varepsilon_b + \sigma)/D$, A^* ’s coefficient in (8), it can be shown that $E_{a,A} = \beta$ only in the special case where $\eta = \sigma$. For U.S. meats where $\eta > \sigma$, we have $E_{a,A} < \beta$, which means the advertising elasticity *overstates* the farm-level demand shift when P_b is endogenous, as might be expected because then there is price rationing in the b market.

Market Power and the Derived Demand Elasticity

As alluded to in connection with the D-S theorem, an industry’s incentive to promote is inversely related to the absolute value of the demand elasticity. Thus, it is of some interest to know how changes in food industry market power might affect λ , since this parameter is pivotal in determining farmers’ incentive to invest in demand-strengthening activities.

The general conclusion to be drawn from such an analysis is that the effect is ambiguous. To gain insight into the problem, it is useful to analyze the special case where S_a is fixed at its initial equilibrium

point (so that the entire burden of equilibrating adjustments falls on S_b). In this special case, the derived demand elasticity may be written as follows:

$$\lambda = \kappa_a' \eta + (1 - \kappa_a') \sigma. \quad (9)$$

where $\kappa_a' = S_a^\circ (1 + \Omega)/(1 - \Psi)$ and S_a° is the fixed farm share value. Taking the partial derivative (9) with respect to the Lerner indices, bearing in mind that η , σ , and ε_a are herein treated as fixed constants, yields:

$$\partial \lambda / \partial \Omega = [S_a^\circ / (1 - \Psi)] (\eta - \sigma)$$

$$\partial \lambda / \partial \Psi = [S_a^\circ (1 + \Omega) / (1 - \Psi)^2] (\eta - \sigma)$$

Since the terms in brackets are always positive, whether λ increases or decreases with increases in market power in this special case depends crucially on the relative magnitudes of η and σ . In particular, if $\eta > \sigma$, which implies that a and b are gross complements (see, e.g., Alston and Scobie) the signs of the above derivatives under the stated assumptions are always positive. In this case, an increase in either oligopoly or oligopsony power always reduces the incentive to promote. The opposite obtains if $\eta < \sigma$, meaning that a and b are gross substitutes.

Although these results must be treated with caution given the simplifying assumptions, it is interesting to note that they are consistent with Zhang and Sexton's analysis, which shows an inverse relationship between the optimal advertising-sales ratio and oligopoly/oligopsony power when a and b are perfect complements ($\sigma = 0$). Since Wolgenant (1989, p. 250) finds that $\eta < \sigma$ for eggs, fresh vegetables, and dairy, the finding that market power may *enhance* farmers' incentive to promote when a and b are gross substitutes is more than a theoretical curiosity. In particular, it suggests that factor substitution may play an important role in moderating market power's effect on promotion incentives, an issue to be addressed in detail later.

Effects of a Change in η on Derived Demand

Quilkey *inter alia* argues that generic advertising's main effect is to alter the demand elasticities (price and income) for the goods in question. Thus, it is of some interest to know how such alterations would affect

farm-level demand in the presence of oligopoly power.

To address this issue we first express (8) in simplified notation as follows:

$$a^* = -E_{a, Pa} P_a^* + E_{a, A} A^* - E_{a, \Psi} \Psi^* - E_{a, \Omega} \Omega^* \quad (8')$$

where $E_{a, Pa}$, $E_{a, \Psi}$ and $E_{a, \Omega}$ are short-hand expressions for the corresponding coefficients given in (8) expressed as absolute values. Then, taking advantage of the fact that $\Psi^* = \xi^* - \eta^*$ and setting $\Omega = 0$ (to focus attention on oligopoly power), the above equation may be written equivalently as:

$$a^* = -E_{a, Pa} P_a^* + E_{a, A} A^* - E_{a, \Psi} (\xi^* - \eta^*). \quad (8'')$$

From (8'') an increase in the retail demand elasticity has an equal and opposite effect on farm-level demand as an increase in the output conjectural elasticity.

