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A DYNAMIC SIMULTANEOUS MODEL OF MARKET STRUCTURE AND PERFORMANCE IN FOOD INDUSTRIES

by

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Abstract

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This paper investigates the simultaneous and dynamic nature of the relationship between structure, conduct, and performance (S-C-P) with particular reference to the U.S. food and tobacco processing sector. The empirical results confirm the essentially simultaneous nature of the S-C-P system. Profit margins and advertising intensity interact within a simultaneous framework while concentration evolves slowly over time without responding much to the current economic environment.

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A large number of studies have presented empirical tests of hypothesized relationships between industrial market structure and performance. Common to most of these studies is the assumption that market structure exerts a unilateral and exogenous effect on market conduct and performance. The underlying theory, however, suggests that the correct specification of the Structure-Conduct-Performance paradigm is a set of equations that are necessarily both simultaneously related and dynamic [Williamson, Caves et al., Pagoulatos and Sorensen].

This paper has two objectives: to develop a dynamic simultaneous equation model of three important structure, conduct and performance variables (concentration, advertising intensity, and profitability) and to make inferences about simultaneity and the dynamic properties of these basic industrial organization relationships. The U.S. food and tobacco manufacturing sector is the setting for the empirical analysis.

I. The Analytical Framework

Following Bain's seminal work in industrial organization, a large literature has already been accumulated utilizing single equation techniques to test industrial organization hypotheses. This work was based on the notion of a unidirectional causality running from structure to conduct to performance. More recent theoretical developments, however, suggest not only that market structure may influence conduct and performance but also that market conduct and performance are likely to provide feedback and to influence market structure. For example, in most studies of the relationship

between structure and profitability, it has been customary to include some measure of advertising intenstiy as a structural variable. This follows the traditional hypothesis that some combination of brand loyalty, induced by advertising and economies of scale in advertising, result in a product differentiation barrier to entry which allows established firms to achieve and maintain higher profit rates. The clear implication of this kind of model is that advertising intensity determines profitability [Commanor and Wilson]. Yet recent theoretical work concerning optimal advertising strategy suggest causation may run the other way [Schmalensee]. That is, higher profit rates induce greater advertising intensity, since, ceteris paribus, the higher the profit rate per unit of sales, the more worthwhile it becomes to advertise in order to capture an additional unit of sales.

We are, therefore, confronted with two contrasting theoretical hypotheses: that advertising leads to higher profits and, in turn, high profits lead to more advertising. Once it is recognized that the direction of causation may run both ways, however, then any correlation obtained between profits and advertising within a single equation model provides no information as to whether high advertising creates high profits, high profits lead to high advertising, or both lines of causation occur simultaneously.

Similar problems of potential simultaneity exist in other industrial organization relationships, such as that between advertising and industry concentration. One line of reasoning suggests that concentration stimulates advertising. This argument is based upon the presence of advertising externalities, where overall industry demand, along with demand for an individual firm's product, increase in response to advertising expenditures [Commanor and Wilson]. To the extent that these externalities exist, higher levels of concentration should generate higher levels of advertising, since

the larger a firm's market share, the greater the proportion of the external industry effects and hence, the benefits of advertising that the firm is likely to be able to internalize.

A second view maintains that it is advertising which leads to increased concentration [Mueller and Hamm]. This conclusion is based on the existence of potentially substantial economies of scale in advertising and the possibility that advertising activity creates barriers to entry. We are, therefore, confronted with the expectation that concentration and advertising may be casually interrelated and, therefore, with the difficulty of interpreting single equation correlations between the two.

The above arguments lead to the conclusion that three variables of considerable interest within the traditional structure-conduct-performance paradigm (advertising, profits and concentration) should be viewed as mutually interdependent. This implies that all three should be considered as jointly determined endogenous variables within a system of simultaneous equations and that single equations models are inappropriate for hypotheses testing. For this reason, we develop a three-equation model in which profits, concentration, and advertising are considered jointly determined. The model which is specified in detail later takes the general form provided below:

$$(1) \quad C_t = f(A_t, C_{t-1}, X_t)$$

$$(2) \quad A_t = g(P_t, A_{t-1}, Y_t)$$

$$(3) \quad P_t = h(C_t, A_t, Z_t)$$

The first equation indicates that a typical structural element such as concentration, observed at a time t (C_t), depends on elements of market conduct, e.g. advertising (A_t), on a vector of exogenous structural factors

(X_t), and on past values of the structural element (C_{t-1}). Lagged structural elements reflect the possibility of learning from past interactions and experiences. The second relationship represents advertising intensity, a typical element of market conduct. Market conduct depends on market performance (P_t), a set of exogenous structural elements (Y_t), and past elements of market conduct. Finally, profitability, a traditional performance variable (P_t), is expected to depend on current structural and conduct elements as well as a subset of exogenous market structure elements (Z_t).

