Will the Voluntary Checkoff Program be the Answer? An Analysis of Optimal Advertising and Free-Rider Problem in the U.S. Beef Industry*

By

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Abstract

This study develops a framework for the analysis of optimal advertising and free-rider problem. Previous studies in the literature were extended in two ways. First, the new framework allows retailer's oligopsony power separately from processor's market power. Second, to examine the free-rider problem, we introduce the trade component to the model and divide domestic producers into two groups: participating producers and non-participating producers in the possible voluntary program. The free-rider problem is measured as the amount of domestic price decrease due to the increased production from importers and non-participating producers. Simulation results for the U.S. beef industry indicate that the industry has under-invested in advertising and promotion, and the possible voluntary program is expected to further under-invest in these programs. As a result, producers are likely to lose 25 to 85 percent of current promotion benefits. The free-riding from non-participating producers would lower market price by 5 to 20 percent.

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The beef checkoff program began in 1987 and has collected $1 for each head of cattle marketed in the U.S. and a $1 per head equivalent fee for the imported beef. The mandatory beef checkoff program has recently faced the constitutional challenge. Since the mandatory checkoff fees are used for collective advertising and promotion efforts, some have argued this violates individual's right to free speech. There have been many litigations on this issue and the Supreme Court is expected to rule soon. If the court rules against it, the mandatory checkoff will be eliminated. Despite these lawsuits against the beef checkoff program, according to a recent survey by the Cattlemen's Beef Promotion and Research Board, almost two-thirds of beef cattle and dairy cattle producers support the current program. The survey result and the general consensus in the beef industry strongly indicate that some type of voluntary program would emerge if the court eliminates the mandatory program. Immediate questions surrounding the possible voluntary program include: If the program changes from mandatory to voluntary participation, can the collected checkoff funds be large enough to finance the ongoing advertising and promotion programs? Will this spending in advertising and promotion be optimal in markets where retail and processing sectors are imperfectly competitive? What would be the extent of the expected free-rider problem? To our knowledge, no study has addressed these questions for the beef industry.

The objective of this study is to examine optimal advertising and free-rider problem in the U.S. beef industry under a possible voluntary checkoff program. The study analyzes whether the collected checkoff funds will be sufficient enough to reach the optimal advertising expenditure in markets where retailers and processors exercise oligopoly and oligopsony power. Furthermore, the study estimates the extent of free-ridership gained by domestic producers and importers. There will be a free-rider problem when some of domestic producers benefit from generic advertising programs without paying checkoff dollars, and a similar problem will occur when importers do not pay checkoff fees voluntarily. Data from the past five years (1998-2002) demonstrate that U.S. imports an average annual amount of over $2 billion beef (fresh, chilled, frozen) from various sources mainly Canada and Australia. The imports account for about ten percent of total domestic consumption.

Several studies have examined optimal investment in advertising (e.g., Dofman and Steiner; Goddard and McCutcheon; Zhang and Sexton; Kinnucan). Although the results of these studies have varied under alternative market structures, a basic concept of analytical derivations has been that the optimality of advertising investment is a function of total sales, elasticities of demand, supply, and advertising, and opportunity cost of alternative investments. We will develop an optimal advertising model with consideration of trade and imperfectly competitive market structure in processing and retail sectors. In particular, the new model will take into account both upstream and downstream (i.e., oligopsony and oligopoly) competitions in retail sector.

Simulation results for the U.S. beef industry indicate that the industry has under-invested in advertising and promotion programs, and the possible voluntary program is expected to further under-invest in these programs. As a result, producers are likely to lose 25 to 85 percent of current advertising/promotion benefits. The free-riding from non-participating producers would lower market price by 5 to 20 percent.

Review of Previous Studies on Optimal Commodity Advertising

Several studies have examined optimal investment levels in advertising under various market conditions. Dorfman and Steiner (DS) generated conditions for optimal advertising intensity under a monopoly market structure, holding quantity produced fixed. They showed that for a monopolist, the optimality condition for joint price and advertising expenditure is characterized by the equality of the ratio of advertising-to-sales with the ratio of the advertising elasticity of demand divided by the absolute price elasticity of demand. When quantity is held constant, the optimal advertising rule derived from the producer's profit maximization was $-\frac{\eta_A}{\eta_P} = \frac{A}{PQ}$, i.e., the ratio of the advertising elasticity to the price elasticity equals to the ratio of the advertising to sales (here P and Q represent sales price and quantity, respectively). When price is fixed, DS show that the optimal advertising rule should change to $\frac{P - MC}{P}\eta_A = \frac{A}{PQ}$, where MC is the marginal cost of the firm. Therefore, when $\frac{P - MC}{P} = -\frac{1}{\eta_P}$, optimal rules from two cases: fixed supply and fixed price are the same.

