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IN THE U.S. COFFEE MARKET

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Abstract

This study examines market structure in the U.S. retail coffee industry and attempts to define the relationship between advertising and market power within the industry. Econometric models developed by Applebaum (1979, 1982) and Schroeter (1988) are extended here to include advertising. The hypothesis that coffee advertising stifles competition and decreases demand elasticities by inducing brand loyalty is tested. Results reveal that the industry is characterized by oligopoly and oligopsony power that has decreased and then increased over the period 1967 to 1992. Simulation results suggest that an increase in advertising expenditure serves to decrease demand and advertising elasticities and increase market power.

Key words: advertising, market power, oligopoly, oligopsony, coffee

Introduction

The question of how advertising affects market structure has stimulated lively debate for decades. There remain two schools of thought, separated by the view of advertising as informative ("Air Canada now flies to Japan") or persuasive ("Be Young. Have Fun. Drink Pepsi"). The former view contends that advertising efficiently transmits information about a product's existence and its characteristics, thus serving to stimulate competition, increase demand elasticities, and lower price. In contrast, others find that advertising changes consumers' tastes by inducing brand loyalty to advertised products, erecting barriers to entry, reducing demand elasticities and raising price at the consumer's expense.[1] The impact of advertising on competition has been recognized for many years. In Vaile's *Economics of Advertising* (1927), he writes that

> "...informative advertising gives to prospective purchasers a better basis for decision as to the most economical, most productive, and most satisfying uses to which he may devote his income... To the extent that informative advertising is successful in these matters, it increases efficiency. Competitive advertising, on the other hand, ... may result in an alliance between rivals, in which case the expenditure results in a simple monopoly ... [Or,] the goods of one firm may gain predominance over those of another. In this case, concentration of production will result." (p. 130-131)

Coffee is one of the most heavily advertised products in the United States, with annual promotional expenditures in the hundreds of millions of dollars. The U.S. coffee roasting industry is also one of the most highly concentrated--dominated by some of the world's largest corporations. General Foods (producers of Maxwell House, Yuban, and Sanka brands) and Proctor and Gamble (producer of Folgers) control two thirds of the U.S. coffee market share with Nestlé (producer of Taster's Choice) commanding a further 13.5 percent (Saporito 1990). Consumers have frequently benefitted from the cutthroat price, product, and promotion wars between these food giants, suggesting untapped potential for cartel behaviour.

As Comanor (1979) points out, theoretical studies of advertising and competition are not compelling, and conclusions about this relationship must rest on empirical results. Thus, the primary objective of this study is to evaluate empirically the impact of coffee advertising on the

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1. Overviews of the literature on advertising and consumer choice appear in Comanor and Wilson (1974) and Albion and Farris (1981). The role of market power in advertising is surveyed by Comanor (1979) and Ekelund and Saurman (1988).

U.S. coffee industry. Advertising is incorporated into an econometric model in the demand function where it may affect the own-price elasticity, and indirectly market power. It also appears as an explanatory variable in an equation describing the conjectural variation. Three hypotheses are tested. Since the coffee industry is highly concentrated, we hypothesize that it is characterized by non-competitive behaviour. Since coffee advertising is largely persuasive, we also test the hypotheses that coffee advertising lowers demand elasticities and/or increases market power.

Estimation of Market Power

Pioneering work in estimating monopoly power is attributed to Applebaum (1979, 1982), whose work was extended to monopsony by Schroeter (1988). The following model follows closely that of Schroeter.

In an industry with N firms producing a homogeneous output Q, we assume that the production technology is characterized by fixed processing conversion ratio (green coffee to roast coffee) and a single material input X_M (green coffee). Additional inputs of labour, X_L, and capital, X_K, are employed in variable proportions. We assume that labour and capital are purchased in competitive factor markets, but firms are not necessarily price-takers in the material input and output markets. Market price and quantities are related via the industry demand and supply functions

$$Q = h(P, Z_1) \tag{1}$$

$$Q = f(W_M, Z_2) \tag{2}$$

where P is the price of output and Z_1 and Z_2 are vectors of exogenous variables. The problem of jth firm is to choose Q to maximize

$$\pi = PQ_j - W_M Q_j - C_j(Q_j, W_L, W_K) \tag{3}$$

subject to (1) and (2). The first-order necessary condition is

$$P\left(1 + \frac{\theta_j}{\eta}\right) = W_M\left(1 + \frac{\theta_j}{\varepsilon}\right) + \frac{\partial C_j}{\partial Q_j} \tag{4}$$

where η is the elasticity of market demand, ε is the elasticity of material input supply and θ_j is the jth firm's conjectural elasticity.

