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# **The Potential Inefficiency of Using Marketing Margins in Applied Commodity Price Analysis, Forecasting, and Risk Management**

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This paper examines the implications of using marketing margins in applied commodity price analysis. The marketing-margin concept has a long and distinguished history, but it has caused considerable controversy. This is particularly the case in the context of analyzing the distribution of research gains in multi-stage production systems. We derive optimal tax schemes for raising revenues to finance research and promotion in a downstream market, derive the rules for efficient allocation of the funds, and compare the rules with and without the marketing-margin assumption. Applying the methodology to quarterly time series on the Australian beef-cattle sector and, with several caveats, we conclude that, during the period 1978:2 - 1988:4, the Australian Meat and Livestock Corporation optimally allocated research resources.

## **Introduction**

Marketing margins have a long and distinguished application in commodity price analysis. Their use greatly facilitates graphical analysis of farm-retail price linkages and makes tractable algebraic representations of food-marketing. However, the use of marketing margins is based on a restrictive assumption that has caused considerable controversy in the food-marketing literature. This assumption is that technology in food marketing is Leontief or fixed proportions. One context within which this has proved most controversial is the computation of research benefits in vertically related markets. This subject is topical for three reasons: First, research-benefit computations are sensitive to the fixed-proportions assumption. Second, the rules for optimal allocations of research and promotion activities depend almost exclusively on cost-benefit calculations. Third, empirical work (Wohlgenant, 1989, p. 250, table 3) draws into question the validity of the hypothesis that food-marketing is fixed-proportions.

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The purpose of this paper is to investigate the consequences of using the marketing-margin assumption in an applied situation. The situation we choose is one in which a producer group levies a tax on its members to fund downstream research and promotion activities. Many producer groups in the United States and elsewhere undertake these activities under the presumption that they are group-efficient. This question is well posed in the US context because the efficiency and legality of research and promotion activities are currently being placed under close scrutiny.<sup>1</sup> Below, we derive rules for optimally collecting and disbursing of revenues mandated by research and promotion. We show how the rules can be implemented empirically in order to assess the efficiency of check-off funds and we suggest methodologies for assessing the bias and inefficiency of invoking the Leontief assumption. The methodology is applied to data on beef promotion by the Australian Meat and Livestock Corporation.

Section two introduces notation and presents the methodology in the context of a simple investment model. Section three incorporates taxation and derives decision rules for optimal receipt and disbursement of tax revenues. Section four shows how the rules are affected by the fixed-proportions assumption. Section five discusses econometric procedures and section six applies one of them to the Australian data. Section seven concludes.

## Downstream Research Cost-Benefit Analysis

Consider the following farm-to-retail system. Primary producers supply output to a marketing sector that combines the farm product with another productive factor. The resulting retail product is sold in a terminal market. Primary producers agree to undertake research in the downstream market (e.g., advertising, promotion, or product development). They agree to share the benefits that result as well as any costs incurred.

Let  $\theta$  denote the output of the research activity, and use  $C(\theta)$  to denote its variable cost, where  $C_\theta(\theta) > 0$  and  $C_{\theta\theta}(\theta) = 0$ .<sup>2</sup> That is, we assume that the research technology is constant returns-to-scale:

$$(1) \quad C(\theta) \equiv \kappa \theta,$$

where  $\kappa > 0$ . The constant returns-to-scale assumption will play an important role in the construction of data series on research output and, consequently, in the development of test statistics, but it seems reasonable in a wide variety of settings. Moreover, in a longer run context in which policy implications are sought, one may suppose that free entry and exit into the research industry yield constant returns.

