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ABSTRACT

This paper examines the existence of leader-follower advertising behavior among pesticide industry oligopolists. This behavior can lead to advertising levels that exceed social and joint private optima. Estimation of advertising response models detected only limited evidence of such imitative behavior in contrast to its more widespread occurrence in the cigarette industry.

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INTRODUCTION

Growing pesticide* use is a key reason for continued gains in U.S. farm productivity. Pesticide use is also big business. Domestic sales were over $2.6 billion in 1979 [U.S. Tariff Comm.] with four- and eight-firm concentration ratios of 0.59 and 0.71 in 1976 [Eichers, p.6]. While domestic pesticide sales (especially of herbicides) grew during the 1970s, the most dramatic growth in this industry occurred in another area, television advertising. The spot and network television advertising by the major manufacturers of both herbicides and insecticides soared by over 500 percent during the decade [Leading National Advertisers]. The objective of this research was to determine if the major pesticide firms were engaged in advertising leader-follower behavior, that is, if these firms were locked into a cycle, an unstable equilibrium, of following new advertising expenditures by a leading firm(s). Such behavior is of concern in a social welfare context because it raises the strong possibility that resources are being squandered in a market share "shell game" which may not stimulate aggregate demand. And this game could take the players to levels of advertising well beyond even their own joint profit-maximizing level [Basmann; Koch]. Although a myriad of social welfare arguments can be made on both sides of the value of advertising debate, when advertising exceeds even the private optimum, the case for advertising excess is especially strong. Public intervention may be appropriate in such an environment to either force or facilitate multilateral de-escalation of the advertising race.

This pattern of escalating nonprice competitive behavior has been rationalized in game theoretic terms as a "prisoners' dilemma" or "isolation paradox" game [Koch, p.255; Scherer, p.334], although the "assurance problem" or game could also apply [Sen]. Strong evidence of it was found in the post-World War II U.S. cigarette industry by Grabowski and Mueller and Basmann. Grabowski and Mueller effectively argued that oligopolists will have an incentive to follow increases in a rival's advertising expenditures if price competition and product innovation are less practical competitive tools. Moreover, they suggest the following firm will respond quickly, lest it lose market share or run the risk of having its retaliatory advertising mistaken for a new round of increases. Unlike stable oligopoly pricing situations, Grabowski and Mueller believe that the chain of events triggered by one firm's new advertising initiatives will not likely reach an equilibrium. Rather, a leader or leaders will periodically emerge because they either feel their advertising campaign will be superior to any the rivals could mount or even if not superior, believe that as the leader they will enjoy a profitable headstart.

An earlier study of the oligopolistic pesticide industry found virtually no evidence that television or magazine advertising in the aggregate had a significant effect on industry-wide sales of either herbicides or insecticides during the 1962-1979 period [Boynton and Schwendiman]. They argued that the results of their three-stage least squares regression

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* "Pesticides" in this article collectively refers to herbicides and insecticides.

analyses offered at least circumstantial evidence of a competitive advertising trap in the U.S. pesticide industry. In view of their findings, the rapid increases in television advertising of pesticides, and the lack of emphasis on price competition, further inquiry into the nature of inter-firm advertising relationships seemed worthwhile. If evidence of leader-follower behavior was found then closer public scrutiny of the competitive relationships in the industry would likely be warranted; if no such evidence was discovered welfare concerns arising from this behavior trap are diminished.

THE ANALYTICAL MODEL

The incidence of leader-follower behavior in the herbicide and insecticide markets was examined with Grabowski and Mueller's competitive action-reaction sequence model [p.268] or what we will call the advertising response model. While we employ the same economic and mathematical formulation they used, estimation of the model in this research relied on more refined statistical procedures. The model estimated here is:

$$A_{i,t} = \alpha A^{\beta}_{j,t-1} C^{\gamma}_{i,t-1} v_t$$

where

$A_{i,t}$ = firm i's advertising expenditures in period t,

$A_{j,t-1}$ = the leading firm's advertising expenditures in period t-1,

$C_{i,t-1}$ = a measure of firm i's capacity to finance advertising in period t-1, and

v_t = random error term.

