Degree of Competition in the U.S. Peanut Butter Industry: A Dynamic Error Correction Approach

Satish Y. Deodhar and Stanley M. Fletcher*

February 11, 1998
FS-98-03

* Authors are Post-Doctoral Associate and Professor, Department of Agricultural and Applied Economics, Griffin Campus, The University of Georgia.

Degree of Competition in the U.S. Peanut Butter Industry:
A Dynamic Error Correction Approach

Abstract

Reforms in the U.S. peanut program entail a reduction in support price of peanuts. The degree to which price reduction is passed on to final consumers of peanut butter is directly related to the degree of competition in the peanut butter market. To assess the impact of changes in the peanut program on final consumers, it is necessary to know the degree of competition in the peanut butter industry. A dynamic error correction model (ECM) developed by Steen and Salvanes is estimated using nonlinear-three-stage-least-squares procedure to measure the degree of competition. Results indicate that the market is characterized by perfect competition in the short-run. The hypothesis of perfect competition is rejected in the long-run, although the long-run solution is close to a perfectly competitive behavior. This result has important implications for the peanut butter industry. Reductions in the support price of peanut may not be fully passed on to peanut butter consumers, but the consumers' welfare gain will certainly be much higher than what it would have been if the market was collusive in structure.

Degree of Competition in the U.S. Peanut Butter Industry:
A Dynamic Error Correction Approach

Peanut butter is a popular food item in the United States (U.S.), and, nutritionally, an important source of protein. During the 1995-96 marketing year, sales of peanut butter in the U.S. totaled more than 1.3 billion dollars. However, it is argued that the U.S. consumers are paying too much for peanut butter. This is based on the premise that U.S. peanuts cost more relative to the world market price of peanuts, due to the U.S. peanut program. For example, assuming perfect competition, the General Accounting Office (GAO) report suggested that an increase in consumers' welfare by a magnitude of $500 million for processed peanut products is possible, if the federal peanut program is eliminated[1]. Opponents, on the other hand, claim that there is no assurance that any reduction in the peanut price would be passed on to the final consumers by peanut butter manufacturers (The Peanut Grower, 1994). The true extent of consumers' gain, however, would depend upon the degree of competition in the peanut industry.

Dixit (1987, 1988), and McCorriston and Sheldon have shown that the degree of price transmission from farm gate to final consumers, and, therefore, the change in consumers' welfare is directly related to the degree of competition in a given market. To understand the exact impact of the changes in the U.S. peanut price policy, one needs to know the degree of competition in the U.S. peanut industry. In the near future, the issue assumes a greater importance as the government eliminates U.S. commodity programs in general, and the peanut program in particular due to free trade negotiations and budget pressures (USDA, 1995).

To date, there has been no study that estimates the degree of competition in the peanut industry. There is a long tradition in the industrial organization literature of empirically estimating degree of competition in a given market[2]. While studies conducted in the 1960s and 1970s focused on reduced-form, cross-section regression analysis of industries (Schmalensee), new studies, now commonly referred to as the 'new empirical industrial organization' (NEIO), use structural econometric models. In two seminal papers, Bresnahan (1982) and Lau presented a structural econometric model to estimate degree of competition in a market where only aggregate industry level data are available.

Recently, there have been many applications of the NEIO methodology to food manufacturing industries (e.g., Schroeter, beef packing; Buschena and Perloff, coconut oil export market). These models, however, are static in nature, and do not take into account the dynamic nature of the markets. For agricultural markets, a dynamic game theoretic modeling approach has been formulated and empirically estimated for rice and coffee export markets by Karp and Perloff (1989, 1991). Their model incorporates production adjustment costs and strategic interaction among firms. However, this approach cannot be used when only aggregate, industry level data are available. An elaborate account of the literature in this field is provided by Bresnahan (1989) and Slade. Moreover, if the time series data used in the estimation procedure are nonstationary then the usual asymptotic theory may not apply to the regression equations in levels (Davidson and Mackinnon).

Except for a recent study by Steen and Salvanes no other study has taken into account the nonstationarity of data.