This implies that an advertising campaign designed to make retail demand less price elastic may be counterproductive in the presence of oligopoly power in that it would tend reduce demand at the farm level. However, there is a countervailing effect in that a decrease in η decreases λ , *ceteris paribus*, which, in turn, increases the incentive to promote, as shown later. The net effect of a change in η on promotion incentives in the presence of oligopoly power, therefore, is an empirical issue.

Optimal advertising tax and intensity

The analysis thus far has considered the relationship between market power and promotion incentives by focusing on a 's quasi-reduced form. To sharpen these results, we now develop an expression for the optimal tax rate, i.e., the rate that maximizes producer surplus when the monies generated by the tax are spent entirely on generic advertising. Conveniently, the expression that defines the optimal tax rate also defines the optimal advertising intensity. Thus, analysis of the expression for the optimal tax *rate* (per-unit levy divided by farm price) also provides information about the optimal advertising intensity.

To derive the optimality condition, we first need to know how a simultaneous increase in the tax and advertising expenditure will affect demand at the farm level when price effects are taken into account. For this purpose, we substitute (5') and (7') into (8') to obtain the reduced-form equation for farm quantity:

$$a^* = [\varepsilon_a (E_{a,A} - \tau E_{a,Pa})/D'] T^* + - [\varepsilon_a E_{a,\Psi}/D'] \Psi^* - [\varepsilon_a E_{a,\Omega}/D'] \Omega^* \quad (10)$$

where $D' = (\varepsilon_a (1 - E_{a,A}) + E_{a,Pa})$. Equation (10) indicates the *net* effects of changes in the exogenous variables on equilibrium farm output, i.e., the effects that take into account induced changes in farm price and advertising expenditure. Under the maintained hypothesis that $D' > 0$, the coefficients of Ψ^* and Ω^* in (10) have the same signs as the corresponding coefficients in (8). This means that endogenizing farm price and advertising expenditure affects the magnitude, but not the direction, of the market-power effects.

T^* 's coefficient in (10) is key from the standpoint of optimizing behavior. This coefficient, which is properly interpreted as a reduced-form elasticity, has an uncertain sign. The reason is that the coefficient represents the net effect on equilibrium farm quantity of a simultaneous shift in supply and demand, with the curves shifting in opposite directions. Thus, the critical question is whether the demand shift induced by the advertising expenditure exceeds the supply shift induced by the tax.

With this in mind, the optimal tax rate can be derived from (10) by invoking the condition developed by Alston, Carman, and Chalfant (p. 157), which states:

[T]he check-off [advertising tax] will be optimized when an increase in the check-off yields an additional vertical shift in demand of the same amount per unit so that, at the margin, the combined advertising and check-off will have no net effect on quantity and $\partial q/\partial t = 0$.

To apply this condition, we set $\Psi^* = \Omega^* = 0$ (since we want to isolate the tax effect), and solve (10) for τ when $a^*/T^* = 0$ to obtain:

$$\bar{\tau} = E_{a,A}/E_{a,Pa}$$

where $\bar{\tau}$ is the tax rate ($= \bar{T}/P_a^o$) that maximizes producer surplus when the tax proceeds are invested entirely in promotion. Substituting the parameter values from (8) into the above relation yields:

$$\bar{\tau} = \beta (\varepsilon_b + \sigma)/(\varepsilon_b \lambda + \eta \sigma), \quad (11)$$

From (11) the optimal tax rate is directly related to the advertising elasticity β , and inversely related to the retail and derived-demand elasticities η and λ , as might be expected based on the D-S theorem.

That (11) is equivalent to optimal intensity can be seen by noting that:

$$\bar{\tau} = \bar{\tau}a/a = \bar{T}a/(P_a a) = \bar{A}/(P_a a) = \bar{\phi}_F$$

where \bar{A} is the optimal advertising expenditure in imperfectly competitive equilibrium, and $\bar{\phi}_F$ is the optimal advertising intensity defined in terms of *farm* value. Since optimal intensity and optimal tax rate are synonymous, we will henceforth refer to (11) as optimal intensity.