On the basis of the previous arguments, it is expected that firm i will respond to an increase in firm j's advertising by increasing its own advertising. And the greater firm i's command over capital, the more it is hypothesized to spend on advertising. Thus both γ and β (the advertising reaction coefficient) are expected to be positive. The multiplicative mathematical form places maximum emphasis on the rivalrous nature of advertising activity. If firm j stops advertising or firm i has no funds available to it, firm i does no advertising.*

With seven firms dominating the herbicide market and six major insecticide manufacturers, it was decided not to a priori select the leader firm(s) in each market. Models were estimated with all possible combinations of one or more leader firms and the model with the best fit was selected. Goodness of fit was evaluated on the basis of signs, significance, and the adjusted coefficient of determination. Multiple leader firm models offered virtually no improvement over the best single leader formulation and so, in the interest of simplicity, only single leader firm models are reported here.

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* While some have argued that if $C_{i,t-1}$ were negative and advertising profitable, firm i would borrow funds to advertise, it is irrelevant here since the command over capital variable was positive in all instances.

Since strong time trends in pesticide advertising were present, especially in the 1970s, it seemed prudent to test the performance of the advertising response model against a time trend or naive model. The formulation of this alternative model differs from the advertising response model only in the substitution of a time trend variable for the lagged advertising expenditure of the leader firm.

Ordinary least squares was used to estimate the primary and the naive forms of the model separately for each of the seven herbicide firms and the six insecticide producers. Inasmuch as firms' advertising decisions were hypothesized to be imitative after a one-period lag, it seemed appropriate to also apply the statistical approach of "seemingly unrelated regressions" (SUR) where the only linkage between the equations is the rather subtle mutual correlation of the error components of each equation [Kamenta, p.518]. When the equations are estimated separately, information about the disturbances' mutual correlation is disregarded and the efficiency of the estimators becomes questionable. The variables in each equation can be redefined to create a generalized linear regression model containing information on any mutual correlation which exists among the disturbances. When the variances and covariances of the regression disturbances are not known a priori, a two-stage Aitken process is a consistent estimator of the mutual correlation and subsequently serves as an estimator of the structural coefficients with all the desirable properties.

DATA SOURCES

Advertising expenditure data are especially difficult and time-consuming to obtain. Unavoidable deficiencies existed in the expenditure data used here, although over time and among firms we are confident of its relative accuracy. Annual data* were collected for the period 1962-1980 for seven herbicide producers and six insecticide firms. Advertising expenditure data were obtained from two sources. Leading National Advertisers (LNA) were relied upon for expenditure data on television advertising gleaned by regularly monitoring broadcasts on 260 stations in the 75 top U.S. markets.** Agricom, Inc. provided the magazine expenditure data from 1969-1980 based upon audits of approximately 165 farm, horse, and veterinary magazines. LNA data on magazine advertisements were used to complete the needed time series.*** Television and magazine expenditures were combined into a single advertising variable, since it seemed plausible that a firm

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* Quarterly or semi-annual data would have been preferred for this lagged imitative advertising model but simply could not be assembled.

** Prior to 1969 the monitored stations did not constitute a representative sample. Consequently, observations prior to 1969 which appeared to be deficient were adjusted upward using a trend line fitted to more recent data.

*** During the period 1962-1968, LNA only audited the three top farm magazines. Since these three magazines represented an average of 41 percent of all pesticide print advertising from 1969-1980 according to Agricom, LNA's 1962-1968 observations were adjusted by this factor.

reacts to another's total advertising effort. To estimate a model linear in its coefficients, the natural logarithm was taken of all variables. Since zero is not in the domain of the log function, when no advertising expenditures were reported in a given year, $10 was substituted for zero.

The variable $C_{i,t-1}$ was designed to measure a firm's command of funds to finance advertising. Net annual cash flow was constructed from each firm's annual corporate financial report. This measure consisted of net profit after taxes plus depreciation less dividends paid.