Goddard and McCutcheon (GM) derived the optimal advertising rule for the case where both quantity and price are not controlled. The study argued that in the fluid milk markets of Ontario and Quebec, it might not be realistic to assume that either producer price or quantity is fixed when the use of advertising expenditures are optimized. Following the same framework that DS used, but allowing both price and quantity vary in response to the effective advertising, they found that the optimal advertising rule should be the same whether quantity is assumed fixed or whether quantity and price are allowed to adjust to advertising.

Nerlove and Waugh (NW) also noted that advertising programs could be implemented in a competitively industry without controlling supply quantity or price. NW argued that previous derivations in particular, in DS, were based on the assumption that producers had no alternatives for the use of collected funds spent on advertising, which led to the first order condition for the producer's profit maximization condition with respect to advertising equaled zero. Recognizing alternative uses of these funds such as buying government bonds, NW equated the marginal returns to the rate of return on alternative forms of investment ρ. The corresponding optimal rule from NW is

$\frac{\eta_A}{(\varepsilon - \eta_P)(1+\rho)} = \frac{A}{PQ}$, where ε is the supply elasticity.

Kinnucan, with the objective of determining the optimal advertising to sales ratio, investigates the impact of food industry market power on farmers' incentives to promote. The study assumes that farm output and 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. Kinnucan concludes that although market power tends to reduce promotion incentives, this decrease in incentives is moderated by factor substitution.

Zhang and Sexton (ZC) recognize that the conditions that characterize optimal advertising intensity under perfect competition for advertising funds do not generally hold when marketing is imperfectly competitive. ZC investigate the optimal collection and expenditure of funds for agricultural commodity promotion for markets where the processing and distribution sectors exhibit oligopoly and/or oligopsony power. More specifically, their study examines the impact of imperfect competition on the level of funds to be collected and expended on a commodity-advertising program. It is concluded from their study that although an imperfectly competitive food marketing sector captures a portion of the benefits generated from commodity advertising, it also bears a share of the costs under funding by a per-unit tax or check-off. They further conclude that the condition for optimal advertising intensity that was developed by DS does not in general apply in the presence of downstream oligopoly power. Unless advertising makes the demand more elastic, downstream oligopoly power reduces the optimal advertising intensity below the level specified by DS. If advertising makes retail demand less elastic, it will increase the oligopoly distortion in the market, which may be harmful to producers as it reduces farm sales.

Model

To develop a framework for the optimal advertising rule and the free-rider problem, we extend previous studies, in particular, Zhang and Sexton, and Kinnucan in two ways. First, the new framework allows retailer's oligopsony power separately from processor's market power. Many studies have typically assumed an integrated processing/retailing sector so that upstream and down stream market power of the integrated sector can be conveniently derived from processor's profit maximization problem (e.g., Azzam; Holloway; Zhang and Sexton; and Kinnucan). However, this type of modeling does not take into account the effect of market power in retailing sector. Several studies in the literature found that the observed food price depends on relative degree of market power of processors and retailers (e.g., Binkley and Connor; Richards *et al.*; Digal and Ahmadi-Esfahani). To account for the effect of market power at the retail sector, profit maximization conditions for three sectors (retailing, processing, and farm) are simultaneously solved and the equilibrium conditions are incorporated in a multi-equation model. Second, to determine the potential free-rider problem, we introduce the trade component to the model and divide domestic producers into two groups: participating producers and non-participating producers in the probable voluntary program. The free-rider problem would be measured as the amount of domestic price decrease due to the increased production from importers and non-participating producers.

Therefore, the new framework developed in this study includes equilibrium conditions of each production stage with consideration of trade and imperfectly competitive market structures in both retailing and processing sectors. We first define a set of market equilibrium conditions and derive marginal effects of a change in assessment rate (t) on equilibrium prices and quantities. Then, the optimal advertising rule and the free-riding problem are determined from the derived marginal effects using conditions of producer surplus maximization.