Importantly, (11) generalizes the D-S theorem (and thus ACC's result) in that it takes into account the marketing channel. In addition, it is more general than Zhang and Sexton's condition (p. 12, equation (15')) in that it permits factor substitution and does not require that P_b be exogenous. However, as noted (11) assumes that η is a fixed constant and does not account for the advertising feedback effect. The relative importance of these restrictions can be determined by considering (11)'s analogue when P_b is exogenous:

$$\bar{\phi}_F' = \beta/\lambda = (1 - \Psi) \beta/[S_a (1 + \Omega) \eta + S_b \sigma]$$

where $S_b = 1 - \Psi - S_a (1 + \Omega)$ is factor b 's rent-exclusive cost share. Multiplying this expression through by $(P_a a)/(P_x x)$ yields:

$$\bar{\phi}_R' = (1 - \Psi) \beta/[(1 + \Omega) \eta + \bar{\omega} \sigma] \quad (12)$$

where $\bar{\phi}_R' = \bar{A}/(P_x x)$ is optimal intensity expressed in terms of *retail* value and $\bar{\omega} = S_b/S_a$ is the cost-share ratio.

By way of comparison, ZS's condition (p. 13) for the case in which η is fixed in our notation is:

$$\bar{\phi}_R^{ZS} = (1 - \Psi + \Psi\beta) \beta/\eta. \quad (13)$$

Comparing (12) and (13) and setting $\Omega = 0$ we see that (12) understates the optimal intensity under fixed proportions, since the feedback term $\Psi\beta$ in (13) is positive in sign. However, since $\Psi < 1$ and β is generally less than 0.05 (see, e.g., Ferrero *et al.*) the degree of understatement in most cases is negligible.

Since market power reduces equilibrium quantity, η in general is expected to increase with increases in market power unless the retail demand curve is a rectangular hyperbola in the relevant range.

Thus, it is of some interest to know how such changes would affect optimal intensity. Since results are qualitatively similar for (12) and (13), we focus on the simpler expression (13), which yields the following derivative:

$$\partial \bar{\phi}_R^{ZS} / \partial \eta = \beta [2 \Psi (1 - \beta) - 1] / \eta^2.$$

From this expression η 's effect is uncertain. In particular, the inverse relationship between optimal intensity and η indicated by the D-S theorem holds only if oligopoly power is sufficiently weak such that $\Psi < 1/[2(1 - \beta)]$. The reason is that an increase in η has two apposing effects: it benefits producers by attenuating the oligopoly distortion, but is also harms producers by weakening advertising's price effect. The upshot is that, owing to the offsetting effects, treating η as a constant should be relatively innocuous when evaluating promotion incentives.

Returning to (12), under fixed proportions ($\sigma = 0$) an increase in either oligopoly or oligopsony power always reduces optimal intensity, which is consistent with ZS's analysis. This simple relationship, however, no longer holds under variable proportions. The reason is that the cost-share ratio $\bar{\omega}$ comes into play when $\sigma > 0$, and this ratio may either increase or decrease with changes in market power. Specifically, letting $\zeta = (1 + \Omega) \eta + \bar{\omega} \sigma$ and taking the partial derivative of (12) with respect to the Lerner indices yields:

$$\partial \bar{\phi}_R' / \partial \Psi = - \beta [\zeta + \sigma (1 - \Psi) (\partial \bar{\omega} / \partial \Psi)] / \zeta^2$$

$$\partial \bar{\phi}_R' / \partial \Omega = - \beta (1 - \Psi) [\eta + \sigma (\partial \bar{\omega} / \partial \Omega)] / \zeta^2.$$

From these expressions, an increase in market power has an unambiguously negative effect on promotion incentives only if $\partial \bar{\omega} / \partial \Psi$ and $\partial \bar{\omega} / \partial \Omega$ are positive in sign. In the present analysis where these derivatives are negative (since S_a is held constant at its initial equilibrium level), the effect is uncertain, and thus is an empirical issue.

That factor substitution plays an important role in promotion incentives can perhaps be best appreciated by noting that when $\Omega = \Psi = 0$ condition (12) reduces to:

$$\bar{\phi}_R^{DS} = \beta / [\eta + ((1 - S_a)/S_a) \sigma] \quad (14)$$

where $\bar{\phi}_R^{DS}$ is hereafter called the “modified D-S theorem.” In particular, (14) indicates optimal advertising intensity in competitive equilibrium when P_b is exogenous and marketing technology is variable proportions. Since for most farm products $\eta < 1$, $(1 - S_a)/S_a > 1$ (USDA, ERS), and $0.25 < \sigma < 1$ (Wohlgenant, 1989), (14) suggests that even modest departures from fixed proportions could significantly weaken farmers’ incentive to promote. Whether such departures are important in determining promotion incentives in the presence of imperfect competition is an empirical issue to which we now turn.