Two indices of market power may be obtained by estimating (4). Oligopoly power, L_j is equivalent to θ_j/η. Oligopsony power, M_j, is equivalent to θ_j/ε. These indices measure market power in terms of price distortions (the difference between price and marginal cost) and are bounded theoretically by zero, representing perfect competition, and one, representing a pure monopoly or monopsony. Since data on individual firms are not available, an aggregation condition (Appelbaum 1982) can be used to write (4) without the *j* subscripts, permitting use of time series data for the industry as a whole.

For the empirical model, we take the industry's non-material cost function to be of the generalized Leontief form, specifically

$$C(Q,W) = b_L W_L + b_K W_K + b_{LL} Q W_L + b_{KK} Q W_K + 2b_{LK} Q (W_K W_L)^{1/2} \tag{5}$$

The marginal cost function becomes

$$\frac{\partial C(Q,W)}{\partial Q} = b_{LL} W_L + b_{KK} W_K + 2b_{LK}(W_K W_L)^{1/2} \tag{6}$$

Substituting (6) into (4) we obtain

$$P(1+\frac{\theta}{\eta}) = W_M(1+\frac{\theta}{\varepsilon}) + b_{LL} W_L + b_{KK} W_K + 2b_{LK}(W_K W_L)^{1/2} \tag{7}$$

The conjectural variation parameter, θ, can be modelled as a general function of exogenous variables to allow equilibrium conjectures to vary with market conditions. Following Lopez (1984) θ is specified as a function of industry concentration and a time trend. Advertising may affect market power directly, by either reducing or increasing competition (Comanor and Wilson 1974). Thus we include advertising, so that θ is defined as

$$\theta_1 + \theta_2 N + \theta_3 T + \theta_4 ADV \tag{8}$$

where T is a time trend variable and ADV is advertising expenditure. Parameters η and ε can be estimated simultaneously with (7) using industry supply and demand equations. Furthermore, if information on capital and labour use in the industry is available, the efficiency of the system may be improved by estimating simultaneously the input demand functions, given by

$$X_K = (b_{KK} + b_{LK}(W_K/W_L)^{1/2})Q + b_K \quad \textbf{(9)}$$

$$X_L = (b_{LL} + b_{LK}(W_K/W_L)^{1/2})Q + b_L \quad \textbf{(10)}$$

Data

Annual data for the period 1967-1992 are used. Advertising expenditure data were only available from 1976 (Leading National Advertisers, various years), so values for the preceding years were generated using an exponential trend. World coffee production figures are taken from various years of the USDA's *World Coffee Situation.* The green coffee price in the supply equation was obtained by dividing the value of U.S. imports by quantity of U.S. imports, both of which are taken from the United Nations trade data system. The roast coffee price in the demand equation was obtained by dividing value of shipments by roasters (USDC, various years) by quantity of imports (adjusted by the processing conversion ratio of 1.19). The cost of labour was obtained by dividing the wage bill in the coffee industry by the number of employees (USDC, various years). Linear interpolation was used to obtain values not accounted for in these industrial census data. Like Schroeter, we were unable to obtain a reliable capital input series, so equation (9) had to be dropped. Population, consumer price indices, and disposable income values are taken from various years of the IMF's *International Financial Statistics.*

Estimation Procedure

The model was estimated with the full information maximum likelihood procedure. Supply and demand equations were included in linear-logarithmic form to ensure that elasticities could vary throughout the sample period. A world green coffee supply elasticity was obtained by the simple model

$$Q_s = A_s + f \ln P_{t-1} + g \ln P_{t-7} \quad \textbf{(11)}$$

where P is the unit import value of green coffee. As a perennial crop, coffee production is characterized by lagged responses to price changes (the crop requires considerable planting effort and 5-6 years to reach maturity). Short-term response to high price may arise through additional pruning or fertilizer application. Demand for coffee by the U.S. was modelled as

$$Q_d = A_d - c\ln P + d\ln ADV + e\ln T \qquad \textbf{(12)}$$

where P is the retail price. Income was excluded from the demand equation because earlier single equation estimations determined that it was insignificant and conflicted with the advertising estimate.