Following Steen and Salvanes we employ the Bresnahan-Lau (BL) model in a dynamic error correction model (ECM) framework which utilizes the available aggregate industry level data of the peanut industry. While the ECM framework takes into account nonstationarity of the time series data, and the dynamic nature of the demand and suppy relations, it allows calculation of a short-run degree of market power and a long-run degree of market power. We augment Steen and Salvanes's estimation method by employing a nonlinear-three-stage-least-squares (NL3SLS) estimation procedure. Since peanut butter constitutes more than fifty-three percent of the processed peanut products (Bouffier), and, only data for peanut butter is available, we estimate the degree of market power in the peanut butter industry. The rest of the paper is organized as follows. The first section describes the peanut butter industry structure. The second section discusses the dynamic formulation of the BL model originally constructed by Steen and Salvanes. The third section details the data and the results of the ECM estimation procedure, and, finally, the fourth section summarizes and draws conclusions.

The Peanut Butter Industry

The peanut butter industry is an important processed food industry in the U.S. Approximately fifty-three percent of all domestically produced peanuts are used in the production of peanut butter. In 1993, the per capita consumption of peanut butter in the U.S. reached a high of 3.3 pounds per year, and the total sales of peanut butter during the

1995-1996 marketing year exceeded 1.3 billion dollars. In 1990, the top three firms, viz. Procter and Gamble Co., ConAgra, and CPC International Inc., manufactured the national brands of peanut butter, Jif, Peter Pan, and Skippy respectively, accounting for seventy-five percent market share (Business Trend Analysts, Inc.). A 1996 survey by Gallup Organization found that 63 percent of the households buy the same brand of peanut butter every time. Thus, there seems to be brand loyalty in the peanut butter market. However, by 1995, the share of the top three brands has come down to about seventy percent, where Jif, Peter Pan, and Skippy accounted for 31.6 percent, 19.6 percent and 20 percent market share respectively. The rest of the market is shared by fringe suppliers who produce generic, regional and/or store brand peanut butter.

Though no information on capacity utilization and economies of scale is available, Bouffier reports that regional brands have production capacity of 32 million pounds per year, and that national brands have production capacity much larger than this number. This suggests that there may be economies of scale that are typically manifested in an imperfectly competitive market structure. On the other hand, the peanut butter industry does not seem to be vertically integrated. National Peanut Council (NPC) reports that none of the peanut manufacturers have their own peanut shelling operations, a capital intensive activity which precedes peanut butter manufacturing. Given this limited information on the structure of the peanut butter industry, one cannot infer unambiguously whether the performance of this industry would be perfectly competitive, imperfectly competitive or collusive. However, it has become very critical to know the degree of competition in the peanut butter market, as it has important policy implications for the elimination of the peanut program.

Methodology

Consider the following aggregate demand function for peanut butter in the U.S.[3]:

(1) $Q_t = q(P_t, P_{t-1}),$

where Q_t is the aggregate quantity demanded of peanut butter in period t, P_t is its price, and P_{t-1} is the lagged price. The lag in the equation takes into account habit formation on the demand side. The industry profit function is considered as:

(2) $\Pi = \sum_{t=1}^{\infty} \left[P_t \cdot Q_t - C(Q_t, Q_{t-1}) \right] \delta^t ,$

where P_t is the inverse functional form of the demand function in (1) represented by $p(Q_t,Q_{t-1})$, and $C(\cdot)$ represents the aggregate cost function. Lags in the cost function account for production adjustment costs. The first-order condition for profit maximization is given by:

(3) $P_t = C'(Q_t, Q_{t-1}) - Q_t \cdot p'(Q_t, Q_{t-1}) + C'(Q_{t+1}, Q_t) - Q_{t+1} \cdot p'(Q_{t+1}, Q_t) .$

We assume that the term $C'(Q_{t+1}, Q_t) - Q_{t+1} \cdot p'(Q_{t+1}, Q_t)$ is zero[4]. Excluding this term, and rewriting the equation in terms of perceived marginal revenue, we have the following condition:

(4) $P_t = C'(Q_t, Q_{t-1}) - \theta \cdot p'(Q_t, Q_{t-1}) \cdot Q_t .$

If the peanut butter industry is perfectly competitive in structure, the parameter θ will be zero so that price equals marginal cost. If the industry is collusive in structure, θ will be one and we have the profit-maximizing condition for a monopolist. For the intermediate cases, the value of θ will vary between zero and one. Therefore, our objective is to give an appropriate empirical specification to equation (1) and (4) and estimate them econometrically. This would provide us the parameter θ that would describe the degree of competition in the peanut butter industry.