Application to U.S. beef industry

To demonstrate the model’s empirical utility, and to gain further insight into the importance of factor substitution, we applied (11) to the U.S. beef industry using parameter values as indicated in Table 1. The beef industry is a useful case study because its promotion program is the third largest in the United States (after dairy and citrus, see Forker and Ward), the four-firm concentration ratio is high (above 0.86), and considerable research has been done to estimate market power and related parameters. Moreover, the model’s assumptions (variable proportions, constant returns to scale, and a closed economy) are approximated in this instance (Wohlgenant, 1989, 1993).⁶ In 1998, the base year for our analysis, the industry invested \$28.3 million in generic advertising. The retail value of beef in that year was \$50.8 billion, which yields an observed advertising intensity of 0.056%. At issue is whether this intensity is too high or low, and the effect of market power on the optimal intensity in the presence of factor substitution.

Parameterization

Since η and σ are critical in terms of assessing market power’s effect on promotion incentives, we entertain a range of values for these parameters. Specifically, η is set alternatively to 0.78, 0.56, and 0.42; 0.78 is the value used by Wohlgenant (1993); the latter two values were estimated respectively by Brester and Schroeder, and by Kinnucan *et al.* For σ we used selected values ranging from zero to 0.72, Wohlgenant’s (1989, p. 250) estimate of this parameter. We choose 0.72 as σ ’s upper limit to address Sexton’s concern

(2000, p. 1095, fn. 14) that empirical estimates of factor substitution elasticities may be overstated due to the use of highly aggregated data.

Despite the attention given to estimating market power parameters for U.S. beef, the estimates remain controversial. For example, Muth and Wohlgenant reject the hypothesis of market power, while Azzam and Schroeter find at least a mild degree of price exploitation. In his 1998 study of captive beef supplies, Azzam used 0.06 as an upper-limit value for θ , and seemed to prefer a value of 0.03 for this parameter. Based on this, and Sexton's (2000) view that empirical estimates of market power parameters are probably understated, we set $\theta \leq 0.10$. As for oligopoly power, the empirical literature suggests that oligopoly power in the beef marketing channel is probably less than oligopsony power, especially when successive oligopsony is considered (Schroeter, Azzam and Zhang). Thus, in this study we assume that $\xi \leq \theta$.

Perhaps as controversial is the generic advertising elasticity for beef. Some studies find β to be positive and statistically significant (Ward and Lambert), while others find the parameter to be insignificant or fragile (Brester and Schroeder; Kinnucan et al.). In an attempt to reconcile these findings, Coulibaly and Brorsen found that results are sensitive to model specification, lag structures, and data sources. With this in mind, we use $\beta = 0.0005$ as a "best-bet" value, since it is in line with estimates obtained in Coulibaly and Brorsen's study. However, to test the sensitivity of results to this parameter, we conduct an additional simulation with $\beta = 0.0011$, Kinnucan *et al.*'s most optimistic point estimate.

The farm supply elasticity is set to $\varepsilon_a = 0.15$, the value used in Wohlgenant's (1993) study. Since this elasticity plays a limited role in the optimality condition, and its value is relatively non-controversial, no sensitivity analysis is done on this parameter. The marketing services' supply elasticity in Wohlgenant's (1993) study was assumed to be infinity. Here we set $\varepsilon_b = 2.0$, a value that seemed to be preferred by Gardner. However, given the wide range of values used in the literature, we set ε_b alternatively to one and infinity to gauge the sensitivity of results to this parameter. The farm cost-share parameter is set to $S_a =$

0.472, USDA's estimate of this parameter for 1998.