II. The System of Equations

In this section the three-equation simultaneous model presented earlier (equations 1, 2 and 3) is specified for econometric estimation. Due to space limitations, the detailed explanation for the inclusion of specific variables in each equation is referenced to Pagoulatos and Sorensen. The detailed information on data sources and methods of variable construction are reserved for Appendix I. The general principle followed in our model specification was to include the most traditional explanatory variables in each equation.

The estimated model of concentration, advertising and profits along with the algebraic signs expected on the basis of theory, is presented below:

$$\text{(1a)}\quad CR72 = a_o + \underset{(+)}{a_1 A/S72} + \underset{(+)}{a_2 CR67} + \underset{(-)}{a_3 GVA} + \underset{(-)}{a_4 LDMOVS} + \underset{(+)}{a_5 MES72}$$

$$\text{(2a)}\quad A/S72 = b_o + \underset{(+)}{b_1 A/S67} + \underset{(+)}{b_2 GVA} + \underset{(+)}{b_3 PCM72} + \underset{(+)}{b_4 CD/S}$$

$$\text{(3a)}\quad PCM72 = c_o + \underset{(+)}{c_1 A/S72} + \underset{(+)}{c_2 CR72} + \underset{(+)}{c_3 K/S72} + \underset{(-)}{c_4 GEOG72} + \underset{(+)}{c_5 NT72}$$

All equations in the above system satisfy both the order and rank conditions for identification. The industry sample utilized in the estimation of the model consisted of the 47 U.S. food and tobacco processing industries defined by the Census at the four-digit level of aggregation. The time period studied is the year 1972 with the lagged values of advertising intensity and concentration being for 1967.

III. The Empirical Results

In light of the previous discussion which detailed the simultaneous linkages between measures of industrial structure, conduct, and performance, three-stage least squares (3SLS) was used to estimate the empirical model. This estimation technique provides asymptotically efficient parameter estimates [Kmenta, p. 573] for simultaneous systems in general. When applying such methods to cross-sectional data it is necessary to assume that the system's error structure is not heteroscedastic [White]. To mitigate this condition, most variables are expressed as ratios in terms of industry sales.

Estimated parameters and associated standard errors are reported in Table 1. In general, the empirical results conform closely to theoretical expectation. In the concentration equation, it is apparent that most of the explanatory power is accounted for by lagged concentration, while advertising intensity is not significant at customary levels. The long-run multiplier of advertising, however, is found to be .373 [Kmenta, p. 593]. Thus, because of the large coefficient value on lagged concentrations we can conclude that concentration evolves slowly over time.

The advertising equation shows that both current profit margins and lagged advertising are important factors. In this equation, lagged levels

Table 1.--The Structural Simultaneous Model

	Dependent Variables		
	CR72	A/S72	PCM72
Intercept	20.74 (7.34)[a]	-19.33 (9.91)	3.82 (3.61)
A/S72	.053 (.045)		.190 (.054)
A/S67		.389 (.066)	
CR72			.231 (.069)
CR67	.858 (.061)		
GVA	-.046 (.034)	.121 (.068)	
LDOMVS	-1.31 (.806)		
MES72	.035 (.034)		
PCM72		.751 (.193)	
CD/S		.211 (.068)	
K/S72			10.64 (4.64)
GEOG72			-.088 (.034)
NT72			.120 (.084)

[a]Asymptotic standard errors in parentheses.

of the dependent variable do not suggest as much inertia as was found in the concentration equation. Finally, both current concentration and advertising appear to be highly significant determinants of current price-cost margins.

