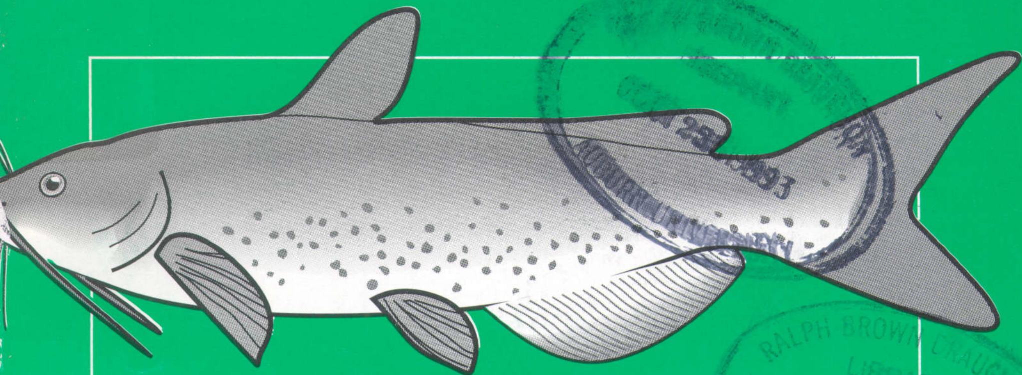

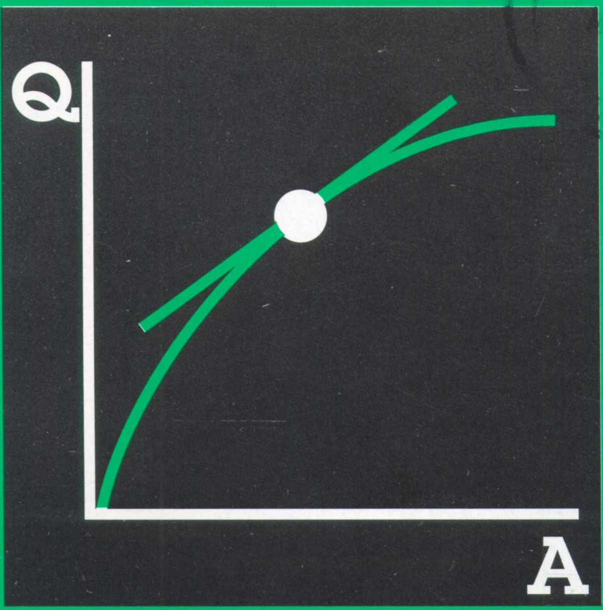

Returns to Catfish Advertising and Optimal Spending Levels

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RETURNS TO CATFISH ADVERTISING AND OPTIMAL SPENDING LEVELS

by

Henry Kinnucan, Walter Zidack, and Upton Hatch[1]

INTRODUCTION

INDUSTRY-SPONSORED media advertising of catfish began in April 1987 after feed mills in Mississippi agreed to a voluntary levy of $6 per ton to finance the program. The program currently produces an annual budget of about $1.5 million and is administered by The Catfish Institute, an industry marketing organization. On July 3, 1989, feed mills in Alabama began remitting to the Alabama Department of Agriculture and Industries $2 per ton on all feed bought, sold, or manufactured in Alabama. The primary intent of the Alabama levy is to fund market development activities for Alabama farm-raised catfish. Unlike the Mississippi levy, the Alabama levy was established through a producer referendum. The referendum provides for producer refunds and must be renewed every 3 years. Although funds from the Alabama levy have not been used yet for media advertising, a decision about whether to participate in the national campaign conducted by The Catfish Institute is currently being debated by industry representatives [Spree and Carlisle (1992)].

The increased support for industry-sponsored promotional programs for catfish follows a national trend. Funds for generic advertising, research, and consumer education programs for commodities, such as beef, pork, dairy, citrus, raisins, walnuts, prunes, avocados, and eggs, have increased from $239 million in 1982 to $750 million in 1990 [Armbruster and Frank (1988); Lenz, Forker, and Hurst (1991)].

Decisions about spending levels, the appropriate levy, and whether programs should be continued are becoming increasingly important in market planning of producers, the industry, and from the perspective of public policy. Yet the information needed to make informed deci-

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sions on these matters requires research into the market impacts of the programs, a task that is often beyond the means of the promotion entity or policy maker.

The purpose of the research reported in this bulletin is to determine the effects of generic advertising on equilibrium prices, output, and producer returns in the catfish industry. An additional objective is to identify optimal spending levels for catfish advertising. The objectives are accomplished by estimating a four-equation econometric model of the catfish industry in which advertising outlays by The Catfish Institute are specified as a shift variable in the demand function. Estimated parameters from the econometric model are used in an optimization formula derived from a theory of cooperative advertising to indicate the level of spending that maximizes producers' returns. A brief review of the conceptual framework and econometric model precedes the discussion of the empirical results.

CONCEPTUAL FRAMEWORK

The conceptual framework consists of vertically linked markets for feed, live (farm-raised) fish, and the processed product.[2] At the feed level, mills produce feed and pay a voluntary per unit levy to fund the advertising program. Part of the levy is passed on to producers in the form of higher feed prices. At the live-fish level, farmers purchase feed and produce fish for sale to processing plants. The plants convert fish into fresh and frozen products for final consumption. Plant sales are affected by competition from "wild" catfish, by advertising, and by other factors affecting retail demand.

The economic impacts of advertising depend on the magnitude of the advertising-induced shifts in the derived demand curve for catfish, the slopes of the supply schedules for catfish at the two market levels, the behavior of the marketing margin, and the extent of the pass-through of advertising costs (whether feed mills absorb all, none, or a portion of the levy). The levy pass-through, which in general depends on the relative slopes of the supply and demand schedules for feed [Chang and Kinnucan (1991)], appears at each stage as a leftward shift in the corresponding supply schedule.

Returns to advertising are measured using the concept of producer surplus. Producer surplus represents the aggregate profits of all firms in the industry plus quasi-rents that accrue to fixed or specially adapted

[2]A similar conceptual framework is developed by Zidack, Kinnucan, and Hatch in their study of the wholesale- and farm-level impacts of the catfish advertising program. The focus of that study was on whether advertising-induced shifts in retail demand translate into increased returns to producers when intermediary groups possess market power.

factors of production, such as ponds, aquaculture managerial expertise, and specialized feeding and harvesting equipment. Producer surplus is measured as the area above the supply curve and below the price line.

For advertising to increase producer surplus, two key factors must be involved: the magnitude of the shift in the demand curve relative to the cost of the program and the responsiveness of producers to price. This relationship is illustrated by figure 1, which is a diagrammatic representation of the U.S. farm-raised catfish market, but does not specify the market level at which price is measured. Further, other factors affecting the market, such as catfish imports and domestic supplies of "wild" catfish, are assumed to be held constant.

The effect of producer price responsiveness on producer returns is indicated in Panel (A) of figure 1. The two supply schedules represent alternative degrees of price responsiveness: the flatter curve *S* indicates greater price sensitivity (at any given output level) than the steeper curve *S*'. An increase in demand associated with advertising is represented by a shift in the market demand schedule from *D* to *D*'.

For the given demand shift, the increase in producer surplus associated with the relatively flat supply schedule *S* is represented by the hatched area *PabP*''. Note that this increase in producer surplus represents the difference between increased industry revenues associated with advertising (areas *PabP*'' and *QabQ*'') and the increased aggregate costs (area *QabQ*'') of producing the extra quantity *Q*'' – *Q*.

The increase in producer surplus associated with the relatively steep supply schedule *S*' is represented by the shaded *PacP*'. Since the shaded area exceeds the hatched area, it is evident that the more steeply inclined (less price responsive) supply schedule generates a larger return to advertising. This is because any demand shift generally affects both quantity and price. The distribution of the impact between price and quantity effects depends on the relative slope of the supply schedule: the steeper the schedule, the greater the effect on price relative to quantity. A relatively larger price effect implies a greater increase in producer surplus, hence greater returns to advertising. Thus, catfish advertising in general will be more profitable the less responsive producers are to price (the steeper the slope of the supply schedule for catfish).

The effect of the magnitude of the demand shift relative to the cost of the program on producer returns is illustrated in Panel (B) of figure 1. The basic idea behind the diagram in Panel (B) is advertising will only be worthwhile if the demand shift is large enough to compensate for the cost of the program. The imposition of a levy to fund advertising means that the cost of producing each unit of catfish must be higher.