Results

To establish a baseline we set $\theta = 0.05$ to indicate oligopsony power and $\xi = 0.05$ to indicate oligopoly power. Based on these parameter values, market power has a pronounced effect on producers' incentive to promote under fixed proportions, but considerably less impact under variable proportions for values of σ beyond about 0.25 (Table 2). For example, in scenario 1 where $\beta = 0.0005$ and $\eta = 0.78$, if $\sigma = 0$ the optimal/actual intensity ratios range from 1.23 under perfect competition to 0.87 under combined oligopoly/oligopsony power, a 29% reduction. If $\sigma = 0.25$ the corresponding range is from 0.86 to 0.73, a 15% reduction. For values of σ above about 0.50 market power's effect on promotion incentives is effectively neutralized.

Comparing oligopoly and oligopsony power, for equal conjectures ($\theta = \xi$) the latter has a larger impact on promotion incentives, as might be expected since $\varepsilon_a < \eta$. For example, under scenario 2 where $\beta = 0.0005$ and $\eta = 0.56$, if $\sigma = 0.25$ the intensity ratio declines from 1.10 to 1.06 under oligopoly to 0.99 under oligopsony, the latter being sufficient to indicate overspending. If consumers are relatively responsive to promotion such that $\beta = 0.0011$ and $\eta = 0.56$ (scenario 4) and $\sigma = 0.25$, oligopsony power reduces the intensity ratio from 2.41 to 2.18, compared to 2.34 for oligopoly power. In this case, the combined effect of oligopoly and oligopsony power is to depress the intensity ratio to 2.11, which is only slightly below the ratio for oligopsony alone. Bearing in mind that empirical evidence suggests that $\theta > \xi$ for beef, these results suggest that oligopsony power exerts the stronger influence on promotion incentives in the beef marketing channel.

Overall it appears that in the case of beef market power is not an important determinant of promotion incentives, at least for the levels of market power contemplated in this study. Much more important are the advertising elasticity, the retail demand elasticity, and the factor substitution elasticity itself. For example, if $\sigma > 0.50$, the 1998 spending level of \$28.3 million would be considered excessive

for values of η greater than about 0.5 when $\beta = 0.0005$, our “best-bet” advertising elasticity. Conversely, if $\beta = 0.0011$, Kinnucan et al.’s most optimistic estimate of this parameter, intensity ratios are uniformly greater than one when $\eta = 0.56$ (the parameter’s middle estimate), which would suggest that the observed expenditure level is too low. For example, in this instance and setting $\sigma = 0.72$ (Wohlgenant’s (1989) estimate) the intensity ratios range from 1.61 for perfect competition to 1.68 for oligopoly/oligopsony power, which suggests an approximate 60% budget augmentation would be needed to reach the economic optimum.

Sensitivity Analysis

To shed further light on interplay between factor substitution and promotion incentives in the presence of market power, we conducted sensitivity analysis by setting $\beta = 0.0005$ and $\eta = 0.56$, our “best-bet” values for these parameters, and varying σ , ε_b , ξ , and θ as indicated in Table 3. Specifically, we set σ alternatively to 0.1 and 0.3, values that would appear to be appropriate for a short-run time horizon, say one year or less. Similarly, ε_b is set alternatively to one and infinity, values that encompass the baseline value of 2.00 and reflect the exogeneity assumption that underlies Wohlgenant’s (1993) and Zhang and Sexton’s analyses. The conjectural elasticities are varied between 0.01 and their posited upper limits of 0.10 in selected steps to identify more clearly market power effects in the short-run time horizon contemplated here.

Results suggest treating P_b as exogenous is innocuous (Table 3). In particular, although optimal/actual intensity ratios with ε_b , the increases are too small to be of consequence. This result, which is consistent with results obtained by Kinnucan (1997) in a multi-market context, suggests that the simpler expressions from the analytical model [(12) and (14)] are adequate for determining optimal intensity.

Turning to the effect of market power on promotion incentives, the main point of this exercise, it can be seen that σ is a pivotal parameter. In particular, if $\sigma = 0.3$ the intensity ratios are predominately below unity, meaning that program is probably over-funded. Conversely, if $\sigma = 0.1$ the intensity ratios are

mostly greater than unity, implying the opposite. Comparing tables 2 and 3, perhaps most striking is the fact that even modest departures from fixed proportions can have a pronounced influence on promotion incentives, both in terms of lowering the optimal intensity, and in terms of attenuating the market power effect. This suggests that accurate estimation of σ could have significant payoffs in terms of improved promotion decisions.