Let  $w$  and  $x$  denote the price and quantity of the farm commodity, and use  $S(\cdot)$  to denote the inverse supply function so that  $w = S(x)$ . Farmers undertake the activity  $\theta$  because it affects farm welfare. That is, it affects farm-commodity prices and quantities and, so, we write  $w(\theta)$  and  $x(\theta)$  to acknowledge this. These expressions denote the implicit solutions to a marketing-system equilibrium in which farm price and quantity are endogenous and the research activity is exogenous. When  $\theta$  adjusts, price and quantity will adjust in a manner yet to be determined, but when making decisions over  $\theta$  farmers take into account the effects of the research activity on the market variables that are relevant to them. In particular, they allocate funds in order to maximize producer surplus less the costs incurred in producing research output. Formally, they solve:

$$\text{PROBLEM 1:} \quad \max_{\theta} \Psi(\theta) \equiv w(\theta) x(\theta) - \int_0^{x(\theta)} S(t) dt - C(\theta).$$

The first-order condition is

$$(2) \quad x(\theta) w_\theta(\theta) \leq C_\theta(\theta),$$

where we have taken account of the fact that the research activity is constrained to be non-negative. Thus, from the point of view of the farm sector, research is unprofitable if its marginal cost exceeds the marginal benefit to producer surplus.<sup>3</sup> At an interior solution, using the fact that  $C(\theta)$  is affine, we have

$$(3) \quad E(w, \theta) = \frac{C(\theta)}{w(\theta) x(\theta)},$$

where  $E(w, \theta) \equiv w_\theta(\theta) \theta / w$  denotes the elasticity of the farm price with respect to the research activity. This elasticity computes the reduced-form effects of research on the farm-commodity price. Its value is easily inferred given data on research output and the relevant farm price. Empirical estimates of similar elasticities in two slightly different contexts are presented in Wohlgenant (1989, tables 1 and 2, pp. 247-49) and in Holloway (1991, tables 1 and 2, pp. 986-88). Equation (3) demonstrates that the efficiency of research activities can be inferred by comparing an estimate of the effects of research output with the cost share of research expenditures in farm revenues.

### Cost-Benefit Analysis With A Self-Financing Levy

The rule developed above offers a fruitful avenue for empirical examination of the efficiency of downstream activities, but it ignores a significant cost of the program. The neglected cost is the level of producer surplus foregone as a result of taxing the farm market. In order to undertake research, taxes must be levied. These taxes are, of course, the controversial aspect of mandatory programs. Thus, analysis of the costs and benefits of the program would not be complete without examination of the market effects of taxation.<sup>4</sup>

Let  $\tau$  denote the level of an ad-valorem tax that is levied in order to finance the scheme.<sup>5</sup> Then, marketing agents pay  $w(1+\tau)$  for each unit of the farm commodity that they purchase and total revenues from tax collection are

$$(4) \quad R(\tau, \theta) \equiv \tau w(\tau, \theta) x(\tau, \theta).$$

Here we have acknowledged the fact that the tax will have an impact on prices and quantities—likely a negative one, although this need not be the case.<sup>6</sup> These effects are important and must be accounted for when determining the optimal allocation of research resources.

When a levy is imposed, producers now receive revenues from two sources, namely the market and tax collection. However, in accordance with the stipulations of most programs, we assume that the revenues from tax collection fully cover the costs of the research activity, or

$$(5) \quad C(\theta) \leq R(\tau, \theta).$$

Given this constraint, it is natural to ask how the tax parameter  $\tau$  adjusts when the desired level of the research activity is adjusted. To determine this rate of change, assume first that the constraint holds with strict equality. Differentiating in (5) using (4)

$$(6) \quad \frac{\partial \tau(\theta)}{\partial \theta} \Big|_{C=R} = \frac{C_\theta - \tau w_\theta x - \tau w x_\theta}{w x + \tau w_\tau x + \tau w x_\tau}$$

At the present level of generality it is not possible to determine the sign of this effect and, so, it is not necessarily the case that the levy must rise as research activity intensifies. Taking account of (6), the budget-constrained problem reduces to maximization over the single variable  $\theta$ , or:

$$\text{PROBLEM 2: } \max_{\theta} \Psi(\tau(\theta), \theta) \equiv w(\tau(\theta), \theta) x(\tau(\theta), \theta) - \int_0^{x(\tau(\theta), \theta)} S(t) dt.$$