Baseline Results

Table 1 shows results of the full information maximum likelihood estimates of the model. The reported t-statistics are generated using the Gauss-Newton approach, which forms the covariance matrix by using a quadratic form of the analytic gradient and the residual covariance matrix. Goodness-of-fit is satisfactory for all equations and most of the coefficients are significantly different than zero. For the estimated cost function to be well behaved, positive values for b_{LL}, b_{KK}, b_L and b_{LK} would guarantee that the cost function is positive and increasing in each factor price for all points in input price space. One of the these coefficients is negative (b_{KK}), but not significant.

Table 1. Results of the FIML estimation.

Variable	Estimate	t-statistic	Variable	Estimate	t-statistic
b_{LL}	0.9087-06	0.32	c	-479200	-10.10
b_{LK}	0.9470-05	5.28	d	195029	3.11
b_{KK}	-0.0690	-1.60	e	23808	7.84
b_L	5.6529	2.56	f	887353	5.21
θ_1	0.0596	0.72	g	431521	3.08
θ_2	0.0007	1.69	A_d	-3077260.	-1.15
θ_3	0.024	2.06	A_s	15.3477	238.05
θ_4	-0.1248-08	-0.09			

R^2 values for:	
Demand for labour (equation 10)	.614
First-order condition (equation 7)	.837
Demand for roasted coffee (equation 6)	.575
Supply of green coffee (equation 13)	.641
Log of the likelihood function	-431.089

In the conjectural variation equation, coefficients on the number of firms and time trend are significant. The coefficient on advertising here is unexpectedly negative but insignificant. The supply elasticity is significant at 0.274, which is close to other estimates.[2] The price elasticity of demand is significant at -0.509 and also consistent with other estimates.[3] The advertising elasticity from the demand equation is 0.206, which has the expected sign and is significant. To our knowledge, no one has estimated coffee advertising elasticities. Compared to elasticities for other food products, this estimate appears to be high, but will be retained for use in simulations.

Likelihood ratio tests were conducted on both advertising coefficients to assess whether they are significantly different than zero (Table 2). The hypotheses that d=0 or that $d=\theta_4=0$ are rejected at the 95 percent confidence level. However, the hypothesis that $\theta_4=0$ may not be rejected. On this basis, the advertising variable that appeared in the conjectural variation equation was dropped from the model. Estimated parameters changed very little, and the remaining results presented in this study are taken from this restricted model.

Table 2. Tests for significance of advertising

Hypothesis	Critical Value ($\chi^2_{.05}$)	Test Statistic
H_0: d=0	3.84	9.44
H_0: $\theta_4=0$	3.84	0.12
H_0: $d=\theta_4=0$	5.99	10.90

Table 3 shows estimates of conjectural elasticities and Lerner indices for the sample period. The first two indices are seen to decline from 1967 to 1977, and subsequently increase in the late 1980s. The initial decline is consistent with the four-firm concentration ratio of 34.8 percent for 1968 and 28.5 percent in 1975 (UNCTAD 1984). Sutton (1991) has documented the trend towards market concentration in the 1980s. The conjectural variation estimate is significantly different from zero and one throughout the time period--a strong indication of the existence of non-competitive (but not monopoly) behaviour in the U.S. retail coffee industry. A similar pattern

2. De Vries (1975), for example, in the period 1947-1972 obtains short-term elasticities for various regions between 0.03 and 0.20 and long term elasticities between 0.14 and 0.44.