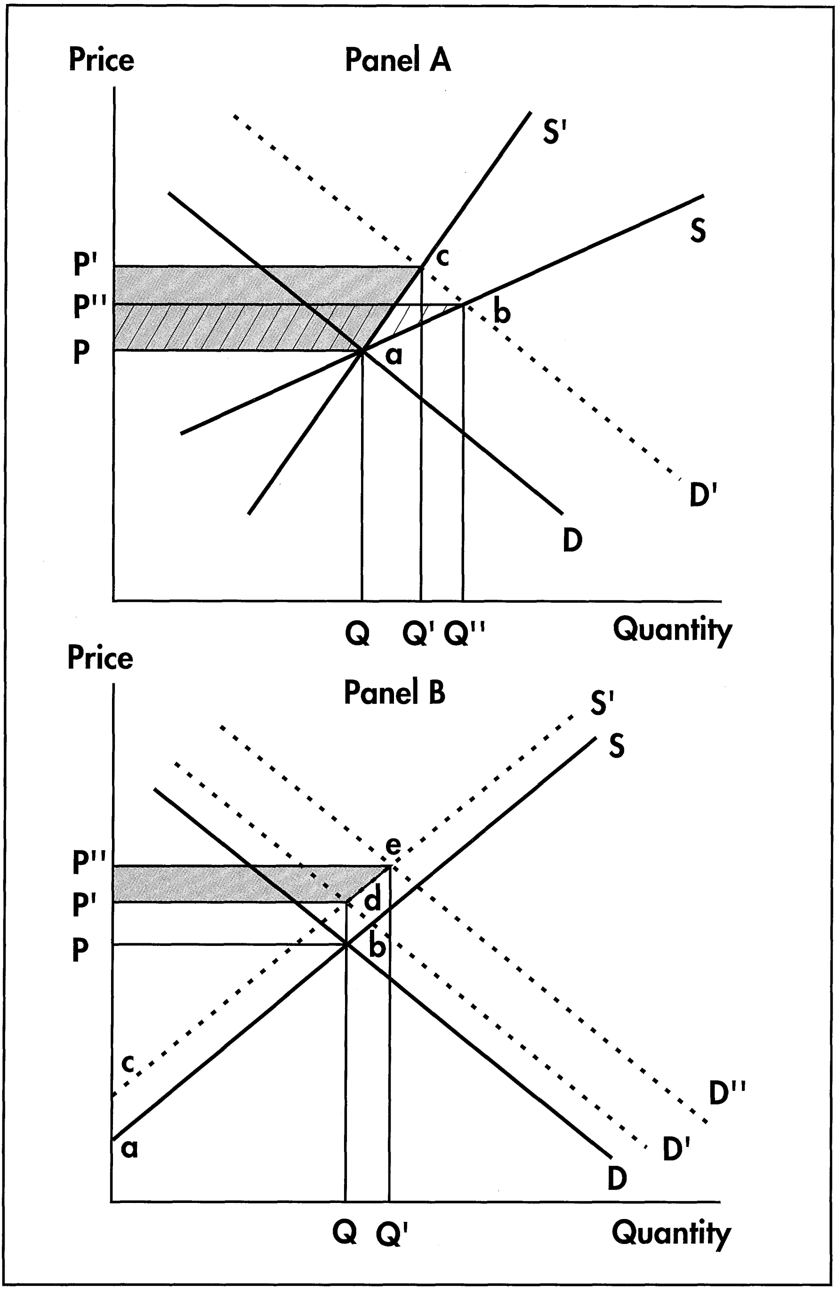


FIG. 1. Effects of increased advertising on price, quantity, and returns to producers.

This can be represented by an upward shift in the supply schedule from *S* to *S*'. Now suppose advertising shifts the demand schedule from *D* to *D*'. The intersection of *S*' and *D*' schedules produces a new equilibrium price *P*', but leaves the equilibrium quantity unchanged at *Q*. In this case, the extra demand generated by advertising is exactly offset by the reduced supply caused by the levy-induced increase in the cost of production. Although the equilibrium market price has increased, producers are no better off. One way to see this is to observe that because $ac = bd$ the triangle representing producer surplus before the levy (triangle *abP*) has the same area as the triangle after the levy (triangle *cdP*').

Thus, to increase producer surplus, the demand shift associated with advertising has to exceed the supply shift associated with the levy. For example, in the diagram if the advertising funded by the levy shifts the demand schedule to *D*" instead of *D*', the triangle representing producer surplus would be *ceP*". This triangle exceeds the original triangle by the area *P'deP*", which represents the net increase in producer surplus generated by the advertising (the increase in producer surplus less the cost of the advertising).

The foregoing analysis assumes that the supply schedule (inclusive of the levy) remains stationary. This presumption may be reasonable for advertising that increases demand temporarily. However, if advertising results in a sustained increase in demand so that firms in the industry experience increases in profits above the normal rate of return, the levy-inclusive supply schedule will likely shift to the right. Under these conditions, the effect of a demand shift on price, output, and producer returns would differ from that illustrated in figure 1.

The case of a sustained increase in demand is illustrated in figure 2. Let *S* be the levy-inclusive supply schedule before the demand shift. Suppose the increase in advertising results in a sustained increase in demand, as depicted by the shift in the market demand schedule from *D* to *D*'. If the supply schedule remains at *S*, equilibrium price and quantity increase to *P*' and *Q*', respectively, generating an increase in producer surplus equal to the shaded area *PacP*'. Now suppose the industry responds to the extra-normal profits by expanding production capacity (building more ponds or adding new firms) or by adopting new technology, so that the supply schedule shifts out to *S*'. The intersection of the *S*' and *D*' curves establishes a new equilibrium in which quantity increases further to *Q*" and price drops to *P*". Because fixed inputs, such as ponds, buildings, and equipment, in this analysis are permitted to be varied in response to price, point b represents a point on the long-run supply curve, S_{LR}. The price drop associated with the supply shift reduces producer surplus to the area *PabP''*. Thus, supply shifts associated with a sustained increase in demand are likely to reduce the profitability of advertising [see, for example, Bockstael, Strand, and Lipton (1992)]. Stated another way, the effect of increased advertising on producer surplus is likely to be greater in the short run than in the long run.

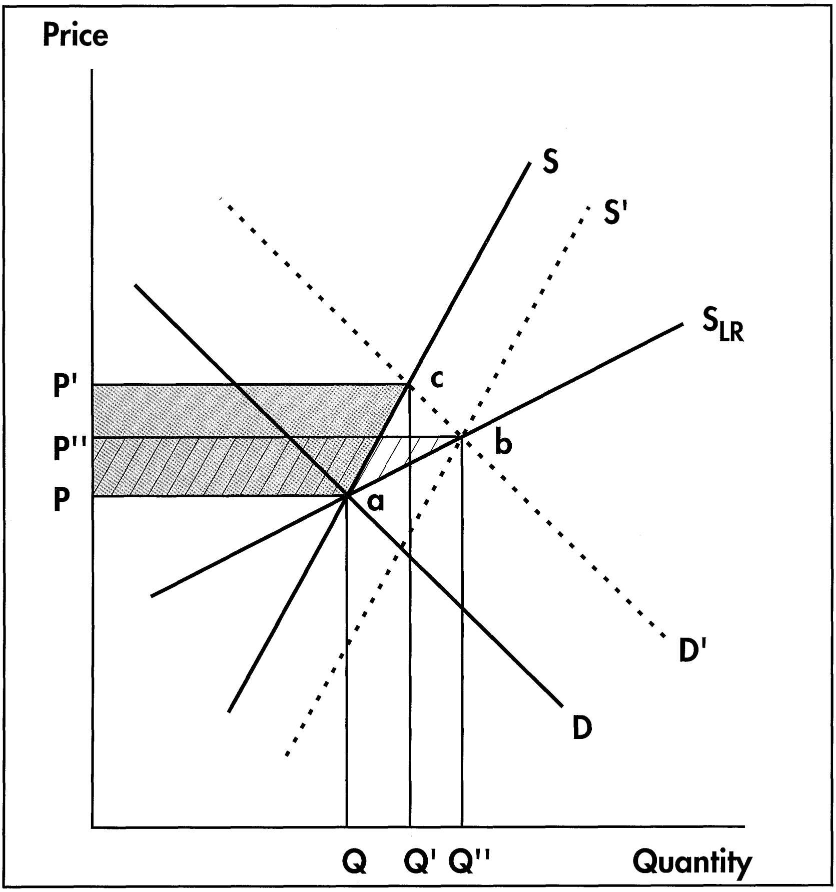


FIG. 2. Effects of a supply shift on producer returns from advertising.

ECONOMETRIC MODEL

The empirical model consists of three structural equations describing farm supply, wholesale demand, and processor price-markup behavior, and one identity that requires ending inventories of processed fish to equal beginning inventories plus any carryover of unsold fish during the month. (The feed market is omitted due to data limitations.) The behavioral assumption underlying the demand, price-markup, and inventory equations is that processors possess sufficient market power to set price [Kinnucan and Sullivan (1986)].

The model is similar to the one specified by French and King for the cling peach industry. Processors are assumed to set price on the basis of input costs (live fish and labor), a normal markup, and the anticipated ending inventory. Feedback on whether price is too high or low is obtained from the demand equation and appears either as an increase or a decrease in actual ending inventories. Price is adjusted accordingly in the subsequent period to maximize long-term profit. Farm supply is treated as predetermined under the assumption that producers' price expectations are based on past prices.