The first-order condition is:

$$(7) \quad x(\theta) w_\theta(\theta) + x(\theta) w_\tau(\theta) \frac{\partial \tau(\theta)}{\partial \theta} \Big|_{C=R} = 0,$$

which should be compared to the condition in (2). Unlike the previous problem, tax revenues exactly offset the costs of research and, thus, the explicit costs no longer play a role; only implicit costs matter. The latter costs are producer surplus foregone due to enactment of the levy. As before, all producer benefits are incurred through the impact of the research on the farm price. Thus, the condition in (7) requires an equality between the marginal benefit and the marginal costs incurred in the farm-commodity market. Making use of (6) and applying similar manipulations to those below (2), (7) reduces to

$$(8) \quad E(w, \theta) + E(w, \tau) = 0,$$

where  $E(w, \tau) \equiv w_\tau(\theta) \tau / w$  denotes the elasticity of the farm price with respect to the research activity and the first term on the left-hand side is defined below (3). This condition states that the marginal impacts of research and taxation must cancel at the equilibrium allocation. The condition is similar to the homogeneity restriction of demand theory, which is routinely applied in empirical work. Therefore, the model derives refutable implications about the efficiency of research activities that may be tested using standard statistical procedures.

In general,  $E(w, \tau)$  will be a function of the tax rate and it is possible, therefore, to determine the optimal rate through manipulations in (8). Given the tax, it is then possible to determine the optimal level of the research activity by exploiting the equality implied by (6) and by making use of the constant-returns assumption in (1).

## Structural Determinants of the Allocation Rule

We motivated the investigation in the context of its relevance to a debate about the use of marketing margins. In particular, we discussed the relevance of the Leontief assumption in the context of measuring the benefits emanating from the research activity. Both of the elasticities in (8) are, in turn, functions of Marshallian elasticities that measure rates of response between endogenous



variables; one of these, of course, is the so-called Hicks-Allen elasticity of substitution, or  $\sigma$ . Consequently, the magnitudes of the elasticities in (8) are affected by the fixed-proportions assumption. In this section we take a closer look at these elasticities with two aims in mind: First, we wish to consider the implications of invoking the assumption when it is inappropriate to do so. Second, we wish to develop methodologies for alleviating this problem.

The equilibrium implications of the fixed-proportions assumption are best observed from examining the variable cost function in marketing. For this purpose, let  $v$  denote a quantity of the non-farm input, let  $m$  denote its price, and let  $y$  denote the quantity of product produced from combining the inputs in fixed proportions. The minimum cost function is

$$(9) \quad C(w, m, y) \equiv \min_{x, v} \{ wx + mv \mid \min\{x; v\} \geq y \} = (w+m)y.$$

The significant implication follows from equating the price of the product, say  $p$ , to the marginal cost function on the right side of (9). An equation of the form  $p - w = m$  results, and its significance in terms of depicting farm- and retail-price relationships is that it forces the difference between the two prices to be equal to some exogenous level,  $m$ , which is commonly referred to as the marketing margin.

More generally, let us consider a cost function of the form  $C(w)y$  where  $C(w)$  is linearly homogeneous in  $w$  and  $m$ , but we suppress  $m$  because it plays an insignificant role in the remainder of the analysis. In addition, let  $D(\cdot)$  denote demand in a terminal market and assume that non-farm inputs are available in perfectly elastic supply.<sup>7</sup> When marketing agents behave competitively, equating marginal costs to price, and producers levy a tax in order to finance research, an equilibrium for the endogenous  $p$ ,  $w$ ,  $y$ , and  $x$  is conditioned by the parameters  $\theta$  and  $\tau$ . These parameters are exogenous to the equilibrium. Accordingly, they generate comparative-static effects through displacements in the system

$$(10) \quad y = D(p, \theta),$$

$$(11) \quad p = C(w(1+\tau)),$$

$$(12) \quad x = C_w(w(1+\tau))y,$$

$$(13) \quad x = S^{-1}(w).$$

To determine how prices and quantities adjust when we alter research effort and the tax rate, we compute adjustments in  $p$ ,  $w$ ,  $y$ , and  $x$  in response to changes in  $\theta$  and  $\tau$ . As usual, these computations can be made more meaningful by depicting the results in proportional-change terms. Therefore, for some variable of interest, say  $u$ , let  $\tilde{u} \equiv \Delta u/u$  denote a proportional change. Applying this procedure in (10)-(13), we obtain:

$$(14) \quad \tilde{y} = -\eta \tilde{p} + \delta \tilde{\theta},$$

$$(15) \quad \tilde{p} = \alpha \tilde{w} + \alpha \left( \frac{\tau}{1+\tau} \right) \tilde{\tau},$$

$$(16) \quad \tilde{x} = -(1-\alpha) \sigma \tilde{w} - (1-\alpha) \sigma \left( \frac{\tau}{1+\tau} \right) \tilde{\tau} + \tilde{y},$$

$$(17) \quad \tilde{x} = \xi \tilde{w},$$

where  $-\eta \equiv (\partial D(p)/\partial p)(p/D(p)) \in (-\infty, 0)$  and  $\xi \equiv (\partial S^{-1}(w)/\partial w)(w/S^{-1}(w)) \in (0, +\infty)$  denote, respectively, the elasticity of demand for the retail product and the elasticity of supply of the farm commodity;  $\alpha \equiv wx/C(w)y \in (0, 1)$  denotes the farmer's share of the food dollar; and  $\sigma \equiv w(1+\tau)C_{ww}(w)/C_w(w)(1-\alpha) \in (0, +\infty)$  denotes the elasticity of substitution between farm and non-farm inputs in the production of the retail product. The reduced-form solutions corresponding to these equations are important for they affect the allocation rules when producers make decisions about self-financed schemes. In particular, the two reduced-form elasticities appearing in equation (8) can be retrieved as solutions to the endogenous movements in the farm price, given changes in  $\theta$  and  $\tau$ . Respectively, these are:

$$(18) \quad E(w, \theta) = \frac{\delta}{\Omega},$$

$$(19) \quad E(w, \tau) = \frac{\Omega - \xi}{\Omega} \left( \frac{-\tau}{1+\tau} \right),$$

where  $\Omega \equiv \xi + \alpha\eta + (1-\alpha)\sigma \in (0, +\infty)$  and the sum  $\alpha\eta + (1-\alpha)\sigma \in (0, +\infty)$  constitutes the Hicks-Allen (reduced-form) elasticity of demand facing the farm sector. This elasticity amalgamates all of the effects of activities occurring in the down-stream markets and expresses them as price effects at the farm gate. Specifically, it combines information from both the retail market—parameter  $\eta$ —and the marketing sector—parameter  $\sigma$ —and weights them according to the magnitude of the cost share of farm inputs in food marketing—parameter  $\alpha$ . When the cost share of non-farm inputs is small,  $\alpha$  is close to one and the elasticity of substitution becomes relatively impotent as a determinant of farm-price movements; however, when  $\alpha$  is large, the elasticity of substitution becomes more significant. Thus, the severity of ignoring substitution possibilities is conditioned, not only by the magnitude of  $\sigma$  itself, but also by the share of non-farm input costs. To illustrate further, consider the problem of computing the optimal tax rate. Substituting (18) and (19) into (8), we derive

$$(20) \quad \frac{\tau^*}{1+\tau^*} = \frac{\delta}{\alpha\eta + (1-\alpha)\sigma}.$$

This rule states that the relative value of the ad-valorem tax must be set equal to the ratio of two effects: The first measures the impact of the research activity on the market for which it is targeted; the second effect measures the elasticity of derived demand in the farm-commodity market. These two effects serve to offset one another in computing the optimal rate of taxation: The greater the impact of the research, the larger is the rate at which the tax should be set, but the greater the elasticity of derived demand, the smaller the optimal rate. Given information about the downstream impact of promotion ( $\delta$ ), the farm-input share in marketing ( $\alpha$ ), preferences for the retail product ( $\eta$ ), and the elasticity of substitution ( $\sigma$ ); it is possible to infer the optimal level of the tax to apply at the farm gate. Once established, the optimal rate can then be compared to the prevailing market rate in order to gauge the efficiency of the program. In general, however, inferences in (20) will be biased and inefficient under the fixed-proportions assumption. Below, we discuss two procedures for assessing the significance of this bias, and another that is capable of circumventing the problem altogether.