3. De Vries (1975) finds a U.S. demand elasticity of -0.22 for the period 1948-73 and Akiyama and Varangis (1989) estimate a value of -0.46 for the period 1968-86.

is seen using the Lerner index that measures monopolistic behaviour in the roast coffee market. Market power in the input (green coffee) market appears to be higher and increasing through most of the sample. The null hypothesis of competitive behaviour is rejected throughout the sample. The hypothesis of perfectly monopsonistic behaviour is rejected for all but a few years. Oligopsonistic behaviour is suggested by an UNCTAD (1984) study which finds that ten trading houses and processing companies import 50 percent of the coffee consumed in the United. States. Large processors often buy directly from producing countries.

Table 3. Estimates of conjectural elasticities and Lerner indices.

	Conjectural Variation			Lerner Index (Monopoly)			Lerner Index (Monopsony)		
		t-statistics			*t*-statistics			*t*-statistics	
Year	θ	H_0:θ=0	H_0:θ=1	L	H_0:L=0	H_0:L=1	M	H_0:M=0	H_0:M=1
1967	.225	5.53	19.04	.477	6.40	7.01	.724	4.96	1.90
1968	.221	5.74	20.19	.569	6.83	5.19	.636	5.20	7.55
1969	.217	5.93	21.38	.440	7.32	9.31	.687	5.46	2.48
1970	.213	6.12	22.61	.428	7.87	10.53	.574	5.74	4.27
1971	.209	6.29	23.76	.460	8.48	9.97	.700	6.04	2.59
1972	.205	6.42	20.94	.437	9.13	11.76	.719	6.34	2.48
1973	.203	6.54	25.62	.462	9.64	11.23	.608	6.61	4.27
1974	.202	6.64	26.35	.393	10.15	15.68	.757	6.89	2.21
1975	.200	6.72	26.94	.418	10.64	14.80	.662	7.17	3.65
1976	.198	6.77	27.47	.411	11.07	15.87	.550	7.45	6.09
1977	.196	6.78	27.82	.312	11.40	25.21	.630	7.25	4.53
1978	.196	6.87	28.12	.378	11.69	19.27	.705	7.99	3.35
1979	.197	6.94	28.40	.403	11.92	17.62	.731	8.27	3.04
1980	.197	7.00	28.59	.383	12.09	19.49	.770	8.55	2.55
1981	.197	7.05	28.78	.330	12.19	24.81	.878	8.83	1.23
1982	.197	7.09	28.90	.360	12.22	21.79	.735	9.11	3.29
1983	.198	7.18	29.05	.330	12.29	24.94	.801	9.41	2.33
1984	.199	7.26	29.22	.360	12.30	21.53	.820	9.71	2.13
1985	.200	7.33	29.23	.378	12.25	20.21	.873	10.01	1.45
1986	.202	7.39	29.35	.394	12.15	18.69	.729	10.30	3.82
1987	.203	7.44	29.25	.413	12.01	17.10	.952	10.59	.53
1988	.208	7.80	29.63	.330	12.10	24.51	.895	10.89	1.28
1989	.215	8.08	29.64	.432	11.86	15.59	.948	10.95	.59
1990	.220	8.29	29.40	.447	11.40	14.11	1.005	10.79	.60
1991	.226	8.41	28.80	.444	10.81	13.52	1.063	10.48	.63
1992	.232	8.45	28.00	.521	10.19	9.35	.966	10.06	.35

Notes: a) θ=(P-MC)/P, L=-θ/η, and M=θ/ε.
b) The null hypothesis H_0:x=0 uses the standard *t*-statistic. The null hypothesis H_0:x=1 is calculated as the absolute value of (x-1)/standard error.

Simulation Model

The above model is extended to a simulation model capable of permitting observation of changes in endogenous variables to a change in one or more exogenous variables. Components of the model include equations (7), (10), (13) and (14), identities that link logged values with non-logged counterparts, plus the Lerner index identities.

Two simulations are run. The first, as the base case, takes values from the above (restricted) estimation. The second uses identical values with the exception that advertising expenditure is increased by ten percent. The statistical significance of the base case model may be evaluated with a variety of measures. Table 4 shows two: correlation coefficients and the root-mean-square percent errors for the endogenous variables. The latter measures the magnitude of the deviation of the simulated variable from its actual time path. Both indicators suggest that the simulated model tracks well.