Farm Supply

The general specification of farm supply response is:

$$(1)\quad S = f(\breve{R}, \breve{P})$$

where S is the supply of live fish, $\breve{R}$ is the expected price of live fish, and $\breve{P}$ is the expected price of feed. Since feed constitutes between 45 and 65 percent of catfish production expenses [Keenum and Waldrop (1988)] and the short-run supply relationship is the main interest, the expected live fish/feed price ratio is assumed to be the salient variable in the production decision.

Product supply for the representative profit-maximizing firm, assuming a Cobb-Douglas production relationship [Beattie and Taylor (1985), p. 172], is:

$$(2)\quad Y = \breve{R}^{(\beta/(1-\beta))} \cdot \left(\phi(\beta/\breve{F})^{\beta}\right)^{(1/(1-\beta))}.$$

Because catfish aquaculture has little impact on input markets, equation (2) can be summed horizontally to derive the aggregate supply function. The aggregate supply response then, assuming firm homogeneity, is:

$$(3)\quad QH_t = n \cdot \breve{R}_t^{(\beta/(1-\beta))} \cdot \left(\phi(\beta/\breve{P}_t)^{\beta}\right)^{(1/(1-\beta))}$$

where QH_t is the supply of food-size fish at time t and n is a variable representing industry growth. If a logistic relation [Griliches (1957)] represents the time path of n, aggregate supply becomes:

$$(4)\quad QH_t = \left(\alpha_0\phi^{(1/(1-\beta))}\beta^{(\beta/(1-\beta))}\right)/\left(1+\exp(\alpha_1+\alpha_2 TR)\right) \cdot (\breve{R}_t/\breve{P}_t)^{(\beta/(1-\beta))}$$

where TR is a trend variable as defined in table 1.

TABLE 1. DESCRIPTION OF VARIABLES

Variable type	Symbol	Definition
1. Raw data	POP	U.S. total population, thousands.
	CPI	Consumer Price Index (1967 = 100), all items.
	QI	Total monthly sales of ice-pack catfish, 1,000 pounds.
	QF	Total monthly sales of frozen catfish, 1,000 pounds.
	PI	FOB processor price of ice-pack whole catfish, dollars per pound.
	PZ	FOB processor price of frozen whole catfish, dollars per pound. Prior to February 1983 monthly averages of PI and PZ reported may have included the value of some further processed catfish products.
	PFRM	Price paid to farmers for live catfish, dollars per liveweight pound.
	IN	End-of-month processor inventory of ice-pack and frozen catfish, 1,000 pounds.
	Q	Total monthly quantity of round weight catfish delivered to processors, 1,000 liveweight pounds.
	IM	Monthly imports of processed catfish, 1,000 pounds.
	DI	Disposable income, billions of dollars.
	NWAGE	Nominal U.S. minimum wage.
	PFEED	Monthly average price of 32 percent floating catfish feed in Mississippi, dollars per ton.
	AD	Monthly advertising expenditures by The Catfish Institute, thousands of dollars.
2. Endogenous	QH	Harvested quantity, Q/1,000.
	D	Per 1,000 capita wholesale quantity, (QI + QF) / POP · 1,000.
	INV	Processed inventory relative to sales, IN / QS.
	PW	Real wholesale price, (QI · PI + QF · PZ) / (QI + QF) / CPI · 100.
	PRA	Real wholesale-equivalent farm price, PFRM / CPI · 100 / DRESS.
	AD	Advertising revenue generated by the voluntary check-off, 1,000 dollars per month.
3. Exogenous	PF	Price of feed, PFEED / CPI · 100.
	P_{t-17}	Lagged ratio of farm price to feed price, PRA_{t-17} / PF_{t-17}.
	WAGE	Real minimum wage, NWAGE / CPI.
	Y	Consumer income, DI / CPI / POP · 100,000.
	IMP	Catfish imports, IM / POP · 1,000.
	QS	Total processor sales, millions of pounds, (QI + QF) / 1,000.
	A_{t-i}	Real per 1,000 capita generic advertising expenditures lagged i periods, (AD / CPI + 0.001) / POP · 100,000.
	MAR	Shift variable, MAR = 1 if month is March; equal to zero otherwise.
	D83	Shift variable, D83 = 0 for the period of January 1980 - December 1982, equal to 1 otherwise.
	DUM	Vector of monthly dummy variables. Base month is December.
	TR	Time trend, TR = 1,2,...,120 (Jan. 1980 - Dec. 1989).
	TAX	Effective check-off on feed to fund advertising, dollars per ton.
	DRESS	Conversion factor from liveweight to processed fish.

The inclusion of binary variables to account for seasonal changes in supply associated with off-flavor[3] yields the stochastic equation:

$$(5)\quad QH_t = \delta_0/\left(1 + \exp(\alpha_1 + \alpha_2 TR)\right) \cdot \breve{P}_t^{\delta 1} \cdot \exp\left(\sum_{i=1}^{11} \tau_i DUM_{i,t}\right) \cdot u_t$$

where $\delta_0 = \alpha_0\, \phi^{(1/(1-\beta))}\beta^{(\beta/(1-\beta))}$, $\breve{P}_t$ is the ratio of expected farm price to expected feed price and $\sum_{i=1}^{11}\tau_i DUM_{i,t}$ are binary variables. Inclusion of a multiplicative error term, u_t, results from the heteroskedastic nature of the variance associated with increases in aggregate production.

A 17-period initial lag is specified based on physical constraints imposed by the time needed to raise a fingerling to a food-size fish (about 13 months), harvest delays associated with off-flavor (about 3 months), and lead time necessary to obtain financing and acquire feed and other inputs (about 1 month). Price expectations are assumed to follow a second-order Almon lag distribution of past prices. Although such expectations in general are not rational [Muth (1961)], they do reflect most of the information available to producers.

Taking the natural logarithm of equation (5) and substituting lagged prices for the unobserved expected prices, the final supply response equation to be estimated is:

$$(6)\quad \begin{aligned} \log(QH_t) &= \log(\delta_0) - \log\left(1 + \exp(\alpha_1 + \alpha_2 TR)\right) + \delta_1\ . \\ &\log\left(\sum_{j=0}^{J} \mu_j P_{t-17-j}\right) + \sum_{i=1}^{11} \tau_i DUM_{i,t} + \log(u_t) \end{aligned}$$

where P_{t-17-j} is the ratio of observed farm price to observed feed price in the t-17-j month and j is the as-yet unspecified length of the second-order polynomial lag distribution [Almon (1965)].

Wholesale Demand

In general form, wholesale demand is hypothesized to be:

$$(7)\quad \breve{D}_t = h(PW_t, A_{t-i}, Y_t, IMP_t, \Omega_t, DUM_{i,t})$$

where $\breve{D}_t$ is the desired level of wholesale demand, PW_t is the wholesale price for whole-dressed catfish, Y_t is income, A_{t-i} is lagged advertising expenditures, IMP_t is imports of processed catfish, Ω_t represents

[3]Off-flavor refers to a condition in which food-size fish are unmarketable because they have absorbed flavor compounds produced by pond organisms that cause the fish to have a muddy or musky flavor. The incidence of off-flavor varies seasonally, reaching a peak of 45 percent in the fall. Fish that are off-flavor must be held in ponds until the problem dissipates. The average harvest delay caused by off-flavor is about 3 months.

consumer adoption over time, and $DUM_{i,t}$ are monthly binary variables to capture seasonal shifts in demand.[4]

Because previous research suggests limited substitution between fish and meat products in general [Cheng and Capps (1988)] and, more specifically, between catfish and other fish species [Kinnucan et al. (1988)], catfish is assumed to represent a separable group for estimation purposes. The above equation is a mixed demand function [Chavas (1984)]. Specifically, the (unobserved) price of wild catfish is replaced by the quantity of wild catfish, which in turn is represented by imports.[5] Imports of catfish, which enter the country in processed form for repackaging and sale to retail grocery outlets, are the chief source of catfish obtained from natural fisheries. Because imports account for a modest and declining portion of total processed sales, they are treated as exogenous.

Conceptually, farm-raised catfish is appropriately viewed as a new product. It differs from wild catfish by (1) diet (consisting largely of grain and fishmeal), (2) the existence of numerous product forms, (3) the industry's use of mass-marketing techniques, such as advertising and coupons, and (4) the recent emergence of catfish aquaculture as a viable farm enterprise. Marketing theory identifies a life cycle for new products encompassing four stages: introduction, growth, maturity, and decline [McCarthy and Perreault (1987)]. Information plays a key role in the introduction and growth phases, either accelerating or retarding the time path to maturity, depending on quantity, type, and quality. Media advertising, store promotions, word-of-mouth, and news stories are common means of information dissemination. Because theory suggests a sigmoid-shaped diffusion path of product sales when plotted against time, market researchers often use a logistic function when describing the product life cycle [Wind (1982)].

To implement the product life-cycle concept, a logistic function was selected to represent the time path of consumer adoption of catfish. The logistic growth component of the wholesale demand relation given by equation (7) is:

$$(8)\quad \Omega_t = 1/(1 + \exp(\omega_0 + \omega_1 TR))$$

[4]Because equation (7) is a derived demand relation, a variable to indicate intermediate costs theoretically should be specified. Previous research, however, showed marketing costs to be insignificant [Kinnucan et al. (1988)] and preliminary analysis with the authors' model verified this result.