## Econometric Procedures

We begin by appending disturbance terms to the structural equations, (14)-(17). The resulting system can be transposed, normalized, and rewritten in the standard form

$$(21) \quad YB + Z\Gamma + E = 0,$$

where  $Y$  denotes a  $T \times M$  matrix of  $T$  observations on the  $M$  endogenous variables;  $Z$  is a  $T \times N$  matrix of observations on the  $N$  exogenous variables;  $B$  is an order- $M$ , square, nonsingular matrix of coefficients;  $\Gamma$  is an  $N \times M$  matrix of coefficients; and  $E$  is a  $T \times M$  matrix of unobserved disturbance terms with mean a  $T \times M$  null matrix and covariance  $\Sigma \otimes I_T$  where  $\Sigma$  is a positive-definite, symmetric matrix of order  $M$ ,  $\otimes$  denotes the kroenecker product, and  $I_T$  denotes the  $T$ -dimensional identity matrix. To derive the likelihood function, first rearrange (21) in the form

$$(22) \quad \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_M \end{pmatrix} = \begin{pmatrix} z_1 & & & \\ & z_2 & & \\ & & \ddots & \\ & & & z_M \end{pmatrix} \begin{pmatrix} \delta_1 \\ \delta_2 \\ \vdots \\ \delta_M \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \\ \vdots \\ e_M \end{pmatrix},$$

where  $y_i$  denotes the  $i^{\text{th}}$  column of  $Y$ ;  $z_i$  is the  $T \times k_i$  matrix of observations on the  $k_i$  explanatory variables appearing in the  $i^{\text{th}}$  equation;  $\delta_i$  is the  $k_i$  vector of unrestricted coefficients appearing in the  $i^{\text{th}}$  equation; and  $e_i$  is the  $i^{\text{th}}$  column of  $E$ . Equations (22) can be rewritten compactly as:

$$(23) \quad y = z\delta + e,$$

and the probability distribution of  $e$ ,

$$(24) \quad g(e) = (2\pi)^{-MT/2} |\Sigma \otimes I_T|^{-1/2} \exp \left\{ -\frac{1}{2} e' (\Sigma \otimes I_T)^{-1} e \right\},$$

can be transformed to derive the likelihood function,

$$(25) \quad \ell(\cdot) \propto |\Gamma|^T |\Sigma \otimes I_T|^{-1/2} \exp \left\{ -\frac{1}{2} (y - z\delta)' (\Sigma \otimes I_T)^{-1} (y - z\delta) \right\}.$$

Inferences about the efficiency of producer levies can be made in the context of maximizing the logarithm of (25) and the validity of the restrictions implied by (8) can be assessed by comparing the value of the maximized likelihood to the one obtained when the restrictions are imposed, a standard procedure. The full-information estimates that result are known to be consistent, and to have the same asymptotic properties as three-stage least squares applied to (23) (Judge et al., p. 653).



When interest lies solely in computing the level of the tax, two alternatives exist. The first involves deriving estimates of (20) through an iterative procedure. Initially, asymptotically consistent estimates of essential parameters are obtained by applying the three-stage least-squares estimator to equations (23). Using (20), an estimate of the tax is obtained. The estimated tax rate is then applied in a restricted estimation of (23), and another estimate of the tax rate is obtained. The procedure is repeated until convergence, if ever, is achieved. Although we have not established the sampling properties of this approach, we conjecture that it is likely to yield consistent estimates of the optimal tax rate. Moreover, with appropriate restrictions imposed across equations (14)-(17), the iterative procedure can also be used to derive estimates of the tax rate that are consistent with the fixed-proportions assumption. Subsequently, differences between the two estimates can be used to assess the magnitude of any bias resulting from this assumption.