Simulation results show that, as expected, advertising increases quantity of roasted coffee demand and its price. Advertising has a varied effect on the price of green coffee--lower in most years but higher in some. Under increased advertising expenditure, advertising elasticities are lower in all cases. This is expected under diminishing marginal returns. Demand elasticities are also lower, consistent with the notion that advertisers strive to induce brand loyalty in consumers, thereby increasing the potential for gains from exercising market power. Supply elasticity is slightly higher from increased demand for input and higher prices.

Figures 1 and 2 show changes in demand and supply elasticities estimated over the sample period, together with base case predicted values and predicted values under increased advertising. If the model is correctly specified, coffee advertising results in more inelastic demand for coffee and more elastic supply (although the latter is difficult to discern on the graph). Estimated and predicted elasticity measures are erratic over time, reflecting price variations in the green coffee market. These fluctuations are largely the result of adverse weather conditions in Brazil. For example, the drought that devastated the Brazilian crop in 1977, drove prices up sharply and temporarily moved market equilibrium to the elastic portion of the demand curve.

Table 4. Evaluation of the simulated model

Endogenous Variable	Correlation Coefficient	Root-mean-square percent error
X_L	.814	9.32%
Q_s	.801	9.62%
Q_d	.781	9.15%
W_M	.951	15.70%
P	.827	10.13%
η	.760	-10.98%
ε	.787	10.41%
L	.885	8.96%
M	.840	7.81%

Figures 3 and 4 show Lerner indices estimated over the sample period, together with predicted values and predicted values with increased advertising. The pattern is largely consistent with the fact that these indices are inversely related to demand and supply elasticities. Increased advertising expenditure appears to increase the output market index over the period simulated and (marginally) decrease the input market index.

Conclusions

The hypothesis that the U.S. coffee industry is characterized by non-competitive behaviour is confirmed. Results strongly suggest that the U.S. coffee industry is composed of firms which exercise power on the material input (green coffee) market and, to a lesser extent, on the output (roast coffee) market. Apparent trends in the Lerner monopoly index reveal that market power declined from the 1960s to the mid-1970s, and rose again in the late 1980s. The Lerner monopsony index suggests increasing market power over the green coffee market.

Although we were unable to conclude whether advertising helps explains conjectural variation, advertising was shown to be important in explaining demand. Simulation results suggest that advertising serves to increase market power in the output market indirectly by reducing demand elasticities. Advertising's effect on the material input (green coffee) appears to be negligible.

Given the importance of market structure in assessing returns to producer investments, these results suggest that analysts of the U.S. coffee industry should be wary of assuming either perfect competition or monopoly in this market. An extension of this research of interest to coffee roasters and producers would be measurement of producer surplus and returns to advertising under the assumption of oligopolistic behaviour. However, the results presented here rest heavily on the way conjectural variation is calculated. Further research could refine measurement of this parameter.