[5]Prices of wild catfish are unavailable. Expressing the unobserved wild catfish prices as a function of wild quantity, farm-raised quantity, income, and advertising and substituting this inverse demand function into the demand function for farm-raised catfish yields the mixed demand function.

where TR is the previously defined trend term.

Following previous studies [Ward and Dixon (1989)], advertising is specified in the demand equation as a shift variable, with expenditures serving as a measure of the volume of information disseminated by the campaign.

The long-run constant elasticity expression of the demand function given by equation (7) is:

$$(9)\quad \breve{D}_t = \alpha_0 \cdot PW_t^{\alpha 1} \cdot Y_t^{\alpha 2} \cdot IMP_t^{\alpha 3} \cdot A_{t-i}^{\alpha 4} \cdot \Omega_t \cdot \exp\left(\sum_{i=1}^{11} \tau_i DUM_{i,t}\right) \cdot u_t$$

where the error term enters multiplicatively due to the increasing heteroskedasticity of per capita quantity over time.

Solving for $\breve{D}_t$ in the constant elasticity analog of the partial adjustment mechanism [Nerlove (1958)], substituting the results into equation (9), substituting equation (8) for Ω_t, and taking the natural logarithm yields the estimating equation:

$$(10)\quad \log(D_t) = \beta_0 + \beta_1\log(D_{t-1}) + \beta_2\log(PW_t) + \beta_3\log(Y_t) + \beta_4\log(IMP_t) + \beta_5\log(A_{t-i}) - \log(1+\exp(\omega_0+\omega_1 TR)) + \left(\sum_{i=1}^{11} \tau_i DUM_{i,t}\right) + E_t\ .$$

Price Markup

As French and King (1986) suggest, the price-markup behavior of processors is hypothesized to be governed by input costs and inventory effects as indicated by the relation:

$$(11)\quad PW_t = g(PRA_t,\ \breve{INV}_t,\ PROC_t)$$

where PW_t is as defined above, PRA_t is the dressed-weight equivalent farm price, $\breve{INV}_t$ is expected ending inventory relative to sales, and $PROC_t$ is a vector of processing cost variables. Labor constitutes the major variable costs of catfish processing [Garrard, Fuller, and Keenum (1988)]. Because most plant workers are paid at or slightly above the minimum wage, the minimum wage rate ($WAGE_t$) serves as the proxy for $PROC_t$.

Processor inventory relative to sales at time *t* is defined by the identity:

$$(12)\quad INV_t \equiv IN_t / QS_t \equiv (IN_{t-1} + DRESS_t \cdot QH_t - QS_t) / QS_t$$

where IN_t is ending processed inventory, QS_t is monthly processed sales, and $DRESS_t$ is the conversion factor from liveweight to processed fish.

Substituting the adaptive expectations relation solved for expected inventory into a linear specification of equation (12) yields the markup relation:

$$(13)\quad PW_t = \phi_0\gamma_0 + \phi_1\gamma_0 INV_{t-1} + (1-\gamma_0)PW_{t-1} + \phi_2 PRA_t - \phi_2(1-\gamma_0)PRA_{t-1} + \phi_3 WAGE_t - \phi_3(1-\gamma_0)WAGE_{t-1}.$$

Because current and one-period lagged values of the *PRA* and *WAGE* variables in equation (13) are highly correlated, and these variables change gradually over time, the lagged terms are dropped. The stochastic version of equation (13) to be estimated is:

$$(14)\quad PW_t = \phi_0\gamma_0 + \phi_1\gamma_0 INV_{t-1} + (1-\gamma_0)PW_{t-1} + \phi_2\gamma_0 PRA_t + \phi_3\gamma_0 WAGE_t + \phi_4 MAR_t + \phi_5 D83_t + u_t$$

where MAR_t is a March dummy variable capturing hypothesized Lent-related processor pricing practices and $D83_t$ is a dummy that accounts for a structural shift in the margin occurring in 1982-83. The margin shift appears to be the result of the combined effects of industry structural change and changes in USDA measurement of catfish prices [USDA (1988)].

Because the PRA_t and $WAGE_t$ variables represent cost, the estimates of $\phi_2\gamma_0$ and $\phi_3\gamma_0$ are expected to be positive. The parameter associated with the lagged dependent variable should be between zero and one to satisfy stability considerations. Because the demand for catfish increases during the Lenten season, ϕ_4 is expected to be positive. Finally, the sign of $\phi_1\gamma_0$ is expected to be negative to reflect processor desire to move the product in the face of increases in inventory.

DATA AND ESTIMATION PROCEDURES

The empirical definitions of the variables are presented in table 1. All data used to estimate the model are monthly and cover the 10-year period 1980-89. The data relating to the prices and quantities of live and processed catfish were obtained from various issues of the USDA report *Catfish*. Data for feed prices were unavailable from published sources and therefore had to be assembled from data provided to the authors by the feed mills. Data relating to population, income, CPI, and minimum wage came from various government publications. Specific sources are cited in a data appendix available from the authors.

Nonbrand catfish advertising is funded by a voluntary levy of $6 per ton of feed, which generates an annual promotion budget of about $1 million [Allen (1990)]. These funds have been used to conduct a print-media advertising campaign on a more or less continuous basis since 1987. The campaign consists of full-page color advertisements in regional editions of *Newsweek*, *Time*, *People*, *Better Homes and Gardens*, *Sunset*, and several other nationally circulated magazines. For more details about the campaign, see Kinnucan and Venkateswaran (1990). Data reflecting the costs of the campaign on a monthly basis were made available by The Catfish Institute [Allen (1990)].

Because the demand equation is specified in logarithms, the zero observations for advertising pose a mathematical problem. Following the procedure suggested by Wu, Kesecker, and Meinhold (1989, p. 141) the authors handled the problem by adding a small positive number (0.001) to each (zero or positive) advertising observation.

The farm supply equation has predetermined or exogenous right-hand-side variables, and therefore Ordinary Least Squares (OLS) will yield consistent estimates of the parameters. The demand and price-markup equations, in view of the price-setting behavioral hypothesis, are treated as a Woldian causal chain [Jang (1973)]. That is, due to the sequential nature of the linkages among endogenous variables implied by the hypothesis, each right-hand-side endogenous variable can be viewed as predetermined for the purposes of estimation. Thus, the demand and price-markup equations can be estimated consistently by OLS. The demand and supply equations, however, contain nonlinear parameters and therefore were estimated using iterative nonlinear least squares [Judge et al. (1985)]. Unless otherwise indicated, the 5 percent probability level is used to determine statistical significance based on simple *t*-tests.

ESTIMATION RESULTS

Farm Supply Equation

The length of the second-order polynomial lag was determined by estimating lags of longer lengths and selecting the one that maximized the log-likelihood function. The resulting lag length is 32 months, see table 2, implying the short-run supply schedule encompasses a period of slightly less than 3 years. The sum of the lag coefficients is 0.15, suggesting catfish supply in the short run is price inelastic.[6]

[6]Due to rapid growth in the size of the industry over the estimation period (a six-fold increase), the supply equation was reestimated over shorter data periods to determine the robustness of the estimated parameters. Results showed some tendency for the estimated supply elasticity to increase as the estimation period shortened. For example, the 1980-87 data period yielded a similar lag length (16 months) but a short-run elasticity of 0.72. The apparent decrease in the supply elasticity over time may reflect technical advances in catfish aquaculture and the attendant increased specialization of inputs.

TABLE 2. SUPPLY EQUATION PARAMETER ESTIMATES

Variable	Parameter	Estimated coefficient	Asymptotic *t*-ratio
—	$\log(\delta_0)$	6.630	0.517
—	δ_1	.152	2.333
—	α_1	4.780	.373
TR	α_2	-.126E-01	-3.278
DUM_1 (Jan.)	τ_1	.180	4.620
DUM_2 (Feb.)	τ_2	.278	7.005
DUM_3 (Mar.)	τ_3	.315	7.596
DUM_4 (Apr.)	τ_4	.182	4.304
DUM_5 (May)	τ_5	.127	3.029
DUM_6 (Jun.)	τ_6	.784E-01	1.869
DUM_7 (Jul.)	τ_7	.713E-01	1.683
DUM_8 (Aug.)	τ_8	.174	4.151
DUM_9 (Sep.)	τ_9	.149	3.681
DUM_{10} (Oct.)	τ_{10}	.168	4.422
DUM_{11} (Nov.)	τ_{11}	.674E-01	1.781
P_{t-17}	μ_0	-1.057	-1.419
P_{t-18}	μ_1	-.532	-1.103
P_{t-19}	μ_2	-.848E-01	-.303
P_{t-20}	μ_3	.284	1.509
P_{t-21}	μ_4	.575	2.406
P_{t-22}	μ_5	.788	2.425
P_{t-23}	μ_6	.923	2.361
P_{t-24}	μ_7	.980	2.308
P_{t-25}	μ_8	.959	2.266
P_{t-26}	μ_9	.859	2.222
P_{t-27}	μ_{10}	.682	2.130
P_{t-28}	μ_{11}	.426	1.781
P_{t-29}	μ_{12}	.927E-01	.444
P_{t-30}	μ_{13}	-.319	-1.008
P_{t-31}	μ_{14}	-.809	-1.541
P_{t-32}	μ_{15}	-1.377	-1.737
R^2		.955	
Estimated variance		.549E-02	
Mean of dependent variable		2.871	
Number of observations		88	
Degrees of freedom		58	
Estimated autocorrelation coefficient		.301	

A supply elasticity of 0.15 is consistent with the assumption of decreasing returns implicit in the Cobb-Douglas specification of the catfish production function, $0 < B < 1$ in equation (2). The inelastic response is consistent with the fact that commercial-sized catfish operations tend to be highly specialized and exclusive (operated as a single enterprise). The seasonal pattern in supply indicated by the monthly binary variables shows supply peaking in the spring and troughing in the summer. This pattern is consistent with industry stocking practices and the associated harvest delays caused by off-flavor.