RESULTS

The coefficient on the leading firm's lagged advertising expenditures was positive and significant at the five percent level in five of the seven herbicide models and positive and significant at the 17 percent level in the case of a sixth herbicide firm (Table 1). This supports the hypothesis of a competitive advertising cycle among herbicide manufacturers. Only for Stauffer's following of Eli Lilly's lead was the reaction coefficient greater than one, implying a more than proportional response on Stauffer's part. The other positive coefficients were all below unity. Thus the overall strength of support for the competitive response model was somewhat limited. Shell was most often the leading firm; Monsanto, Dupont, and Standard Oil of California all followed Shell's lead. The "access to funds for advertising" coefficient was found significant in only two cases. The adjusted coefficient of determination was reasonably high in all cases, except the Standard Oil model. No conclusive evidence of serial correlation was found in the response models. Using $\bar{R}^2$ as the sole criterion, the response model was superior to the naive model in three of the seven cases. In the remaining four cases, the two forms fit equally well (where at least a 0.05 difference between the $\bar{R}^2$ was required to establish a formulation's superiority). This head-to-head comparison suggests limited applicability of the competitive advertising response model in the herbicide market.

The insecticide results were quite similar to those for herbicides. However, even less support was shown for a competitive advertising cycle. Five of the six reaction coefficients were positive and significant at the 5 percent level (Table 2). As in the herbicide case, Dow Chemical was the only firm not exhibiting the expected follower behavior. Only FMC responded at least proportionally to the leader's expenditures. FMC was the most frequent leader, leading Dupont and Shell. The Dow and Standard Oil models were the only two with especially low $\bar{R}^2$ values. Limited evidence of serial correlation in the response models was found. The naive models performed less strongly than they did in the herbicide case in terms of the significance of the time trend variable, but using the $\bar{R}^2$ criterion, the naive model proved superior in two of the six cases, inferior in two others, and equal to the response model for the remaining two insecticide firms. This comparative performance suggests that the competitive advertising response model is appropriate in the case of only two insecticide firms.

The "seemingly unrelated regression" results were virtually identical to the OLS estimates of the reaction coefficients. For this reason, the SUR results are not reported here. This close agreement between the estimation processes suggests the disturbances among the equations were not correlated

Table 1. Competitive Advertising Response Models and Naive Models for Herbicides, OLS Regression Results, 1962-1980.

Dependent or Follower Firm's Name	Leader Firm's Name	Regression Coefficients 1/ Constant	$A_{j,t-1}$	$C_{i,t-1}$	Time Trend	$\overline{R}^2$	Durbin-Watson Statistic 2/
Eli Lilly	Stauffer	1.4	0.1*	0.4		.68	1.27[a]
		(.68)	(.02)	(.09)			
	Naive	-8383*		-2.8	1110*	.67	0.44[b]
		(.03)		(.05)	(.02)		
Monsanto	Shell	-11.5	0.7**	1.2		.73	1.65[c]
		(.44)	(.00)	(.18)			
	Naive	-10930**		-1.4	1444**	.55	1.69[c]
		(.01)		(.29)	(.01)		
Dupont	Shell	-10.5	0.1**	1.2*		.67	1.07[a]
		(.13)	(.00)	(.02)			
	Naive	-2205**		0.3	291**	.70	1.14[a]
		(.00)		(.32)	(.00)		
Dow	Shell	-14.1**	-0.2	1.6**		.56	2.54[c]
		(.00)	(.01)	(.00)			
	Naive	4211*		2.7**	-559	.51	1.58[c]
		(.04)		(.00)	(.02)		
Stauffer	Eli Lilly	-16.3*	4.0**	-0.7		.88	1.42[a]
		(.02)	(.00)	(.18)			
	Naive	-14955**		-3.8	1977**	.59	0.81[b]
		(.00)		(.07)	(.00)		
Std. Oil Calif.	Shell	-17.2	0.2	1.6		.28	3.13[c]
		(.44)	(.17)	(.18)			
	Naive	-6241		-1.5	826	.29	2.92[c]
		(.27)		(.36)	(.14)		
Shell	Stauffer	-19.9	0.9**	1.5		.76	1.97[c]
		(.27)	(.00)	(.15)			
	Naive	-19994**		-6.2	2646**	.75	0.88[b]
		(.00)		(.02)	(.00)		

1/ * and ** indicate significance at the 5% and 1% levels, respectively. All tests are one-tailed (positive) except for the constant term for which a two-tailed test was used. Figures in parentheses are significance levels.

2/ Durbin-Watson two-tailed test for first order serial correlation at the 5% level was:

[a]inconclusive

[b]indicative of serial correlation

[c]indicative of no serial correlation.

Table 2. Competitive Advertising Response Models and Naive Models for Insecticides, OLS Regression Results, 1962-1980.