Consider a three-sector model where retailing and processing sectors are imperfectly competitive in both raw material and output markets, and farm sector is perfectly competitive in output market. In this framework, retailers and processors exercise oligopsony (or monopsony) power procuring their raw materials while they also exercise market power in selling their products. Let $Y^f = Y^a + Y^n + Y^m$, and $A = tY$, where Y^f is the aggregate quantity at farm level, Y^a is domestic production of firms participating in the voluntary check off program, Y^n is domestic production of firms not participating in the voluntary check off program, Y^m is the quantity imported, A is the advertising expenditure (assuming all collected money is utilized for adverting), and t is the per-unit tax on domestic production and imports. Assuming constant return to scale in the food processing technology and fixed proportions with Leontief coefficient 1 in converting from farm to retail products results in $Y = Y^r = Y^p = Y^f$, where Y^r and Y^p are aggregate product quantities at retail and processing level, respectively. Then, the market equilibrium is defined by the following set of equations,

(1) $Y = D[P^r, A(t)]$, retail demand,

(2) $Y^d = S^d(P^f, t)$, domestic supply from both participating and nonparticipating producers, i.e., $Y^d = Y^a + Y^n$;

(3) $Y^m = S^m(P^r, t)$, imported supply, and

(4) $Y^r = Y^d + Y^m$, identity relating imports to domestic production. Here, p^r, p^p, and p^f are prices at retailing, processing, and farm level.

(5) $Y^d = Y^a + Y^n$, identity relating domestic supply of participating and nonparticipating producers;

(6) $A = tY(Y^d, Y^m)$, is the advertising expenditure. Note that nonparticipating producers do not pay the check off tax t.

Considering n^r identical retailers, i.e., $Y = n^r y^r$, we have a representative retailer's profit maximization problem as

$$\underset{y}{Max} \quad \pi = P^r(Y,t)y^r - [P^p(Y,t) + m]y^r$$

where y^r and m represent finished product sales and constant marketing cost per unit for the representative retailer, respectively. The first order condition to the retailer's problem with respect to y^r can be expressed as

$$\frac{d\pi}{dy^r} = P^r(Y,t) + \frac{dP^r(Y,t)}{dY}\frac{\partial Y}{\partial y^r}y^r - [P^p(Y,t) + m] - \frac{dP^p(Y,t)}{dY}\frac{\partial Y}{\partial y^r}y^r = 0$$

Rearranging the first order condition leads to

(7) $$P^r(Y,t)(1+\frac{\xi}{H(Y,t)}) = P^p(Y,t)(1+\frac{\omega}{\varepsilon_P^S}) + m$$

where $\xi = (\partial Y^r / \partial y^r)(y^r / Y^r)$ and $\omega = \partial Y^p / \partial y^r)(y^r / Y^p)$ are conjectural elasticities reflecting degree of competition among retailers in selling finished product (ξ) and procuring processed product (ω), respectively; $H(Y,t) = (dY / dP^r)(P^r / Y)$ and $\varepsilon_P^S = (dY / dP^p)(P^p / Y)$ are total price elasticity and elasticity of supply for processors.

Considering n^p identical processors, i.e., $Y = n^p y^p$, a representative processors' profit maximization problem is

$$\underset{y^p}{Max} \ \pi = P^p(Y,t)y^p - [W^p(Y,t) + c]y^p,$$

where y^p and c represent processed product sales to retailers and constant processing cost per unit for the representative processor, respectively; and W^P is the price paid by processors, and the relationship between W^P and P^f is represented by $W^p = P^f + t$. The first order condition of the processor's problem is

$$\frac{d\pi}{dy^p} = P^p(Y,t) + \frac{dP^p(Y,t)}{dY}\frac{\partial Y}{\partial y^p}y^p - [P^f(Y,t) + t + c] - \frac{dP^f(Y,t)}{dY}\frac{\partial Y}{\partial y^p}y^p = 0$$

which can be rewritten in elasticity form as

(8) $$P^p(Y,t)(1+\frac{\phi}{\varepsilon_P^S}) = P^f(Y,t)(1+\frac{\theta}{\varepsilon_F^S}) + t + c$$

where the conjectural elasticity, $\theta = (\partial Y^f / \partial y^p)(y^p / Y^f)$, and $\phi = \partial Y^p / \partial y^p)(y / Y^p)$ represent degree of competition among processors in procuring farm product and selling processed product, $\varepsilon_F^S = (dY^f / dP^f)(P^f / Y^f)$ is supply elasticities at farm level. Substituting equation (8) in equation (7) results in

(9) $$P^r(Y,t)(1+\frac{\xi}{H(Y,t)}) = \frac{1}{1+\phi/\varepsilon_P^S}[(1+\frac{\theta}{\varepsilon_F^S})P^f(Y,t)+t+c](1+\frac{\varpi}{\varepsilon_P^S})+m$$

To get the optimum advertising rule, we totally differentiate equations (1), (2), (3), (4), (5) and (9) with respect to t and obtain