Demand Equation

The signs and magnitudes of all estimated coefficients agree with *a priori* expectation. The income and import parameter estimates, however, are not significant, table 3. The insignificance of the import variable is consistent with the findings of Kinnucan et al. (1988) based on disaggregated data from an earlier time period. The lack of significance may be attributable to the limited markets in which imports compete, such as retail grocery, and the declining importance of imports. Be-

TABLE 3. DEMAND EQUATION PARAMETER ESTIMATES

Variable	Parameter	Estimated coefficient	Asymptotic *t*-ratio
—	β_0	2.502	1.696
$\log(D_{t-1})$	β_1	.269	3.150
$\log(PW_t)$	β_2	-.732	-4.569
$\log(Y_t)$	β_3	.276	.525
$\log(IMP_t)$	β_4	-.130E-01	-1.383
$\log(A_{t-4})$	β_5	.551E-02	2.626
—	ω_0	.699	2.001
TR	ω_1	-.258E-01	-9.272
DUM_1 (Jan.)	τ_1	.222	7.194
DUM_2 (Feb.)	τ_2	.341	10.463
DUM_3 (Mar.)	τ_3	.384	9.596
DUM_4 (Apr.)	τ_4	.259	5.724
DUM_5 (May)	τ_5	.255	6.452
DUM_6 (Jun.)	τ_6	.180	4.763
DUM_7 (Jul.)	τ_7	.213	6.418
DUM_8 (Aug.)	τ_8	.266	8.099
DUM_9 (Sep.)	τ_9	.193	5.754
DUM_{10} (Oct.)	τ_{10}	.188	6.051
DUM_{11} (Nov.)	τ_{11}	.633E-01	2.056
R^2		.988	
Estimated variance		.362E-02	
Mean of the dependent variable		3.393	
Number of observations		116	
Degrees of freedom		98	
Estimated autocorrelation coefficient		-.099	

cause previous studies have indicated a negative relationship between income and catfish consumption [Hu (1985)], the lack of significance of income found in this study suggests the industry may be overcoming an image problem reported in earlier studies [Kinnucan et al.(1988)]. Then, too, the development of new product forms, such as fillets and nuggets, may have increased the desirability of catfish among the higher income segments of the population.

The coefficient of the lagged dependent variable supports the hypothesis of rigidities in buyer response, but the implied lag is relatively short (about 2.3 months). The long-run price elasticity of -1.01 indicates an elastic wholesale demand, in agreement with the results obtained by Kinnucan et al. (1988). The seasonal pattern indicated by the coefficients of the binary variables (December base) agrees with past research [Kinnucan et al. (1988)]. Two seasonal demand peaks are noted, one during the Lenten season (February/March) and another, albeit a lesser one, during August. Both parameters of the logistic relation are significant, supporting the product life-cycle specification.

The advertising variable, lagged four periods, is positive and significant. The four-period lag indicates that it took about 4 months for the advertising campaign to "take hold" in terms of increased sales. This delay period is consistent with other studies. For example, Kinnucan (1987) found a 2-month delay in the consumer response to the fluid-milk advertising campaign in Buffalo, New York.[7] The estimated long-run advertising elasticity of 0.0075 is consistent with other estimates. For example, a recent study by Liu et al. (1990) puts the long-run advertising elasticities for fluid milk and manufactured dairy products in the U.S., respectively, at 0.018 and 0.006.

Price-Markup Equation

Estimated coefficients of the markup relation have the correct signs and in general are significant, table 4. Insignificance of the intercept term suggests processors use a simple percentage markup rather than the combination rule described by George and King (1971). The negative sign of the inventory variable is consistent with the behavioral hypothesis of price setting in which processors are assumed to adjust prices in response to feedback from the market as manifested by changes in ending inventory. The coefficient of the lagged dependent variable implies a delay of about 12 months before realizing 95 percent of the total wholesale price adjustment due to a change in processing costs. This result is consistent with the notion of price "stickiness" characteristic of imperfectly competitive markets.

The long-run farm-to-wholesale price transmission elasticity, evaluated at data means, is 0.68. This estimate, albeit larger than the estimate of 0.29 by Kinnucan and Wineholt (1989) for the period 1980-83, appears reasonable given other estimates of transmission elasticities for livestock products, ranging from 0.58 to 0.77 [George and King (1971), p.62] and the decrease in the marketing margin from 56 percent of farm price during 1980-82 to 21 percent during 1983-89. The smaller marketing margin in the more recent period is consistent with the mar-

[7]Delays in the market response to advertising are consistent with the hierarchy-of-effect model that proposes consumers process information in a sequential manner and will not respond to the advertising message until sufficient time has elapsed for beliefs and attitude to be affected [Kinnucan and Venkateswaran (1990)]. The longer delay associated with the catfish campaign vis-a-vis the fluid milk campaign may be related to differences in media and duration of the programs.

gin theory developed by Gardner (1975) that indicates an inverse relationship between the marketing margin and the price transmission elasticity [Kinnucan and Forker (1984)].

TABLE 4. PRICE MARKUP EQUATION PARAMETER ESTIMATES

Variable	Parameter	Estimated coefficient	Asymptotic *t*-ratio
—	$\phi_0\gamma_0$	-0.106	-1.802
INV_{t-1}	$\phi_1\gamma_0$	-.656E-01	-2.544
PW_{t-1}	$1-\gamma_0$	.706	16.950
PRA_t	$\phi_2\gamma_0$	.261	7.405
$WAGE_t$	$\phi_3\gamma_0$	.879E-01	4.718
MAR_t	ϕ_4	.141E-01	1.856
$D83_t$	ϕ_5	-.638E-01	-3.876
R^2		.985	
Estimated variance		.115E-02	
Number of observations		119	
Degrees of freedom		112	
Estimated autocorrelation coefficient		-.104	

MODEL SIMULATION

The wholesale- and farm-level impacts of the generic advertising campaign were evaluated by simulating the model under two scenarios: no advertising and advertising held constant at the mean level for the period 1987-89. The simulations were performed by first collapsing the econometric model into the following (static) deterministic system of five equations in five endogenous variables, QH, PRFM, D, PW, and AD, (see table 1 for definitions):

(15) (Farm supply) $QH - a_0(PFEED + \phi \cdot TAX)^{-a_1} \cdot PFRM^{a_1} = 0$

(16) (Wholesale demand) $D - b_0 \cdot PW^{b_1} \cdot AD^{b_2} \cdot (1{,}000/POP)^{b_2} = 0$

(17) (Price markup) $PW - c_0 - c_1 \cdot (PFRM/DRESS) - c_2 \cdot (INV_{-1}/PD)$

(18) (Advertising revenue) $AD - \Phi \cdot \Psi \cdot QH \cdot 1{,}000 \cdot TAX \cdot (1\text{ton}/2{,}000\text{ lbs})$

(19) (Equilibrium condition) $DRESS \cdot QH - POP \cdot D/1{,}000{,}000 = 0$

This system identifies the equilibrium values for the endogenous variables under the assumption that inventory changes and regression residuals are zero. The model implicitly assumes wholesale and farm quantities (expressed on a wholesale-equivalent basis) are the same in equilibrium.

The identity expressing advertising as a function of the exogenous promotion levy TAX is added to the system so that simulated equilibrium values will reflect any levy-induced shifts in the supply schedule for catfish. The parameters Φ, Ψ, and ϕ are, respectively, the proportion of the levy spent for media advertising, the feed conversion ratio, and the proportion of the feed levy borne by farmers. For the simulations discussed below, $\Phi = 0.9$, $\Psi = 2.0$, and $\phi = 1.0$ (to reflect the most conservative view that farmers pay all of the promotion check-off).