Given the attenuation in the market power effect associated with factor substitution, the question arises as to whether the D-S rule, modified to account for factor substitution, might be adequate for defining optimal intensity. To determine this, and to determine the importance of including the “feedback effect” in the analysis, we simulated (12) - (14) for alternative values of σ ranging from 0 to 0.7 with remaining parameters set to values as indicated in table 4, note a. Focusing first on the case where $\sigma = 0$, (12) and (13) both give an optimal intensity of 0.0733%. Thus, the feedback effect is negligible, as claimed. Turning to (14), the modified D-S rule gives an optimal intensity of 0.0893% when $\sigma = 0$. Since (14) ignores market power, the modified D-S rule overstates optimal intensity by 22% in this instance for the considered parameter values. However, this overstatement decreases steadily with increases in σ away from zero, and becomes negligible for $\sigma \geq 0.4$. Thus, in the case of U.S. beef it appears that the D-S rule, suitably modified to account for factor substitution, suffices to indicate optimal intensity. Conversely, a rule that includes market power but excludes factor substitution would cause optimal intensity to be overstated by a non-trivial amount for $\sigma \geq 0.4$ (compare last two columns in table 4).

Concluding comments

The basic theme of this paper is that substitution possibilities in the marketing channel play an important role in determining farmers’ incentive to promote. Building on this theme, we develop a model of oligopoly/oligopsony power in a multi-stage production system that includes fixed proportions (Leontief) technology as a special case. Results suggests that food industry market power does indeed influence promotion incentives at the farm level, as previous research suggests. However, our analysis suggests that

the factor substitution elasticity σ plays pivotal role. In particular, the inverse relationship between market power and promotion incentives found (for example) in Zhang and Sexton's study is attenuated when $\sigma > 0$. In fact, the attenuation is such that for plausible parameter values the Dorfman-Steiner rule, suitably modified to account for factor substitution, suffices to indicate optimal advertising intensity in the U.S. beef sector.

Although accounting for market power does not appear to be important in determining promotion incentives in the U.S. beef sector, this does not mean that market power *per se* is unimportant. In particular, study results suggest that owing to the inelastic demand for beef, even a modest degree of oligopoly power (as measured by the Lerner index) can have significant negative effects on demand at the farm level. Moreover, since beef's advertising elasticity is minute (less than 0.0012 according to recent econometric work), increases in oligopoly power would tend to swamp advertising effects at the farm level. In fact, if generic advertising made retail demand less price elastic, as might be expected if the ads emphasized product differentiation, the advertising might be counterproductive in that the oligopoly distortion would be exacerbated. Empirical evidence to date suggests beef advertising has not affected the demand elasticity (Brester and Schroeder, pp. 975-76). Still, this is a point that program managers might want to bear in mind when developing future ad campaigns.

A caveat in interpreting our results is that they are based on the assumption that the retail demand elasticity is unaffected by changes in market power. Although we do not believe this assumption to be limiting, it needs to be tested before one can have complete confidence in the accuracy of the results. In the meantime, study results showing a strong inverse relationship between optimal intensity and σ suggest that taking into account factor substitution could lead to improved generic advertising decisions. The model presented in this paper provides a framework for analyzing such decisions in instances where middlemen possess market power, advertising funds are raised through a per-unit assessment on farm output, and the price of marketing services is endogenous.

Footnotes

¹ I thank Richard Sexton and Mingzia Zhang for pointing this out. As shown in an appendix available from the author, firm-level endogeneity requires that (3) be replaced with $P_x f_a (1 - \Psi) = P_a (1 + \Omega - \Phi)$ where $\Phi = \beta \Psi / S_a$ is an advertising “feedback” term. Since this term is vanishingly small in the present analysis, it can be safely ignored.