Dependent or Follower Firm's Name	Leader Firm's Name	Regression Coefficients[1/]				$\overline{R}^2$	Durbin-Watson Statistic[2/]
		Constant	$A_{j,t-1}$	$C_{i,t-1}$	Time Trend		
FMC	Stauffer	-22.0	1.0*	1.9		.49	.80[b]
		(.38)	(.02)	(.21)			
	Naive	-12942**		-3.0	1711**	.67	1.43[a]
		(.00)		(.12)	(.00)		
Dupont	FMC	-2.9	0.5**	0.3		.49	.82[b]
		(.91)	(.00)	(.43)			
	Naive	-2916		1.7	382	.13	1.02[b]
		(.25)		(.29)	(.13)		
Dow	Shell	-6.9	-3.5	2.5**		.26	1.55[c]
		(.43)	(.01)	(.01)			
	Naive	-2585		-0.4	342	0	1.21[a]
		(.70)		(.45)	(.35)		
Stauffer	Dupont	-25.7**	0.2*	2.8**		.81	0.23[b]
		(.00)	(.03)	(.00)			
	Naive	4085*		5.2**	-545	.83	0.30[b]
		(.03)		(.00)	(.01)		
Std. Oil Calif.	Dow	-3.1	0.2**	0.6		.32	1.69[c]
		(.63)	(.01)	(.13)			
	Naive	-9517**		-5.9	1265**	.70	0.70[b]
		(.00)		(.00)	(.00)		
Shell	FMC	5.5	0.1**	0.002		.43	2.23[c]
		(.13)	(.01)	(.50)			
	Naive	-2267**		0.9	301**	.44	2.12[c]
		(.01)		(.06)	(.01)		

1/ * and ** indicate significance at the 5% and 1% levels, respectively. All tests are one-tailed (positive) except for the constant term for which a two-tailed test was used. Figures in parentheses are significance levels.

2/ Durbin-Watson two-tailed test for first order serial correlation at the 5% level was:

[a]inconclusive

[b]indicative of serial correlation

[c]indicative of no serial correlation.

to any significant degree. Stated differently, the close agreement between the two procedures implies that the OLS estimators are not only consistent and unbiased, but also efficient.

CONCLUSIONS

The objective of this research was to determine if the major pesticide firms were engaged in rivalrous advertising behavior. The advertising response model used to test the existence of leader-follower advertising behavior fit the data well and on initial consideration supported the existence of competitive advertising behavior among most pesticide firms. When the response model was judged against the naive, time trend model, however, rivalrous advertising behavior was found to be prevalent among less than half the herbicide producers, and only a third of the insecticide firms. The reduced support for a competitive advertising response among insecticide firms relative to the herbicide case can likely be explained by the fact that the herbicide market has been the fastest growing segment of the pesticide industry. Advertising expenditures on herbicides were more than double those on insecticides and herbicide sales volume and revenue were also nearly double those of insecticides in 1979.

It thus appears that as a group neither herbicide nor insecticide firms have not been engaged in an unstable system of advertising leader-follower behavior. Social welfare concerns and private profit maximization concerns deriving from aggregate advertising excesses as the result of such an advertising trap are consequently mitigated. These concerns are not entirely eliminated, however, in light of support for the leader-follower hypothesis for three herbicide and two insecticide firms and the findings of previous research in this area. The advertising behavior of pesticide firms would seem to deserve periodic research attention.

It seems reasonable to inquire why pesticide firms as a group are behaving differently than cigarette companies with respect to their advertising. There are several explanations. Perhaps the most likely reason is that the pesticide industry is relatively young and has not yet developed the patterns of rivalrous advertising the older cigarette companies did. Two other possible explanations are directly related to the competitive environment in the pesticide industry. Recall that a precondition for the cyclical leader-follower behavior pattern was that a lag exist between a leader's expenditures and his rival's ability to respond in kind. Perhaps such a lag in the pesticide industry does not consistently occur (or cannot be relied upon), thus discouraging advertising leadership behavior, or it is possible that annual data masked any lag that did exist. Finally, the development of competitive advertising behavior is believed to occur in the absence of price competition and product innovation. However, the little research and development expenditure data that exist for the major pesticide firms suggest a relatively high degree of investment in innovation, perhaps discouraging competitive advertising.

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