The standard BL estimation method is a special case of the above formulation, where (1) and (4) are estimated without any consideration to lagged variables in the system. Essentially, we consider the following system:

(5) $Q_t = a_0 + a_1 P_t + a_2 PI_t + a_3 I_t + a_4 B_t + a_5 Z_t + \varepsilon_t$

(6) $P_t = b_0 + b_1 Q_t + b_2 W_{1,t} + b_3 W_{2,t} - \theta \cdot Q_t^* + \eta_t$,

where I_t is the income variable, B_t is the price of a substitute good, Z_t is the population variable, and $W_{1,t}$ and $W_{2,t}$ are input cost variables. PI_t variable is a product of the variables, P_t and I_t, used to rotate the demand curve[5]. The terms to the left of the minus sign in equation (6) represent marginal cost function, and the variable $Q_t^* = \left[Q_t / (a_1 + a_2 I_t) \right]$, where $(a_1 + a_2 I_t)$ is the slope of the demand function.

The above formulation has two limitations. First, by ignoring the lagged values of the variables, it ignores the dynamic effects of habit formation on the demand side, and production adjustment cost on the supply side. We incorporate this by using the autoregressive distributed lag (ADL) method. Second, time series data for the above variables may be nonstationary in levels, but stationary in first differences, i.e., I(1). As a result, the usual asymptotic theory may not apply to the regression equations in levels (Davidson and Mackinnon). On the other hand, if differenced data is used, one cannot capture the short-run dynamics of the data. However, if the variables are I(1), and a linear combination of these variables in levels is stationary, then it is possible to capture both the short-run and long-run dynamics in the data by employing the ECM technique.

The demand equation (5), with one lag and no intercept term, can be represented by the ADL form:

$$\begin{aligned} Q_t &= a_{01}P_t + a_{02}PI_t + a_{03}I_t + a_{04}B_t + a_{05}Z_t + \\ &a_{11}P_{t-1} + a_{12}PI_{t-1} + a_{13}I_{t-1} + a_{14}B_{t-1} + a_{15}Z_{t-1} + a_{16}Q_{t-1} + \varepsilon_t . \end{aligned} \tag{7}$$

By adding and deleting Q_{t-1}, a_{01} P_{t-1}, a_{02} PI_{t-1}, a_{03} I_{t-1}, $a_{04}B_{t-1}$, a_{05} Z_{t-1}, rearranging the terms and using the difference operator, equation (7) can be written in the ECM format as follows:

$$\begin{aligned} \Delta Q_t &= a_{01}\Delta P_t + a_{02}\Delta PI_t + a_{03}\Delta I_t + a_{04}\Delta B_t + a_{05}\Delta Z_t + \\ &(1-a_{16})\left[\begin{array}{l} \frac{(a_{01}+a_{11})}{(1-a_{16})}P_{t-1} + \frac{(a_{02}+a_{12})}{(1-a_{16})}PI_{t-1} + \frac{(a_{03}+a_{13})}{(1-a_{16})}I_{t-1} + \\ \frac{(a_{04}+a_{14})}{(1-a_{16})}B_{t-1} + \frac{(a_{05}+a_{15})}{(1-a_{16})}Z_{t-1} - Q_{t-1} \end{array}\right] + \varepsilon_t . \end{aligned} \tag{8}$$