Figure 1. Demand elasticities from estimation and simulations

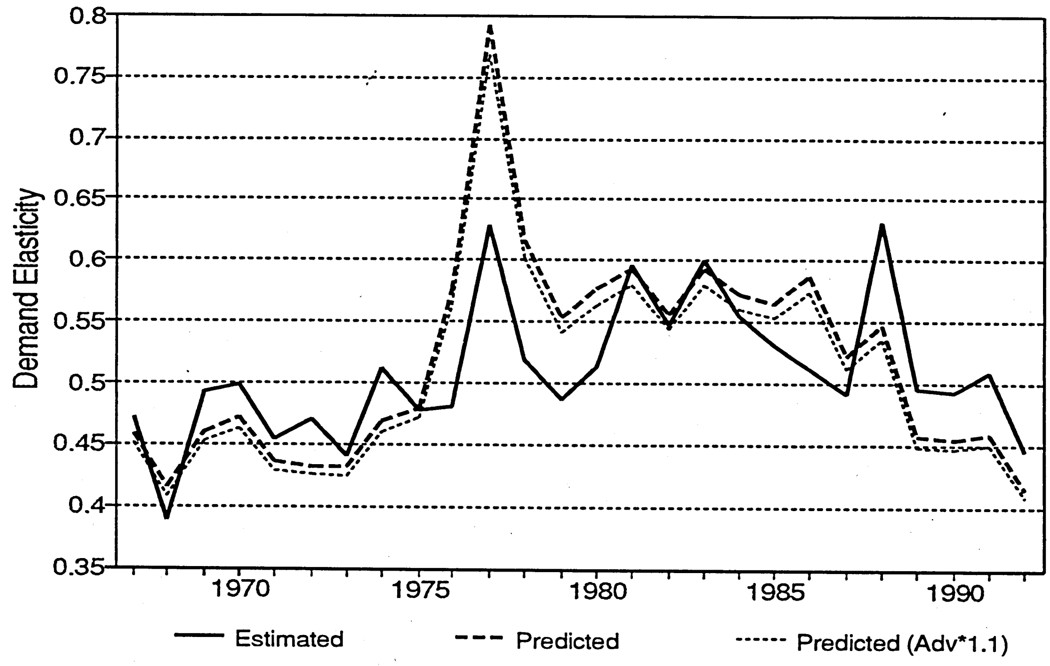


Figure 2. Supply elasticities from estimation and simulations

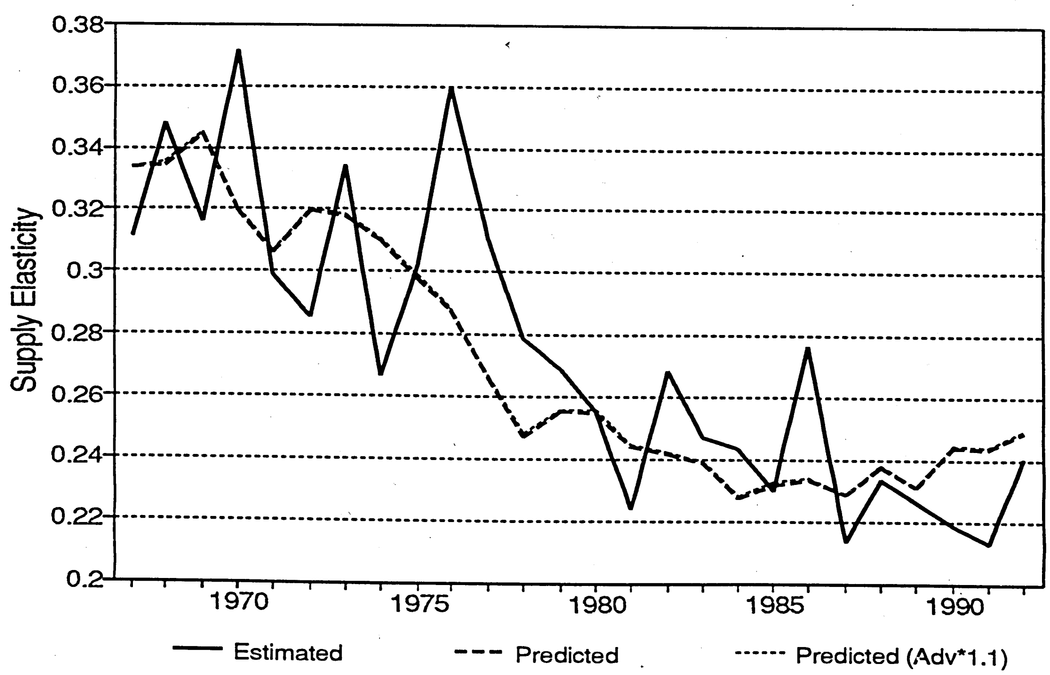