A second procedure for inferring the level of the tax rate is based on a limiting assumption that is conditioned by the periodicity of the data. This is that, throughout the sample period, supplies of farm inputs to the marketing sector are completely inelastic.<sup>8</sup> In terms of equations (14)-(17) this is equivalent to assuming that the farm-commodity supply elasticity ( $\xi$ ) is zero. Using this assumption in equation (19), the reduced-form elasticity  $E(w, \tau)$  reduces to the expression in the left side of (20). Thus, efficient estimates of the tax rate can be obtained from ordinary-least-squares estimates of a single coefficient in the reduced-form equation explaining movements in the farm-commodity price. To test the exogeneity of farm-commodity supplies in the farm-level demand equation we advocate use of the Wu-Hausman procedure. Due to the simplicity of the third technique, we advocate its use prior to proceeding with either the iterative three-stage least squares or maximum-likelihood techniques.

## Empirical Model

We apply the methodology to 42 quarterly observations (1978:2-1988:4) on the Australian beef sector. Throughout the sample period the Australian Meat and Livestock Corporation has been actively engaged in a national advertising campaign, the stated objective of which is to enhance retail demand for Australian beef. Initial decisions to undertake the project were made in response to two concerns, namely a possible decline in consumer preferences for red meat, and a lack of objective information on the effects of advertising on net returns to Australian beef producers (Fisher, 1989). A study was commissioned (Ball and Dewbre, 1989) and an analysis conducted of the historical effects of advertising on retail prices. It was estimated that, in response to a \$1 million (Australian) increase in advertising expenditures, average retail prices of beef would increase by 1.2 cents per kilogram. It was concluded that, during a twelve year period beginning 1978, beef producers had gained considerably from the effects of advertising in the downstream market.

These conclusions are reconfirmed by a recent study (Piggott et al., 1996). Using the advertising expenditure series tabulated in Ball and Dewbre, Piggott et al. find consistent evidence of positive impacts of advertising on retail demand for beef. Moreover, this result was found to be quite robust, appearing invariant to a variety of model specifications including single- and multiple-equation procedures.

The present application takes another look at these Australian data. Specifically, we examine the reduced-form equation:

$$(26) \quad \tilde{w}_t = E(w, \theta_t) \tilde{\theta}_t + E(w, \tau_t) \tilde{\tau}_t + E(w, x_t) \tilde{x}_t + \sum_{i=1}^N E(w, z_i) \tilde{z}_{it} + \varepsilon_t, \quad t=1,2,\dots,T;$$

where  $\tilde{w}_t$   $t=1,2,\dots,T$  denote observations on movements in the farm price;  $\tilde{\theta}_t$   $t=1,2,\dots,T$  are observations on movements in advertising intensity;  $\tilde{\tau}_t$   $t=1,2,\dots,T$  denote inter-period movements in

the tax rate;  $\tilde{x}_t$   $t=1,2..T$  denote observations on farm-commodity quantities;  $\tilde{z}_{it}$   $i=1,2..N$   $t=1,2..T$  are observations on  $N$  additional instruments; and  $\varepsilon_t$   $t=1,2..T \sim N(0, \sigma^2)$  are random errors. The farm price used is a weighted average of Australian saleyard prices of live yearling cattle, oxen, and cows (Commodity Statistical Bulletin).<sup>9</sup> The remaining data on advertising expenditures and two instruments are taken directly from Piggott et al. Respectively, the instruments are the retail price of lamb ( $i=1$ ), and total expenditures on all meats ( $i=2$ ).

Movements in advertising intensity are proportional to advertising expenditures. This result follows from equation (1) and an additional assumption that advertising rates have not adjusted substantially across the sample period.<sup>10</sup> Observations on the tax rate are readily constructed from these assumptions. In fact, the balanced-budget condition in (5) and the constant-returns assumption in (1) imply an identity between movements in the tax rate and movements in three other variables in the system, namely the farm price and quantity and advertising expenditures. Herein a problem arises because the farm price is endogenous.<sup>11</sup> Specifically, and for each time period, the budget constraint implies the equality

$$(27) \quad \tilde{\tau}_t = \tilde{\theta}_t - \tilde{w}_t - \tilde{x}_t, \quad t=1,2..T.$$