(10) $$\frac{dY}{dt} = \frac{\partial D}{\partial P^r}\frac{dP^r}{dt}+\frac{\partial D}{\partial A}\frac{dA}{dt} = \frac{\partial D}{\partial P^r}\frac{dP^r}{dt}+\frac{\partial D}{\partial A}[Y(Y^d,Y^m)+t(\frac{dY^d}{dt}+\frac{dY^m}{dt})]$$

(11) $$\frac{dY^d}{dt} = \frac{\partial S^d}{\partial P^f}\frac{dP^f}{dt}$$

(12) $$\frac{dY^m}{dt} = \frac{\partial S^m}{\partial P^r}\frac{dP^r}{dt}$$

(13) $$\frac{dY^r}{dt} = \frac{dY^d}{dt}+\frac{dY^m}{dt}$$

(14) $$\frac{dY^d}{dt} = \frac{dY^a}{dt}+\frac{dY^n}{dt}$$

(15)

$$(1+\frac{\xi}{H(Y,t)})\frac{dP^r}{dt}-\frac{\xi P^r}{H^2}\frac{dH}{dt} = -\frac{1}{(1+\phi/\varepsilon_P^S)^2}\frac{\phi}{(\varepsilon_P^S)^2}\frac{d\varepsilon_P^S}{dt}[(1+\frac{\theta}{\varepsilon_F^S})P^f+t+c](1+\frac{\varpi}{\varepsilon_P^S})$$
$$+[(1+\frac{\theta}{\varepsilon_F^S})\frac{dP^f}{dt}-\frac{\theta P^f}{(\varepsilon_F^S)^2}\frac{d\varepsilon_F^S}{dt}+1](1+\frac{\varpi}{\varepsilon_P^S})(\frac{1}{1+\phi/\varepsilon_P^S})-(\frac{1}{1+\phi/\varepsilon_P^S})[(1+\frac{\theta}{\varepsilon_F^S})P^f+t+c]\frac{\varpi}{(\varepsilon_P^S)^2}\frac{d\varepsilon_P^S}{dt}$$

In elasticity form, equation (15) can be rewritten as

(15′) $$(1+\frac{\xi}{H(Y,t)})\frac{dP^r}{dt}-\frac{1}{1+\phi/\varepsilon_P^S}(1+\frac{\varpi}{\varepsilon_P^S})(1+\frac{\theta}{\varepsilon_F^S})\frac{dP^f}{dt} = -\frac{1}{(1+\phi/\varepsilon_P^S)^2}\frac{\phi E_{\varepsilon_P^S,t}}{t\varepsilon_P^S}[(1+\frac{\theta}{\varepsilon_F^S})P^f+t+c](1+\frac{\varpi}{\varepsilon_P^S})$$
$$+(-\frac{\theta P^f}{t\varepsilon_F^S}E_{\varepsilon_F^S,t}+1)](1+\frac{\varpi}{\varepsilon_P^S})(\frac{1}{1+\phi/\varepsilon_P^S})-(\frac{1}{1+\phi/\varepsilon_P^S})[(1+\frac{\theta}{\varepsilon_F^S})P^f+t+c]\frac{\varpi}{t\varepsilon_P^S}E_{\varepsilon_P^S,t}+\frac{\xi P^r}{Ht}E_{H,t}$$

where $E_{H,t} = \frac{dH}{dt}\frac{t}{H}$, $E_{\varepsilon_F^S,t} = \frac{d\varepsilon_F^S}{dt}\frac{t}{\varepsilon_F^S}$, and $E_{\varepsilon_P^S,t} = \frac{d\varepsilon_P^S}{dt}\frac{t}{\varepsilon_P^S}$. $E_{H,t}$ represents the percentage change in total demand elasticity H in response to 1 % increase in advertising assessment t. $E_{\varepsilon_F^S,t}$ and $E_{\varepsilon_P^S,t}$ represent the percentage change in supply elasticities in farm and processing sectors in response to 1 percent increase in advertising assessment t, respectively

Equations (10), (11), (12), (13), (14) and (15′) can be rewritten in matrix form as

$$(16)\quad \begin{bmatrix} 1 & -\frac{\partial D}{\partial P} & -t\frac{\partial D}{\partial A} & -t\frac{\partial D}{\partial A} & 0 & 0 \\ 0 & 0 & 1 & 0 & -\frac{\partial S^d}{\partial P^f} & 0 \\ 0 & -\frac{\partial S^m}{\partial P^r} & 0 & 1 & 0 & 0 \\ 1 & 0 & -1 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 \\ 0 & 1+\frac{\xi}{H} & 0 & 0 & \frac{-(1+\frac{\varpi}{\varepsilon_P^S})(1+\frac{\theta}{\varepsilon_F^S})}{1+\phi/\varepsilon_P^S} & 0 \end{bmatrix} \begin{bmatrix} \frac{dY}{dt} \\ \frac{dP^r}{dt} \\ \frac{dY^d}{dt} \\ \frac{dY^m}{dt} \\ \frac{dP^f}{dt} \\ \frac{dY^a}{dt} \end{bmatrix} = \begin{bmatrix} \frac{\partial D}{\partial A}Y \\ 0 \\ 0 \\ 0 \\ \frac{\partial Y^n}{\partial t} \\ \Omega \end{bmatrix}$$