Numerical values for the parameters subscripted with a zero were computed by multiplying the estimated coefficients of the predetermined variables in the respective econometric equations by the sample means of the respective variables, summing these products, and adding the result to the intercept in the respective equations. The slope parameters (those with a nonzero subscript) refer to long-run coefficients. Numerical values for these parameters were computed either by summing the coefficients of lagged terms (in the case of the supply equation) or by dividing the respective short-run coefficients by one minus the coefficient of the lagged dependent variable in the respective equations. The parameters are:

$a_0 = 29.345$	$a_1 = 0.152$	
$b_0 = 93.517$	$b_1 = -1.001$	$b_2 = 0.00754$
$c_0 = 0.394$	$c_1 = 0.888$	$c_2 = -0.223$

The values of the five endogenous variables consistent with "no advertising" were determined by setting TAX equal to 0.01 (1 cent) and solving the system using a nonlinear search algorithm [Burden and Faires (1985), pp. 511-517]. To determine the effect of advertising, the above procedure was repeated, only this time setting TAX equal to 3.67 ($3.67 is the average effective advertising check-off for the period covered by the campaign). The difference in values of the endogenous variables from the two simulations was then taken to be the effect of the advertising campaign.

Results suggest the advertising campaign increased farm and wholesale revenues by 8.0 percent and 9.5 percent, respectively, table 5. However, because of inelastic supply, most of the simulated revenue enhancement is due to price increases rather than quantity increases. In particular, while equilibrium quantities at the farm and wholesale levels are estimated to have increased 1.3 percent as a result of advertising, associated price increases are estimated at 6.7 percent and 8.2 percent, respectively. Thus, in the case of catfish, generic advertising appears to have affected price more than quantity.

A necessary condition for generic advertising to offer a welfare improvement to producers is that the program yields net increases in producer surplus. Results based on the simulations suggest the advertising

TABLE 5. WHOLESALE- AND FARM-LEVEL IMPACTS OF GENERIC ADVERTISING, U.S. CATFISH INDUSTRY, 1987-89

Market level	Variable	Unit	Simulated long-run equilibrium values: Without advertising	With advertising	Absolute difference	Percent difference
Wholesale:						
	Price	$/lb.	1.64	1.75	0.11	6.7
	Quantity	mil. lbs./mo.	12.88	13.04	.16	1.3
	Revenue	mil. dols./mo.	21.12	22.82	1.70	8.0
Farm:						
	Price	$/lb.	.73	.79	.06	8.2
	Quantity	mil. lbs./mo.	24.76	25.09	0.33	1.3
	Revenue	mil. dols./mo.	18.08	19.82	1.74	9.5

campaign increased monthly producer surpluses at the wholesale and at the farm levels of the market by $1.4 and $1.5 million, respectively, table 6.[8] Subtracting the average monthly cost of the campaign over the sample period yields benefit/cost ratios of about 13:1 for each market level. By way of comparison, previous research based on cross-section data indicates that in the first 12 months the catfish advertising program generated benefit/cost ratios ranging from 0.5 to 7.5, depending on the assumed value of the supply elasticity [Kinnucan, Venkates-

TABLE 6. COST AND RETURNS FROM GENERIC ADVERTISING, U.S. CATFISH INDUSTRY, 1987-89 AVERAGE

Item	Market level: Wholesale	Farm
Increase in producer surplus attributable to promotion[1] (mil. dols./mo.)	1.426	1.496
Cost of advertising (mil. dols./mo.)	.104	.104
Net return (mil. dols./mo.)	1.322	1.392
Returns/cost ratio	12.7	13.4

[1]Calculated using the formula R(•) = ΔP(Q* = ½ ΔQ) where R(•) is the promotion-induced change in industry producer surplus at the wholesale (G(W)) and farm (G(F)) market levels, ΔP is the promotion-induced change in equilibrium price, Q* is the industry equilibrium output in the absence of promotion, and ΔQ is the promotion-induced increase in equilibrium output.

R(W) = .11(12.88 + ½.16) = 1.426
R(F) = .06(24.76 = ½.33) = 1.496

[8]Since feed mills share in the cost of the advertising levy, one may question whether measuring surpluses at the wholesale or farm level captures the surplus generated at the feed level. The answer is yes, provided that changes at the intermediate levels do not affect prices of other products or factors. Analysis of the more general case suggests the surplus measures provided in this paper are only first approximations [Just and Hueth (1979)].

waran, and Hatch; Kinnucan and Venkateswaran (1991)]. In the present study, the favorable rents accruing to advertising are due in large part to the highly price-inelastic supply schedule for catfish. This fact highlights the importance of supply response as a determinant of the welfare impacts of generic advertising programs.

A potential limitation of the foregoing analysis of cost and benefits is that adjustment costs are ignored. That is, simulations do not take into account costs that may have arisen as a result of market disequilibrium induced by the advertising program. The causes of advertising-induced market disequilibrium, more fully explained by Clement (1963), stem primarily from the lags associated with the market responses to price and advertising. For example, because of biological and other constraints enumerated earlier, producers require about a 17-month lead time to begin to increase the market supply of catfish in response to an increase in market price. This lag means that the market supply schedule for catfish is essentially vertical for this period of time. Because of uncertainties about whether a price increase is temporary or permanent and other factors, another 15 months is required for producers to respond fully to the price change. Thus, the short-run supply schedule for catfish (defined as the supply schedule that permits only feed to be varied in response to a change in price), encompasses a period of about 32 months.

The market demand response to a one-time increase in advertising, on the other hand, is completed in about 7 months, according to our econometric estimates. The implications of the differing lag structures for advertising and supply can be illustrated with the aid of figure 3. The initial market equilibrium (equilibrium before the increase in advertising), is indicated by the price/quantity pair P and Q, which is generated by the intersection of the market demand schedule D with the immediate- and short-run supply schedules S_{IR} and S_{SR}. The increase in demand associated with an increase in advertising is represented by a shift in the market demand schedule from D to D'.

The initial impact of the demand increase is to raise the market price to P'. This increase in price will occur within about 7 months following the increase in advertising and will be sustained for an additional period of at least 13 months.[9] During this period, producers will base their expectations of the future price of catfish on P'. Note, however, that P' exaggerates the true effect of the advertising campaign in terms

[9]The authors say "at least" because some producers will begin responding to the price increase as soon as it is observed in the market. According to the econometric results, price will begin rising about 4 months following the increase in advertising. Recalling that the supply schedule is vertical for 17 months, some product will reach market as soon as 21 months following the increase in advertising.

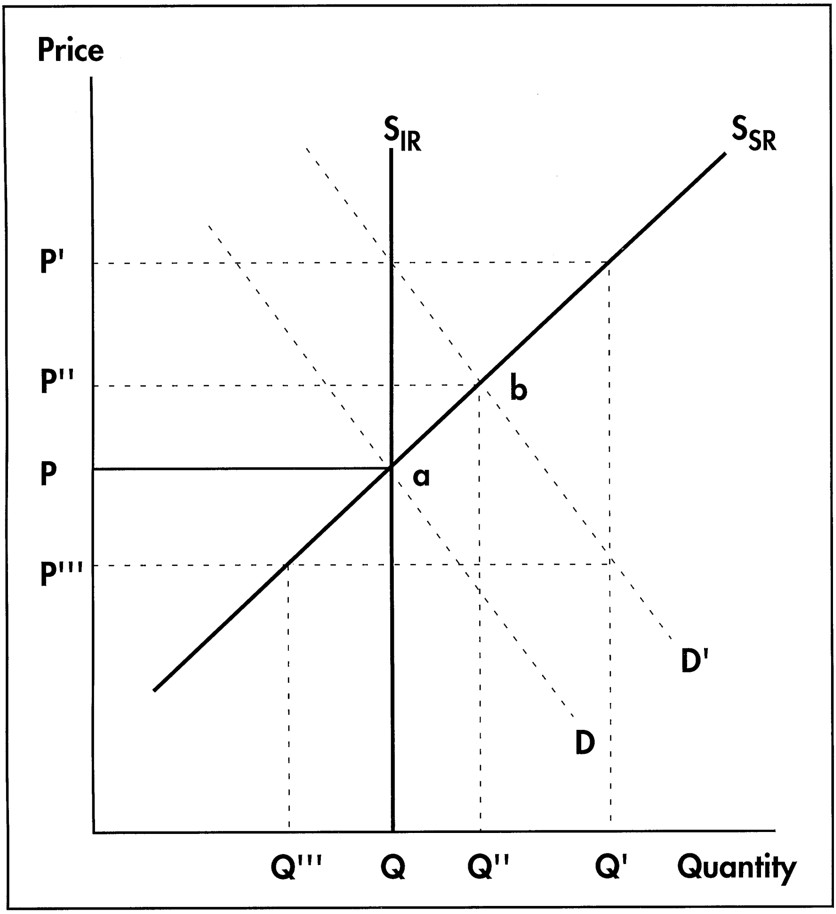


FIG. 3. Dynamic adjustment of supply and price to advertising.

of its ability to increase price over the longer run. The true price effect of the increased advertising is determined by the intersection of the D' and S_{SR}, which generates the lower price P''. The upshot is that producers are encouraged to overexpand, to increase output to Q' instead of the smaller quantity Q'' that is the correct amount in competitive equilibrium. Any overexpansion in the industry induced by advertising implies that the full costs of the program are not being recovered.