Making appropriate substitutions and allowing for the endogeneity of the tax rate, the reduced-form price equation, is:

$$(28) \quad \tilde{w}_t = \phi_\theta \tilde{\theta}_t + \phi_x \tilde{x}_t + \sum_{i=1}^N \phi_i \tilde{z}_{it} + \xi_t, \quad t=1,2..T;$$

where:

$$\phi_\theta \equiv \frac{E(w, \theta_t) + E(w, \tau_t)}{1 - E(w, \tau_t)},$$

$$\phi_x \equiv \frac{E(w, x_t) - E(w, \tau_t)}{1 - E(w, \tau_t)},$$

$$\phi_i \equiv \frac{E(w, z_{it})}{1 - E(w, \tau_t)}, \quad i=1,2..N, \quad \text{and}$$

$$\xi_t \equiv \frac{\varepsilon_t}{1 - E(w, \tau_t)}.$$

Two points about this specification that are noteworthy. First, when farm-commodity supplies are exogenous, which is implicit in (28), the value of the elasticity of the farm price with respect to the tax rate can never exceed one. As shown in (19), when farm supplies are exogenous the coefficient of the tax-rate variable is the optimal level of the tax rate. Unfortunately, however, this rate cannot be identified from (28) and estimation of the structural equations must be made, yielding only consistent estimates. We do not pursue this matter further.

The second noteworthy feature of (28) follows from examining the definition of the first coefficient in the right-hand side. From the rule established in (8), we see that the test for an efficient allocation of producer levies reduces to a test that the coefficient of the movement in advertising expenditures is zero. In other words, the test for an efficient allocation is

$$(29) \quad H_0: \phi_\theta = 0 \quad \text{against} \quad H_a: \phi_\theta \neq 0,$$

for which a simple  $t$  test is applicable. Moreover, by returning to Problem 2 and re-examining the first-order conditions we learn that we can infer from the value of the first coefficient in (28) whether an under-allocation of resources has arisen or, perhaps, an over-allocation has occurred. In the first case, the estimated coefficient will be positive and significantly different from zero; in the second it will be negative.

## Results

Table 1 presents parameter estimates and associated statistics from ordinary least squares applied to (28). The results are satisfactory from a predictive stand-point; over one half of the variation in the dependent variable is explained by the movement in the instruments. The reported Durbin-Watson statistic was obtained from the projection of predicted values on actual values. It suggests that first-order, auto-correlation is not present.

Focusing on the coefficient estimates, livestock quantities, the retail price of lamb, and total expenditures on meats are each significant in explaining movements in the farm price of live cattle. The coefficient of advertising expenditures is small and insignificant. Therefore, subject to three important caveats that we outline below, we offer this conclusion: From the point of view of Australian cattle farmers, the historical allocation of promotion expenditures by the Australian Meat and Livestock Corporation is approximately efficient.

## Concluding Remarks

Our results are subject to a number of limitations. Although the present version of the model is satisfactory, improvements are no doubt possible. One issue is the quality of data; a second is the level of aggregation in the linkage between the retail sector in which the promotion activities are targeted and the corresponding producers to whom benefits accrue; a third is the neglect of cross-commodity effects in making inferences in a single sector.

The first two issues may be resolved jointly, but only through improvements in the quality of reports of research and promotion activities. The Australian Meat and Livestock Corporation attempts to raise producer profits through a variety of media, some of which are national in coverage, others are decidedly regional. The residual impacts of expenditures on revenues and profits in the farm sector depend crucially on the initial impacts of research in the specific markets in which it is targeted, and the elasticity of price transmission between these markets and the farm markets from which the primary product originates. Therefore, it may be fruitful to take more specific account of the regional aspects of downstream activities in an effort to identify possibilities for adjustment within the current portfolio and, possibly, reallocations across regions. This, however, would require a model that is considerably more elaborate than the present one.

The third issue is more complex. The Meat and Livestock Corporation has attempted to change consumer preferences for all red meats, including mutton, lamb and beef. Lamb is a strong substitute for beef—this fact is readily confirmed from our empirical results. The possibility exists that the programs may, in fact, have altered preferences within the red-meats group. If this is true, and significant, then it may impute a bias into single-commodity analyses such as the present one. Therefore, work proceeds toward a multi-commodity analysis of the relevant issues. The analytical procedures and the principals of the tests appear to be robust to this extension.