Figure 3. Lerner (monopoly) indices from estimation and simulations

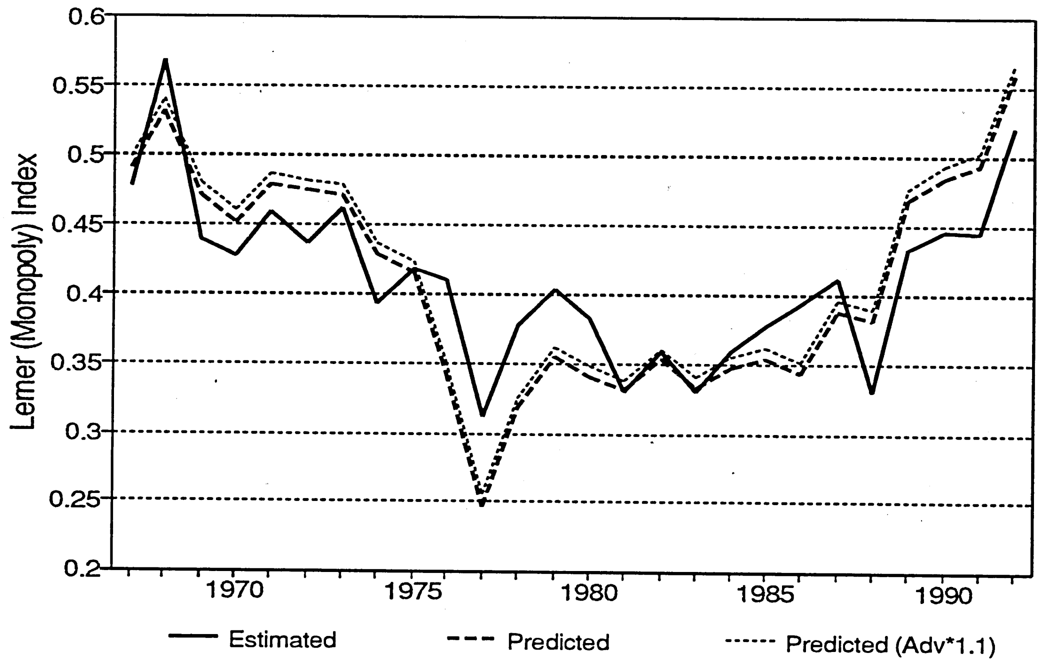
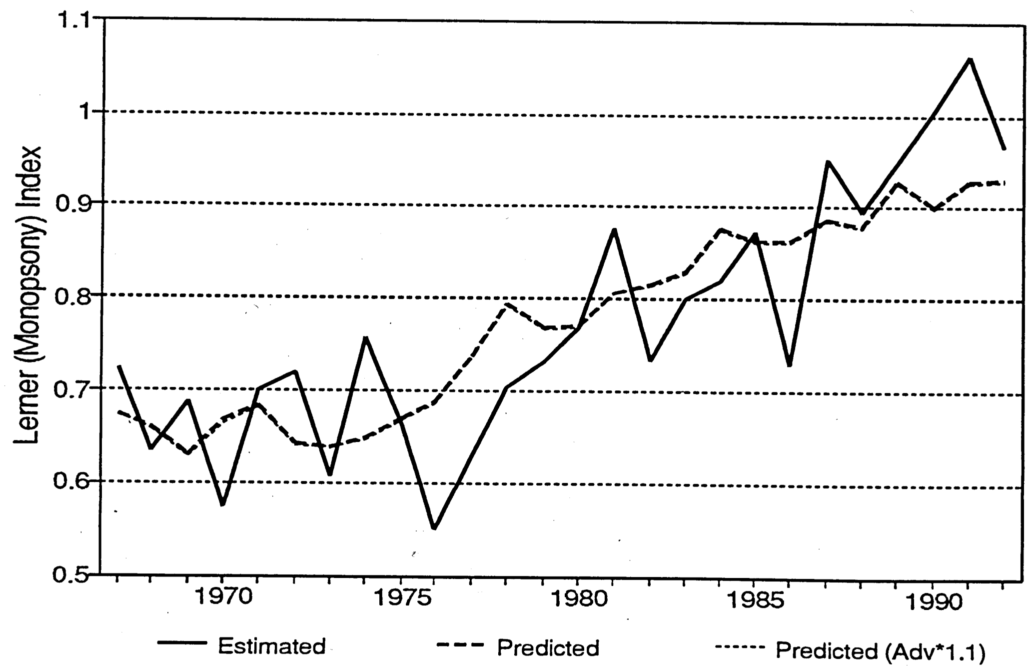


Figure 4. Lerner (monopsony) indices from estimation and simulations



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