where

$$\Omega = -\frac{1}{(1+\phi/\varepsilon_P^S)^2}\frac{\phi E_{\varepsilon_P^S,t}}{t\varepsilon_P^S}[(1+\frac{\theta}{\varepsilon_F^S})P^f + t + c](1+\frac{\varpi}{\varepsilon_P^S})$$

$$+(-\frac{\theta P^f}{t\varepsilon_F^S}E_{\varepsilon_F^S,t}+1)](1+\frac{\varpi}{\varepsilon_P^S})(\frac{1}{1+\phi/\varepsilon_P^S}) - (\frac{1}{1+\phi/\varepsilon_P^S})[(1+\frac{\theta}{\varepsilon_F^S})P^f + t + c]\frac{\varpi}{t\varepsilon_P^S}E_{\varepsilon_P^S,t} + \frac{\xi P^r}{Ht}E_{H,t}$$

Then, from equation (16), marginal effects of change in t on domestic supply (Y^d) and farm level price (P^f) are

$$(17)\quad \frac{dY^d}{dt} = \frac{1}{\Psi}[(\Omega t\frac{\partial D}{\partial A}\frac{\partial S^m}{\partial P^r} - \Omega\frac{\partial S^m}{\partial P^r} + (1+\frac{\xi}{H})\frac{\partial D}{\partial A}Y + \Omega\frac{\partial D}{\partial P^r}]\frac{\partial S^d}{\partial P^f}$$

(18) $$\frac{dP^f}{dt} = \frac{1}{\Psi}[\Omega \frac{\partial S^m}{\partial P^r}(t\frac{\partial D}{\partial A} - 1) + (1 + \frac{\xi}{H})\frac{\partial D}{\partial A} Y + \Omega \frac{\partial D}{\partial P^r}]$$

where:

$$\Psi = \frac{(1+\frac{\varpi}{\varepsilon_P^S})(1+\frac{\theta}{\varepsilon_F^S})}{1+\phi / \varepsilon_P^S}(\frac{\partial S^m}{\partial P^r} - t\frac{\partial D}{\partial A}\frac{\partial S^m}{\partial P^r} - \frac{\partial D}{\partial P^r}) + \frac{\partial S^m}{\partial P^r}(1+\frac{\xi}{H})(1 - t\frac{\partial D}{\partial A})$$

$$-(\frac{1}{1+\phi / \varepsilon_P^S})[(1+\frac{\theta}{\varepsilon_F^S})P^f + t + c]\frac{\varpi}{t\varepsilon_P^S}E_{\varepsilon_P^S, t} + \frac{\xi P^r}{Ht}E_{H,t}$$

To derive optimal advertising rule, we consider producers' producer surplus maximization problem that would decide the per-unit assessment rate *t* and consequently advertising expenditure.

(19) $$\underset{t}{Max}\, PS = \int_{P^f(0)}^{P^f(Y^d(t))} S(P^f)dP^f$$

where *S* and $P^f(0)$ are the farm supply curve and its intercept value, respectively. Then, the first order condition of equation (19) gives

(20) $$\frac{\partial PS}{\partial t} = S(P^{f*}(t))\frac{\partial P^{f*}}{\partial Y^d}\frac{\partial Y^d}{\partial t} = 0.$$

The optimal tax condition from equation (20) is

(21) $$\frac{\partial Y^d}{\partial t} = 0\,.$$

Assuming $E_{\varepsilon_F^S, t} = 0$, $E_{\varepsilon_P^S, t} = 0$, and $\varepsilon_P^S = \infty$[1], and applying the optimal tax condition in equation (21) to the matrix (16), we have

(22) $$[\Omega t\frac{\partial S^m}{\partial P^r} + (1+\frac{\xi}{H})Y]\frac{\partial D}{\partial A} = \Omega(\frac{\partial S^m}{\partial P^r} - \frac{\partial D}{\partial P^r})$$

Rearranging equation (22) and writing it in elasticity form results in optimal advertising rule:

(23) $$\frac{A^*}{P^*Y^*}=\frac{\eta_A}{\Omega(\tau\eta_m-\eta_P)}[\Omega t\frac{\tau}{P^r}\eta_m+(1+\frac{\xi}{H})]$$

where A is the advertising expenditure; $\Omega=1+\frac{\xi P^r}{Ht}E_{H,t}$ is a constant; $\eta_A=\frac{\partial D}{\partial A}\frac{A}{Y}$ is the elasticity of demand with respect to advertising expenditure; $\eta_P=\frac{\partial D}{\partial P^r}\frac{P^r}{Y}$ is the partial price elasticity of demand; $\eta_m=\frac{\partial S^m}{\partial P^r}\frac{P^r}{S^m}$ is the import elasticity; $\tau=\frac{S^m}{Y}$ is the share of imports from total consumption. Equation (23) is similar to Zhang and Sexton's optimal advertising rule when an integrated retail and processing sector is assumed and international trade is restricted to zero.

The free-rider effect can be measured as the amount of farm price decrease due to the increased production from non-participating producers. The free-riding effect can be examined from the equilibrium conditions in matrix (16). The marginal effect of changing t on producer price is

(24) $$\frac{dP^f}{dt}=\frac{1}{\Psi}[\Omega\frac{\partial S^m}{\partial P^r}(t\frac{\partial D}{\partial A}-1)+(1+\frac{\xi}{H})\frac{\partial D}{\partial A}Y+\Omega\frac{\partial D}{\partial P^r}].$$

After rearranging terms and expressing it in elasticity form, equation (24) can be rewritten as:

(24′) $$\frac{dP^f}{dt}=\frac{Y^r}{\Theta}[\Omega\frac{\tau}{P^r}\eta_m(\eta_a-1)+(1+\frac{\xi}{H})\frac{\eta_a}{t}+\Omega\frac{\eta_p}{P^r}]$$

where: $$\Theta=\frac{Y^m}{P^r}\eta_m[\frac{(1+\frac{\varpi}{\varepsilon_P^S})(1+\frac{\theta}{\varepsilon_F^S})}{1+\phi/\varepsilon_P^S}(1-\eta_a)+(1+\frac{\xi}{H})(1-\eta_a)]-\frac{(1+\frac{\varpi}{\varepsilon_P^S})(1+\frac{\theta}{\varepsilon_F^S})}{1+\phi/\varepsilon_P^S}\eta_P\frac{Y^r}{P^r}+\frac{\xi P^r}{Ht}E_{H,t}$$

As the current mandatory program changes to a voluntary program, we expect at least importers would be nonparticipating. Equation (24′) suggests that the increase in farm price due to advertising tax, dP^f/dt, would increase without imports, i.e. $\eta_m = 0$, with an assumption that $(1+\xi/H) > 0$. In other words, participating producers face lower price due to the increased supply provided by importers. If ξ/H <-1 then it is not straightforward to predict the sign of dP^f/dt with zero imports analytically. The extent of free-rider problem, caused by .importers and nonparticipating producers will be estimated via numeric simulations.

Application to the U.S. Beef Industry

This section provides results from numeric simulations for impacts of possible voluntary checkoff program on the U.S. beef industry. Based on the optimal advertising rule in equation (23), we first examine if the advertising expenditures under the voluntary checkoff program would be optimal. If advertising programs under the voluntary checkoff program would be under-invested, the potential loss of producer benefit due to the decreased advertising budget would be estimated. Finally, the free-riding problem is numerically illustrated.

Table 1 lists parameters used for the numeric simulations. Most of the parameters are obtained from previous studies. Parameters in table 1 are applied to Equation (23), and advertising intensities, advertising-sales ratios, derived from a range of parameters are reported in table 2. Results in table 2 indicate that beef industry would be under-invested under the voluntary programs. The simulated optimal advertising intensities are mostly much greater than current advertising intensity, 0.0005. Case 1 assumes competitive retail and processing sectors without consideration of trade. Results show that the optimal advertising intensity increases as advertising effectiveness increases while it decreases as demand is more elastic. Case 2 considers imperfectly competitive retail and processing sectors. Since processor's market power is not relevant to the estimation of advertising intensity in equation (23), only retailer's oligopoly power is considered. As retail market is more imperfectly competitive, the optimal advertising intensity becomes smaller. Case 3 includes both market power and trade parameters . The optimal advertising intensity decreases as import supply elasticity becomes more elastic. A few cases where advertising elasticity is extremely small and import supply elasticity is highly elastic with a imperfectly competitive retail market results in lower optimal advertising intensity than current advertising-sales ratio.