An additional point to note is that the advertising program may set in motion a series of boom and bust cycles [Zidack and Hatch (1991)]. For example, when the output Q' that is induced by the initial price increase comes to market, the price of catfish will drop to P'''. This price encourages producers to reduce output to Q''', which is too low relative to equilibrium amount Q''. Price, therefore, rises again in the ensuing period, signaling the need for more output, which, in turn, depresses price in yet a later period. And so it goes. Although the industry eventually will shift from point *a* to the new and (presumably) more profitable equilibrium point *b* in figure 3, in the interim some firms will have experienced losses in profits and investments. To the extent that these adjustment costs are present, the static simulations represented by the system of equations (15) - (19) will overstate the true benefits of the catfish advertising program.

OPTIMAL SPENDING LEVELS

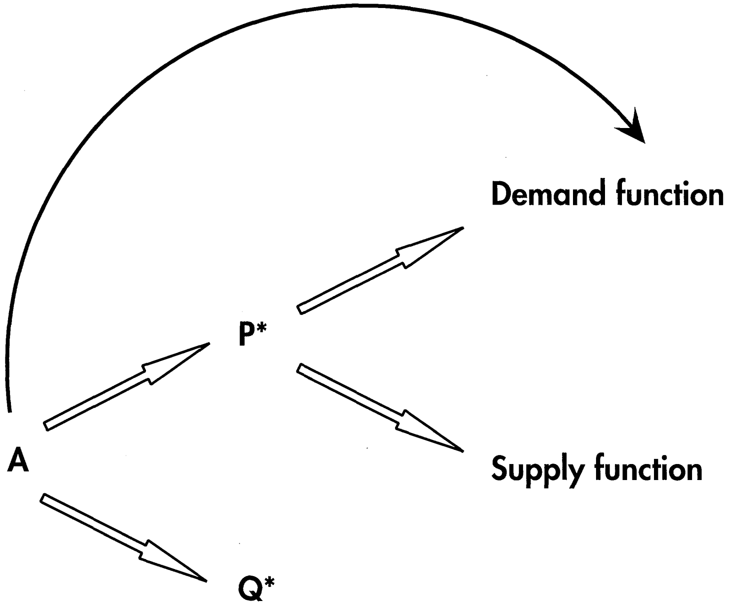
The optimal advertising level depends in part on the industry's objectives. Objectives may include increasing aggregate sales, changing consumers' beliefs and attitudes, reducing excess inventory, or maximizing producer returns. Lenz, Forker, and Hurst (1991, p.12) found that 68 percent of the small promotion organizations, such as those with annual budgets between \$0.5 and \$1.0 million, identify maximization of producer net returns as the chief objective. Accordingly, it is assumed that the catfish industry wishes to maximize the profits that can be earned from their advertising investment, where profits are defined as producer surplus net of the cost of advertising.

Net producer surplus measures the increase in industry profits attributable to advertising after all economic costs (inclusive of the levy) have been subtracted. A formula, derived in the appendix, that gives the level of spending that maximizes net producer surplus is:

$$\lambda = \beta / [(\varepsilon - \eta)(1 + \rho)] \quad . \tag{20}$$

where λ is the optimal advertising/revenue ratio (optimal advertising expenditures divided by total industry revenues in competitive equilibrium), β is the advertising elasticity, ε is the price elasticity of the industry supply curve (assumed to be positive), η is the price elasticity of the industry demand curve, and ρ is the opportunity cost of advertising funds (the interest rate that could be earned from alternative investments of advertising funds).

Equation (20), based on a theory of cooperative advertising (see appendix), identifies four basic economic forces governing the optimal spending ratio: the advertising elasticity, the price elasticities of supply and demand, and the opportunity cost of advertising funds. The equation summarizes the direct and indirect influences of advertising on supply and demand, as indicated in figure 4. Advertising has a direct effect on demand through the provision of information to consumers. It



NOTE: The curved line indicates the direct effect; straight lines indicate indirect effects. P* and Q* represent price and quantity in competitive equilibrium.

FIG. 4. Direct and indirect effects of advertising on supply and demand. The curved line indicates the direct effect; straight lines indicate indirect effects; P* and Q* represent price and quantity in competitive equilibrium.

also affects demand and supply indirectly by raising the equilibrium market price, see figures 1 and 2.

The direct effect of advertising (A), represented by the curved arrow in figure 4, is captured by the β parameter. This parameter measures the effectiveness of advertising in terms of its ability to increase industry sales. If advertising is ineffective, β would be zero, in which case λ equals zero. A nonzero (and positive) β implies the advertising program was successful in raising demand to a higher level. And the larger the β, the more successful the campaign; hence, the greater the shift in the market demand schedule. Thus, as β increases, *ceteris paribus*, so too does the optimal advertising ratio.

The indirect effects of advertising, represented by the straight arrows in figure 4, are indicated by the ε and η parameters. Indirect effects occur because advertising in general increases not only equilibrium quantity (Q^*) but also equilibrium price (P^*), see figure 1. Recalling that producers in a competitive industry have no control over price or output, the indirect effect of advertising on market price sets in motion two responses: producers expand production and consumers decrease consumption. Both of these responses are undesirable from the standpoint of the industry. That is, price-induced increases in quantity supplied or decreases in quantity demanded dilute the profits that can be obtained from the advertising program.

Because ε and η measure the price responsiveness of producers and consumers, it can be seen that the undesirable indirect effects of advertising are minimized as ε and η become smaller in absolute value. A small negative number for η means that consumers will not significantly reduce their consumption when advertising increases price. By the same token, a small positive number for ε means that producers will not significantly increase production when advertising raises price. Thus, because the consumption and production responses to price are attenuated as η and ε become smaller in absolute value, *ceteris paribus*, the optimal advertising ratio rises.

The ρ parameter measures the income foregone by investing in advertising rather than new product development, nutrition education, research, the money market, or other options. Because all productive resources have alternative uses, it is important to consider the income foregone (opportunity cost) by employing the resource in one use rather than another.

In the case of advertising, if the income that could have been earned from alternative investments exceeds the net revenue generated by advertising, it does not pay to continue the program. The opportunity cost of continuing a cooperative advertising program, such as for catfish, may include the income foregone from investing in new feed mill technology or plant and equipment. The greater the opportunity cost of advertising, the less should be spent. Thus, as ρ increases, *ceteris paribus*, the optimal advertising ratio becomes smaller.

To apply equation (20) to the catfish program, the econometric analysis of the previous sections was used. In that analysis the authors obtained the parameter estimates: $\beta = 0.0075$, $\varepsilon = 0.15$, and $\eta = -1.01$. Because of interest in optimal spending levels at the farm level, and because demand parameters (β and η) refer to the wholesale level, some assumptions were made.

First, it was assumed that the demand shift measured at the wholesale level reflects an equivalent shift at the farm level. Technically, this assumption requires that the marketing margin remains constant as demand increases. The marketing margin might in fact widen if processors possess sufficient market power to retain the benefits of a demand increase. Then, too, the marketing margin might narrow if increases in volume lower per unit processing costs. Considering these offsetting factors and that market power does not seem to have adversely impacted producer returns [Zidack, Kinnucan, and Hatch (1992)], the constant-margin assumption appears reasonable, at least as a first approximation. Thus, β is interpreted as a farm-level advertising elasticity.

The second assumption required to apply equation (20) to the catfish market is that catfish processing represents a fixed-proportion production process. This means that processors cannot escape higher fish prices by substituting inputs such as labor for live fish: marketing inputs and live fish are perfect complements.

Although the assumption of fixed-proportions in general is overly restrictive [Wohlgenant and Haidacher (1989)], it is used here as a first-order approximation in order to convert the wholesale demand elasticity estimated earlier to a farm-level elasticity. In particular, if fixed-proportions hold, it is possible to obtain the farm-level elasticity by multiplying the wholesale-level demand elasticity (η) by the farm-to-wholesale elasticity of price transmission [Gardner (1975)]. The transmission elasticity estimated in the econometric analysis is 0.68. Thus, the demand elasticity used in equation (20) is -0.68 (= -1.01 × 0.68).

The appropriate value for ρ to use in equation (20) depends on prevailing interest rates, the internal rate of return from catfish investment projects, and the returns to new product development or other potential uses of the levy. Because it is difficult to specify an appropriate interest rate *a priori*, optimal spending ratios were computed for a range of values of ρ, as indicated in table 7. In addition, because the es-

TABLE 7. RATIO OF OPTIMAL TO ACTUAL ADVERTISING EXPENDITURES FOR ALTERNATIVE VALUES OF THE SUPPLY ELASTICITY AND THE OPPORTUNITY COST OF ADVERTISING FUNDS, U.S. CATFISH INDUSTRY, 1989[1]

Opportunity cost (ρ)	Supply elasticity (ε)		
	0.15	0.55	0.72
0	2.28	1.54	1.36
5	2.18	1.47	1.29
10	2.08	1.40	1.23
15	1.99	1.34	1.18
20	1.90	1.29	1.13
25	1.83	1.24	1.08
30	1.76	1.18	1.04

[1]The ratios are computed using $R = \lambda/k$ where λ is the optimal advertising/revenue ratio [computed using equation (20) in the text] and k is the actual advertising/revenue ratio in 1989. Because the industry in 1989 spent $1 million on advertising and farm revenue was $252 million, k is set equal to 1/252.

timated supply elasticity was sensitive to the sample period, calculations are presented for several values of ε that reflect the range in the estimates.[10]

Results indicate that the industry is underspending, table 7. Depending on the opportunity cost of advertising funds and the magnitude of the supply elasticity, the budget should be increased between 4 percent and 128 percent if the objective is to maximize producer surplus. Using the mid-range supply elasticity estimate of 0.55 and an opportunity cost of 15 percent, results indicate that to maximize producer returns from the advertising investment spending should be increased 34 percent.