² Technically, the present model reduces to Azzam’s model for the case where open-market and captive supplies in the latter model are perfect substitutes. In verifying this reduction, I discovered an error in Azzam’s model that was graciously confirmed by the author. Specifically, referring to page 78, equation (13) of Azzam’s paper, the $(1 + \Omega)$ term that multiples \hat{a} ’s coefficient is errant and should be deleted. In addition, there appears to be an error (probably typographic) in Holloway’s model, which, if not corrected, will frustrate attempts to reduce (1) - (6) to that model. In particular, Holloway (p. 983) defines the value-share terms as $\omega_i = S_i (\theta + \eta) / \eta$ $i = a, b$. As shown in an appendix available from the author, the correct definition is $\omega_i = S_i \eta / (\theta + \eta)$.

³ Although equilibrium displacements associated with generic advertising are typically small (since the advertising elasticities are generally minute), this may not be the case for market power. However, in the latter case there is a mitigating factor in that a market-power induced increase in η will tend to have opposing effects on optimal advertising intensity (as shown later), and thus may be may be largely self-canceling.

⁴ The term “value share” is suggested by Waterson who derived an expression for the derived demand elasticity under oligopoly using duality theory.

⁵ I thank Julian Alston for this observation (personal communication). Technically, it hinges on the assumption that all firms are identical and that producers can forecast accurately the effect of the advertising on market price. Since in reality producers are unlikely to know the true price effect, risk averse behavior would suggest a conservative forecast, which, in turn, would imply a sub-optimal tax rate.

⁶ A shortcoming of the present analysis is that it does not take into account demand interrelationships, which are important in the case of beef. One way to handle this deficiency without complicating the model is to re-interpret β and η as “total” elasticities, i.e., elasticities that take into account cross-commodity substitution and advertising spillover. Since for substitute goods the total advertising and price elasticities are *both* smaller than their partial counterparts (Buse; Kinnucan 1996), ignoring demand interrelationships may be innocuous in terms of defining the optimal intensity.

TABLE 1. Baseline Values and Parameters for U.S. Beef, 1998

Item	Definition	Value
P_x	Retail beef price (\$/lb.)	2.77 ^a
x	Retail beef quantity (million lbs.)	18,412 ^a
S_a	Farmers' cost share	0.472 ^a
v	Farm value (million \$ (= $S_a P_x x$))	24,073
A	Generic advertising expenditure (million \$)	28.3 ^b
ϕ_R	Advertising intensity (= $A/P_x x$)	0.00056
β	Advertising elasticity	0.0005 ^c or 0.0011 ^d
η	Retail demand elasticity (absolute value)	0.42 ^d , 0.56 ^e , or 0.78 ^f
σ	Factor substitution elasticity	0, 0.25, 0.50, or 0.72 ^f
ε_a	Farm supply elasticity	0.15 ^f
ε_b	Marketing services supply elasticity	1.00, 2.00 ^g or ∞ ^f
ξ	Output conjectural elasticity	0 to 0.10 ^h
θ	Input conjectural elasticity	0 to 0.10 ^h

^a USDA/ERS.^b National Cattlemen's Beef Association.^c "Best-bet" value, see text.^d Kinnucan, Xiao, Hsia, and Jackson.^e Brester and Schroeder.^f Wohlgenant, 1993.^g Gardner's most frequent value.^h "Best-bet" upper limits, see text.

TABLE 2. Effect of Food Industry Market Power on Optimal Generic Advertising Intensity
for Beef, United States, 1998