To conduct numeric simulations on impacts of the voluntary checkoff program on producer benefit, we introduce linear functional forms for retail demand and farm supply functions while assuming perfectly elastic supply function for processing sector. Linear retail demand and farm supply functions are:

$$Y^r = a + \gamma\sqrt{A} - \alpha P^r$$

$$P^f = b - \beta Y^d$$

Applying these demand and supply functions to profit maximization problems for retailer, processor, and producer results in

$$(25) \quad Y^{r*} = \left(\frac{\gamma\sqrt{t}(2+\xi) + \sqrt{\gamma^2 t(2+\xi)^2 + 16\Omega(\alpha\beta - \alpha t + 1)}}{4\Omega} \right)^2$$

where $\Omega = (1+\xi) + \alpha\beta(1+\theta) - \alpha\beta\tau(1+\theta)$

Normalizing price and quantity without advertising in competitive retail and processing sectors to be unitary, we get $\alpha = -\eta_P$, and $\beta = \frac{f}{\varepsilon_F^s}$. Applying these relations to equation

(25) results in the solution Y^{r*} in a elasticity form as

$$(26)\quad Y^{r*} = \left(\frac{\gamma\sqrt{t}(2+\xi) + \sqrt{\gamma^2 t(2+\xi)^2 + 16\Omega(-\eta_p f \ / \varepsilon_F^s + \eta_p t + 1)}}{4\Omega} \right)^2$$

where $\Omega = (1+\xi) - \eta_p f \ / \varepsilon_F^s (1+\theta) + \eta_p f / \varepsilon_F^s \tau(1+\theta)$.

For the linear functional forms of demand and supply functions, producer benefit from advertising can be measured as the change in producer surplus as

$$(27)\quad \begin{aligned} \Delta PS &= \int_{b+t}^{P_1^f} \frac{1}{\beta}(P_1^f - t - b)dP^f - \int_{b}^{P_0^f} \frac{1}{\beta}(P_0^f - b)dP^f \\ &= \frac{\beta}{2}[(Y_1^{r*})^2 - (Y_0^{r*})^2] = \frac{f}{2\varepsilon_F^s}[(Y_1^{r*})^2 - (Y_0^{r*})^2] \end{aligned}$$

Applying parameters in table 1 to equations (26) and (27), we estimate change in producer benefits for three different levels of participation rates, 55%, 70%, and 85%, and results are reported in tables 3 and 4. Table 3 presents changes in producer benefits due to voluntary program with no consideration of trade and market power in retailing and processing sectors. Results indicate that producers may lose 27 to 73 percent of current advertising benefit, and the extent of loss increases as the advertising effectiveness increases. When market power and trade parameters are incorporated in the model, the expected producer loss increases as the retailing and processing market power increases. For example, when retailing and processing sectors are highly non-competitive, i.e., $\xi=\theta=0.5$, the expected producer loss reaches to 64 to 86 percent of current benefit. Finally, table 5 reports the amount of farm price decrease due to the increased production from non-participating producers. The free-riding problem diminishes as market power in retailing and processing sectors increases. Results show that the free-riding from non-participating producers would lower market price by 5 to 20 percent.

Discussions and Conclusions

This study develops a framework for the analysis of optimal advertising and free-rider problem. Previous studies in the literature were extended in two ways. First, the new framework allows retailer's oligopsony power separately from processor's market power. Second, to examine the free-rider problem, we introduce the trade component to the model and divide domestic producers into two groups: participating producers and non-participating producers in the possible voluntary program. Then, the free-rider problem was measured as the amount of domestic price decrease due to the increased production from importers and non-participating producers.

The optimal advertising rule derived in this study indicates that as retailer's oligopoly power increases the optimal advertising level decreases. The oligopsony power is not relevant to the determination of optimal advertising intensity, which is consistent with Zhang and Sexton. The optimal advertising rule also suggests that as import supply elasticity becomes more elastic, the optimal intensity decreases. The newly derived rule is consistent with Dorfman and Steiner in which as demand elasticity is more elastic, the optimal advertising intensity decreases, while the intensity increases as the advertising effectiveness increases.

Simulation results for the U.S. beef industry indicate that the industry has under-invested in advertising and promotion programs except a few cases where advertising effectiveness is extremely low (0.0005), the degree of imperfect competition is exceptionally high (0.3), and import supply elasticity is highly elastic (higher than 5). The possible voluntary program is expected to further under-invest in advertising and promotion programs, and as a result, producers are likely to lose 25 to 85 percent of current promotion benefits. The free-riding from non-participating producers would lower market price by 5 to 20 percent.

Footnotes

1. We assume a horizontal supply curve at the processing sector and advertising has no impact on changing slopes of supply curves at both farm and processing sectors.