CONCLUSIONS

Results based on a four-equation econometric model of the catfish industry suggest generic advertising increased producer returns. The distribution of the impact between price and quantity effects appears to favor price effects; advertising-induced increases in revenue occurred mainly due to increases in price rather than quantity. The relatively large benefit/cost ratios estimated for the program (about 13:1) are attributable in part to an inelastic short-run supply schedule for catfish. Inelastic supply ensures that any demand shifts associated with advertising translate into relatively large increases in producer surplus.

Optimal spending levels were computed to range from 1.04 to 2.28 times the actual level of spending in 1989, depending on the opportunity cost of advertising funds and the supply elasticity. It appears, therefore, that the program could have generated more profits if it were better funded. For example, assuming an opportunity cost for advertising funds of 15 percent, results suggest that an 18 to 99 percent increase in the advertising budget is warranted if the objective is to maximize producer returns.

A potential limitation of the study is that results assume a stationary (levy-inclusive) supply schedule and simulations were based on a static version of the econometric model. If the supply schedule shifts out as a result of the advertising effort, the estimated price effect would be overstated, the quantity effect understated, and the estimated effect on producer returns would be exaggerated. Whether in fact this is a problem depends on how rapidly the industry can add productive capacity in response to extra-normal profits generated by advertising. If the lead

[10]In light of the discussion surrounding figure 2, estimates of the optimal advertising/sales ratio based on the larger supply elasticities may be interpreted as estimates pertaining to the longer run responses to the advertising program.

times are relatively long, 2 years or more, then the returns estimated in this study from a lump-sum investment in advertising should be fairly accurate.

The biases that may be present due to static simulations of the model are more difficult to gauge. Because of lags involved in both the consumer response to the advertising campaign and the producer response to price increases, the equilibrating adjustments proceed in a complex manner through time. For example, biological and behavioral constraints suggest the supply schedule for catfish is essentially vertical for about 17 months. The econometric results, moreover, suggest that the short-run supply schedule encompasses a period of about 32 months. The response period for advertising, on the other hand, appears to cover about 7 months (an initial period of 4 months when no response occurs and another 3 months of carryover).

The combination of relatively long lags for supply response and relatively short lags for advertising response suggest that increases in advertising will have a relatively large initial effect on price. One implication of the large initial price impact is that production may be overstimulated relative to the amount consistent with long-run competitive equilibrium. As the extra supply stimulated by the price increase comes on the market, price may be depressed below the long-run equilibrium level, setting up a cobweb-type cycle of boom and bust. The ensuing disequilibrium, to the extent that it reflects the actual workings of the catfish market, imposes a cost on the industry that is not reflected in the static simulations of the model.

Bearing in mind the foregoing limitations, results of the study indicate that the catfish advertising program has increased returns to producers. Spending levels, moreover, were probably suboptimal in the sense that even greater returns could have been achieved if the program were better funded.

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APPENDIX

Optimal Spending Function

A function to indicate the optimal expenditures for advertising can be developed as follows. First, denote the industry demand and supply equations as

$$(A.1) \quad Q^d = D(P, A)$$

$$(A.2) \quad Q^s = S(P)$$

where Q^d is quantity demanded, Q^s is quantity supplied, P is price, and A is advertising expenditures. Let market equilibrium be defined by the implicit function [Chiang (1984, pp. 204-6)]

$$(A.3) \quad F(P^*, A) = S(P^*) - D(P^*, A) = 0$$

where P^* is the market clearing price.

The industry profit function is

$$(A.4) \quad \pi = P^*Q^* - \int_0^{Q^*} S^{-1}(t)dt - A$$

where π is producer surplus net of the cost of advertising, Q^* is the equilibrium quantity, S^{-1} is the industry supply schedule written in inverse form [price as a function of quantity in equation (A.2)].

The equation that solves $\pi_A = 0$, where π_A is the partial derivative of equation (A.4) with respect to advertising, gives a formula for optimal advertising expenditures assuming that the opportunity cost of advertising funds is zero. However, because the producer can earn interest by investing the advertising levy in financial instruments, advertising funds do have an opportunity cost. Opportunity cost is incorporated into the analysis by setting the marginal returns from advertising equal to ρ [Nerlove and Waugh (1958)]

$$(A.5) \quad \pi_A = \rho$$

where ρ is the market rate of interest.

Obtaining a mathematical expression for π_A requires a series of manipulations involving elementary calculus and algebra. First, differentiate equation (A.4) with respect to A

$$(A.6) \quad \pi_A = P^*\, dQ^*/dA + Q^*\, dP^*/dA - S^{-1}(Q^*)\, dQ^*/dA - 1.$$

Recognizing that $S^{-1}(Q^*) = P^*$, equation (A.6) simplifies to

$$\pi_A = Q^* \, dP^*/dA - 1. \tag{A.7}$$

Applying the implicit function theorem [Chiang (1984, p. 208)] to equation (A.3), results in

$$dP^*/dA = -F_A/F_P = D_A/(S_P - D_P) \tag{A.8}$$

where D_A is the partial derivative of the demand function with respect to advertising, S_P is the slope of the industry supply function, and D_P is the slope of the industry demand function.

Substituting equation (A.8) into equation (A.7) yields

$$\pi_A = Q^* \, D_A/(S_P - D_P) - 1\,. \tag{A.9}$$

Equation (A.9) can be expressed in elasticity form by first multiplying the numerator and the denominator of the first term on the right hand side of the equation by P^*/Q^*

$$\pi_A = D_A \, P^*/(\varepsilon - \eta) - 1\,. \tag{A.10}$$

where ε and η are, respectively, the price elasticities of supply and demand.

Now multiply the numerator of equation (A.10) by A^*/Q^* and by Q^*/A^*

$$\pi_A = \beta \, V^*/A^*(\varepsilon - \eta) - 1\,. \tag{A.11}$$

In equation (A.11), β is the advertising elasticity and $V^* = P^*Q^*$ is the equilibrium value of industry revenues.

Substituting equation (A.11) into equation (A.5) and rearranging yields the desired optimal spending function

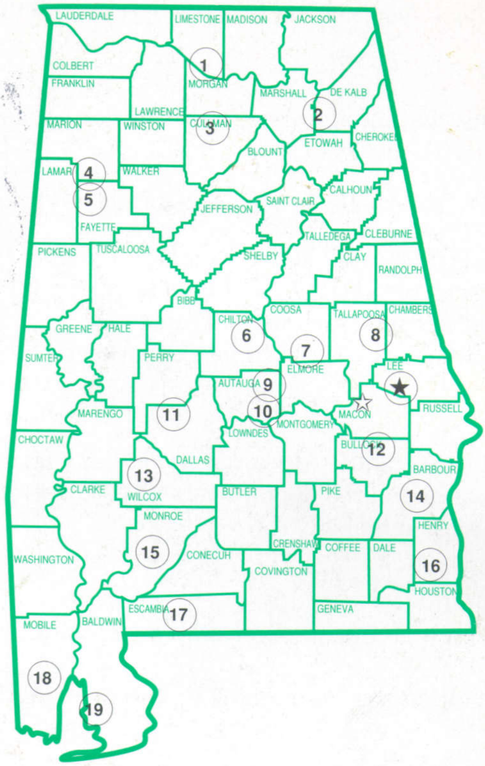
$$\lambda = \beta/[(\varepsilon - \eta)(1 + \rho)] \tag{A.12}$$

where λ is the advertising/revenue ratio (A^*/V^*) that maximizes net producer surplus.

A caveat in using equation (A.12) is that it is based on a purely economic theory of cooperative advertising. In practice, noneconomic factors, such as keeping the levy low enough to maintain producer support for the program, may outweigh profit considerations. Political implications of the levy may be especially important if the program is voluntary, as is currently the case for catfish. Still, if producers wish to maximize returns from their advertising investment, equation (A.12) gives an indication of how much should be spent.

Alabama's Agricultural Experiment Station System
AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Foresty Unit, Autauga County.
10. Prattville Experiment Field, Prattville.
11. Black Belt Substation, Marion Junction.
12. The Turnipseed-Ikenberry Place, Union Springs.
13. Lower Coastal Plain Substation, Camden.
14. Forestry Unit, Barbour County.
15. Monroeville Experiment Field, Monroeville.
16. Wiregrass Substation, Headland.
17. Brewton Experiment Field, Brewton.
18. Ornamental Horticulture Substation, Spring Hill.
19. Gulf Coast Substation, Fairhope.