While the structural simultaneous model permits examination of the inter-dependencies among measures of structure, conduct, and performance, it allows for the analysis of only the partial effects of the exogenous variables in the system. To determine the total effects of these variables on each of the endogenous variables, the reduced form equations are presented in Table 2. Table 2 also provides the asymptotic standard errors associated with the derived reduced form [Schmidt, p. 236]. Because the structural parameters are estimated via an asymptotically efficient method, the corresponding reduced form is asymptotically efficient relative to ordinary least squares estimates of the reduced form [Schmidt, p. 241].

In Table 2, the reduced form equation for concentration again indicates that lagged concentration is the dominant explanatory variable. The large coefficient of lagged concentration indicates that the adjustment period to changes in other explanatory variables is quite long. In order to assess the accuracy of each reduced form model, its predicted values were correlated with the actual values of the corresponding dependent variable. The correlation between predicted and observed concentration is .954, indicating a very successful fit.

In the advertising equation we observe a coefficient on lagged advertising that is larger than that in the structural equation. More interesting is the result that past market structure (in the form of lagged concentration) has a significant effect on current advertising. Predicted and observed advertising have a correlation of .857. Finally, from the

Table 2.--The Derived Reduced Form

	Dependent Variables		
	CR72	A/S72	PCM72
Intercept	19.93 (7.42)[a]	-15.17 (11.66)	5.54 (5.29)
CR67	.867 (.064)	.175 (.065)	.233 (.065)
A/S67	.024 (.022)	.459 (.072)	.093 (.028)
GVA	-.039 (.033)	.133 (.081)	.016 (.021)
LDOMVS	-1.32 (.816)	-.266 (.193)	-.355 (.241)
MES72	.035 (.034)	.007 (.007)	.009 (.009)
CD/S	.013 (.012)	.249 (.079)	.050 (.021)
K/S72	.499 (.499)	9.42 (4.73)	12.55 (5.56)
GEOG72	-.004 (.004)	-.078 (.035)	-.103 (.038)
NT72	.006 (.006)	.106 (.079)	.142 (.099)

[a]Asymptotic standard errors in parentheses.

profitability equation we can observe that both lagged concentration and lagged advertising have significant effects on current profit margins. We can conclude, therefore, that industry price-cost margins are determined by forces which extend over a lengthy period. A respectable correlation of .754 was found for predicted and observed profitability.

The general dynamic implication suggested by the reduced form equations is the existence of considerable inertia in industrial organization relationships. Furthermore, it is apparent that market structure does not respond much to the current economic environment but has a long evolutionary component.

IV. Conclusions

This paper has investigated the simultaneous and dynamic nature of the relationship between structure, conduct, and performance with particular reference to the U.S. food and tobacco processing sector. The empirical results confirm the essentially simultaneous nature of the structure-conduct-performance system. Profit margins and advertising intensity appear to interact within a simultaneous framework while concentration evolves slowly over time without responding much to the current economic environment. A dynamic simultaneous-equation model is logically appropriate for examining the major hypotheses of industrial organization.

APPENDIX I:

Definitions of Variables and Sources of Data

CR72, CR67 -- are the four-firm concentration ratios for 1972 and 1967, respectively, as reported by the Census of Manufactures.

A/S72, A/S67 -- are the advertising to sales ratios for 1972 and 1967, respectively, obtained from the U.S. Input-Output tables.

PCM72 -- is the price cost margin calculated as value added - (payroll + rentals + supplemental labor cost + advertising) as a percent of industry shipments for 1972. The data for its construction were obtained from the Census of Manufactures and the Annual Survey of Manufactures.

GVA -- is the growth rate in nominal value added between 1967 and 1972.

LDOMVS -- is the logarithm of domestic value of shipments in 1972.

MES72 -- is the economy of scale variable. It was calculated as the size of the midpoint plant in value added as a percentage of industry value added. The data for its construction were obtained from the Census of Manufactures.

CD/S -- is the percentage of industry output sold to the final demand sector. It was calculated with data from the 1972 U.S. Input-Output tables.

K/S72 -- is the capital-output ratio defined as gross value of fixed assets divided by shipments. The data for this variable were obtained from the Census of Manufactures.

GEOG72 -- the geographical dispersion of production in 1972 obtained from Connor.

NT72 -- the nominal tariff rate obtained from U.S. International Trade Commission.

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