Finally, and more generally, this paper has demonstrated that inferences about a topical issue in food marketing can be made without the need use marketing margins. In general, the fixed-proportions assumption will bias upward estimates of optimal tax rates. This, in turn, is likely to create inefficiencies and, quite possibly, lead to research allocations that are higher than the optimal ones. Use of the Leontief assumption in applied commodity price analysis is inadvisable. Often, it is unwarranted. More often than not, a satisfactory alternative exists.

## Footnotes

<sup>1</sup> For example, Piggott et al. note that the mandatory check-off fund for US beef has recently been challenged by a lawsuit filed in the US district court in Kansas (Goetz v. United States of America, Civil Action No. 94-1299-FGT).

<sup>2</sup> Throughout, partial derivatives are denoted by subscripts.

<sup>3</sup> Since  $C(\theta)$  is affine in output, the second-order sufficient conditions require that the derivative of the terms on the left side of the inequality be negative.

<sup>4</sup> It is surprising that the funding aspect of the program and, in particular, market inefficiencies that stem from tax collection are neglected in the literature on producer promotion programs. For an interesting account of the implications of these costs in a different setting see Alston and Hurd (1990).

<sup>5</sup> We adopt an ad-valorem tax because it is algebraically convenient to do so. Later, we examine comparative statics expressed in proportional-change terms, for which an ad-valorem tax is more amenable. The equivalent per-unit levy is easily implemented. The two effects are, of course, identical when the agents generating the equilibrium behave competitively, a result that is well known from the public finance literature.

<sup>6</sup> This occurrence, known as the Laffer-curve effect, offers some additional complications, which we will not pursue in this paper, although we allude to them, briefly, during comparative statics. For a fairly complete discussion of the Laffer-curve effect at an introductory level see Varian (1993, pp. 278-89).

<sup>7</sup> This is the common assumption in most empirical work. See, for example, Wohlgenant (1989), Holloway (1991).

<sup>8</sup> Both Wohlgenant (1989) and Holloway (1991) have employed this assumption over the same, annual time series. Wohlgenant found supporting evidence in several of the major US food groups; Holloway used the assumption without validation.

<sup>9</sup> Prices are on an estimated dressed-weight basis and, with the exception of yearling cattle are quoted for export quality stock: oxen, 301-350 kilograms; cows, 201-250 kilograms. The actual quotation is the monthly average of fat-stock prices in each major state market, weighted by monthly production of each meat in the respective state.

<sup>10</sup> Applying the proportional-change calculus in (1) yields:  $\tilde{C}(\theta) \equiv \tilde{\kappa} + \tilde{\theta}$ . The assumption that advertising rates have not changed is equivalent to assuming  $\tilde{\kappa} = 0$ .

<sup>11</sup> Differentiating in (19) and expressing the changes in proportional terms, we have:

$$\tilde{\tau} + \tilde{w} + \tilde{x} \equiv \tilde{\theta}.$$

This identity is consistent with regulation in which advertising expenditures in any given period are allocated according to the observed level of tax revenues in a previous period. In other cases, this equation would hold with probability, and be included as an additional equation in the structural model.



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**Table 1. Reduced-Form Estimates of Quarterly Movements in Prices Received By Australian Cattle Producers (1978:2-1988:4).**

Explanatory Variable	Coefficient	Estimate	t - Ratio
Proportional Changes in:			
Advertising Expenditures	$\phi_0$	-0.003 (0.006)	-0.51
Livestock Quantities	$\phi_x$	-0.621 (0.132)	-4.70
Retail Price of Lamb	$\phi_1$	0.701 (0.177)	3.95
Total Expenditure on Meats	$\phi_2$	0.829 (0.254)	3.26
R <sup>2</sup>	0.562		
Durbin Watson	1.844		

Note: Values in parentheses are standard errors. The R<sup>2</sup> value is obtained from a regression of predicted values against actual values, and the Durbin Watson was computed from this regression.