2. Current advertising expenditures include dollars spent in advertising and promotion programs in 2001. Hogan reports that the data is obtained from annual financial reports from Cattlemen's Beef Promotion and Research Board.

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Table 1. Values of parameters and variables for the U.S. Beef Industry.

Parameters/Variable	Value
η_P	-0.282[a], -0.45[b]
η_A	0.0005[c], 0.012[d], 0.05
ε^s_F	0.15[e]
η_m	1, 2, 5
τ	0.097[f]
ζ	0.223[a]
θ	0.178[a]
P^f ($/cwt)	72.21[f]
Y^f (cwt)	338,832,500[f]
P^r ($/cwt)	337, 700[f]
Y^r (cwt)	188,400,000[f]
f	0.57[a]
Current Advertising Expenditures ($)[2]	29,976,380[f]

a. Zhang and Sexton
b. Brester and Wohlgenant
b. Alston, Freebairn, and James
c. Ward and Lambert
d. Wohlgenant
e. USDA, ERS
f. Hogan

Table 2. Optimal Advertising Intensity

Case 1. No Trade in Competitive Market	
Parameters	**Intensity**
η_A= 0.0005 η_P= -0.282	0.0018
η_P= -0.450	0.0011
η_A= 0.012 η_P= -0.282	0.0426
η_P= -0.450	0.0267
η_A= 0.05 η_P= -0.282	0.1773
η_P= -0.450	0.1111
Case 2. No trade in imperfectly competitive market	
Parameters	**Intensity**
η_A= 0.0005 η_P= -0.282	
ζ= 0.1	0.0009
ζ= 0.223	0.0007
ζ= 0.3	0.0004
η_A= 0.012 η_P=-0.282	
ζ= 0.1	0.276
ζ= 0.223	0.0093
ζ= 0.3	0.0022
Case 3. Trade in imperfectly competitive market	
Parameters	**Intensity**
η_A= 0.0005 η_P= -0.282	
ζ= 0.1	
η_m=1	0.0009
η_m=2	0.0007
η_m=5	0.0004
ζ= 0.223	
η_m=1	0.0003
η_m=2	0.0002
η_m=5	0.0001
η_A= 0.012 η_P= -0.282	
ζ= 0.1	
η_m=1	0.0206
η_m=2	0.0165
η_m=5	0.0102
ζ= 0.223	
η_m=1	0.0069
η_m=2	0.0055
η_m=5	0.0034

Current advertising intensity (in 2001): 0.0005

Table 3. Impact of voluntary program on producer benefit with no trade in competitive markets

η_A	Participation Rate	ΔPS ($million)	%
0.0005	0.55	14	31.1
	0.70	22	48.9
	0.85	33	73.3
	1.00	45	
0.012	0.58	48	29.0
	0.70	80	48.4
	0.85	118	71.5
	1.00	165	
0.05	0.55	87	27.7
	0.70	145	46.2
	0.85	221	70.3
	1.00	314	

Table 4. Impact of voluntary program on producer benefit with trade and imperfectly competitive retail and processing sectors[a]

	Participation Rate	ΔPS ($million)	%
θ=0.5 ζ= 0.1	0.55	12	30.0
	0.70	19	47.5
	0.85	29	72.5
	1.00	40	
ζ= 0.223	0.55	8	22.2
	0.70	14	38.9
	0.85	20	55.6
	1.00	36	
ζ= 0.5	0.55	4	14.3
	0.70	7	25.0
	0.85	10	35.7
	1.00	28	
ζ= 0.223 θ= 0.178	0.55	14	30.4
	0.70	22	47.8
	0.85	33	72.7
	1.00	46	
θ= 0.3	0.55	12	28.6
	0.70	20	47.6
	0.85	30	71.4
	1.00	42	

[a] Results are calculated with η_A= 0.012, η_p= -0.282, ε^s_f= 0.15, and τ = 0.097

Table 5. Free-Rider Problem - farm price decrease due to the increased production from non-participating producers[a]

	Participation Rate	ΔP (%)
$\zeta = 0.1$, $\theta = 0.178$	0.55	20.2
	0.70	16.3
	0.85	9.5
$\zeta = 0.223$, $\theta = 0.3$	0.55	14.0
	0.70	11.1
	0.85	6.4
$\zeta = 0.5$, $\theta = 0.5$	0.55	11.4
	0.70	8.9
	0.85	5.0

[a]Results are calculated with $\eta_A = 0.012$, $\eta_p = -0.282$, , $\varepsilon^s{}_f = 0.15$, and $\tau = 0.097$