Scenario/ Substitution Elasticities	Ratio of Optimal to Actual Intensity When Vertical Market Is: ^a			
	Perfectly Competitive	Oligopoly Only ($\xi = 0.05$)	Oligopsony Only ($\theta = 0.05$)	Oligopoly and Oligopsony
<u>No. 1: $\beta = 0.0005$ and $\eta = 0.78$:</u>				
$\sigma = 0$	1.23	1.16	0.93	0.87
$\sigma = 0.25$	0.86	0.83	0.75	0.73
$\sigma = 0.50$	0.69	0.68	0.65	0.64
$\sigma = 0.72$	0.60	0.60	0.60	0.59
<u>No. 2: $\beta = 0.0005$ and $\eta = 0.56$:</u>				
$\sigma = 0$	1.72	1.57	1.29	1.17
$\sigma = 0.25$	1.10	1.06	0.99	0.96
$\sigma = 0.50$	0.85	0.85	0.84	0.83
$\sigma = 0.72$	0.73	0.74	0.75	0.76
<u>No. 3: $\beta = 0.0005$ and $\eta = 0.42$:</u>				
$\sigma = 0$	2.29	2.02	1.72	1.51
$\sigma = 0.25$	1.34	1.30	1.25	1.21
$\sigma = 0.50$	1.00	1.01	1.02	1.04
$\sigma = 0.72$	0.85	0.87	0.91	0.94
<u>No. 4: $\beta = 0.0011$ and $\eta = 0.56$:</u>				
$\sigma = 0$	3.78	3.45	2.84	2.58
$\sigma = 0.25$	2.41	2.34	2.18	2.11
$\sigma = 0.50$	1.87	1.86	1.84	1.83
$\sigma = 0.72$	1.61	1.62	1.66	1.68

^a Computed using text equation (11) with $\varepsilon_b = 2$.

TABLE 3. Sensitivity of Optimal Generic Advertising Intensity to Conjectural Elasticities ξ and θ and Marketing Services' Supply Elasticity ε_b , U.S. Beef Industry, 1998

Parameter value	Optimal/Actual Intensity		Optimal/Actual Intensity	
	When $\sigma = 0.1^a$		When $\sigma = 0.3^a$	
	$\varepsilon_b = 1.0$	$\varepsilon_b = \infty$	$\varepsilon_b = 1.0$	$\varepsilon_b = \infty$
$\xi = 0.01$				
$\theta = 0.01$	1.28	1.35	0.98	1.05
$\theta = 0.03$	1.19	1.24	0.96	1.01
$\theta = 0.07$	1.04	1.07	0.91	0.94
$\theta = 0.10$	0.95	0.97	0.87	0.89
$\xi = 0.03$				
$\theta = 0.01$	1.25	1.32	0.97	1.04
$\theta = 0.03$	1.16	1.21	0.95	1.00
$\theta = 0.07$	1.02	1.04	0.90	0.93
$\theta = 0.10$	0.93	0.94	0.86	0.88
$\xi = 0.07$				
$\theta = 0.01$	1.19	1.25	0.96	1.01
$\theta = 0.03$	1.10	1.14	0.93	0.97
$\theta = 0.07$	0.96	0.98	0.88	0.90
$\theta = 0.10$	0.88	0.89	0.84	0.85
$\xi = 0.10$				
$\theta = 0.01$	1.14	1.19	0.94	0.99
$\theta = 0.03$	1.06	1.09	0.91	0.95
$\theta = 0.07$	0.92	0.93	0.86	0.88
$\theta = 0.10$	0.84	0.84	0.82	0.83

^a Based on text equation (11) with $\eta = 0.56$ and $\beta = 0.0005$.

TABLE 4. Optimal Intensities Computed from Different Formulae Under Fixed and Variable Proportions, U.S. Beef Industry, 1998

Substitution	Optimal Intensities (%) ^a			Ratio	
Elasticity (σ)	$\bar{\phi}_R'$	$\bar{\phi}_R^{ZS}$	$\bar{\phi}_R^{DS}$	$\bar{\phi}_R^{ZS}/\bar{\phi}_R'$	$\bar{\phi}_R^{DS}/\bar{\phi}_R'$
0 (fixed proportions)	0.0733	0.0733	0.0893	1.00	1.22
0.1	0.0648	0.0733	0.0744	1.13	1.15
0.2	0.0580	0.0733	0.0638	1.26	1.10
0.3	0.0525	0.0733	0.0558	1.40	1.06
0.4	0.0480	0.0733	0.0496	1.53	1.03
0.5	0.0442	0.0733	0.0447	1.66	1.01
0.6	0.0409	0.0733	0.0406	1.79	0.99
0.7	0.0381	0.0733	0.0372	1.93	0.98

^a Computed using text equations (12) - (14) with $\beta = 0.0005$, $\eta = 0.56$, $\theta = 0.10$, $\Omega = 0$, and $S_a = 0.472$. Note:

actual intensity is 0.056%.

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