The generalized form of this equation for k lags and an intercept term is as follows:

$$\begin{aligned} \Delta Q_t &= a_{00} + \sum_{i=0}^{k-1} a_{i1}\Delta P_{t-i} + \sum_{i=0}^{k-1} a_{i2}\Delta PI_{t-i} + \sum_{i=0}^{k-1} a_{i3}\Delta I_{t-i} + \\ &\sum_{i=0}^{k-1} a_{i4}\Delta B_{t-i} + \sum_{i=0}^{k-1} a_{i5}\Delta Z_{t-i} + \sum_{i=1}^{k-1} a_{i6}\Delta Q_{t-i} + \\ &m_0\left[m_1 P_{t-k} + m_2 PI_{t-k} + m_3 I_{t-k} + m_4 B_{t-k} + m_5 Z_{t-k} - Q_{t-k}\right] + \varepsilon_t , \end{aligned} \tag{9}$$

where $m_0 = (1 - \sum_{i=1}^{k} a_{i6})$, and $m_j = \frac{\sum_{i=0}^{k} a_{ij}}{m_0}$, $j = 1,2,..,5.$

If all the variables are I(1), then all the summations in equation (9) are stationary. Moreover, if the variables are cointegrated, the ECM term, i.e., the linear combination of variables represented in brackets, is also stationary. The summations capture the short-run dynamics, and m_j coefficients represent the stationary long-run impacts of the right-hand-side variables. The parameter m_0 measures the rate of adjustment of short-run deviations towards the long-run equilibrium.

Similarly, the first-order condition represented in equation (6) with one lag and no intercept term can be expressed in ADL form in the following way:

$$(10)\quad \begin{aligned} &P_t = b_{01}Q_t + b_{02}W_{1,t} + b_{03}W_{2,t} - \theta_0 Q_t^* + \\ &b_{11}Q_{t-1} + b_{12}W_{1,t-1} + b_{13}W_{2,t-1} - \theta_1 Q_{t-1}^* + b_{14}P_{t-1} + \eta_t . \end{aligned}$$

By performing transformations similar to the one performed on equation (7) we get the ECM formulation as follows:

$$(11)\quad \begin{aligned} &\Delta P_t = b_{01}\Delta Q_t + b_{02}\Delta W_{1,t} + b_{03}W_{2,t} - \theta_0 \Delta Q_t^* + \\ &(1-b_{14})\begin{bmatrix} \frac{(b_{01}+b_{11})}{(1-b_{14})}Q_{t-1} + \frac{(b_{02}+b_{12})}{(1-b_{14})}W_{1,t-1} + \frac{(b_{03}+b_{13})}{(1-b_{14})}W_{2,t-1} - \\ \frac{(\theta_0+\theta_1)}{(1-b_{14})}Q_{t-1}^* - P_{t-1} \end{bmatrix} + \eta_t . \end{aligned}$$

The generalized form of this equation for k lags and an intercept term is as follows:

$$(12)\quad \begin{aligned} &\Delta P_t = b_{00} + \sum_{i=0}^{k-1} b_{i1}\Delta Q_{t-i} + \sum_{i=0}^{k-1} b_{i2}\Delta W_{1,t-i} + \sum_{i=0}^{k-1} b_{i3}\Delta W_{2,t-i} - \sum_{i=0}^{k-1} \theta_i \Delta Q_{t-1}^* + \\ &\sum_{i=1}^{k-1} b_{i4}\Delta P_{t-i} + n_0\left[n_1 Q_{t-k} + n_2 W_{1,t-k} + n_3 W_{2,t-k} - \theta \cdot Q_{t-k}^* - P_{t-k}\right] + \eta_t , \end{aligned}$$

where $n_0 = (1 - \sum_{i=1}^{k} b_{i4})$, $n_j = \frac{\sum_{i=0}^{k} b_{ij}}{n_0}, j = 1,2,3.$, $\theta = \frac{\sum_{i=0}^{k} \theta_i}{n_0}$.

The interpretation of the terms of this equation is similar to the interpretation of terms of equation (9). The coefficient θ captures the long-run degree of competition in the market, and the coefficients θ_i capture the short-run degree of competition. The variable Q_t^* is defined using the long-run parameters of the demand equation, viz., $Q_t^* = Q_t / (m_1 + m_2 I_t)$. The value of adjustment parameters n_0 and m_0 in the two equations should be between 0 and 1. While value of 0 would indicate no adjustment, value of one would indicate an instant adjustment of the short-run deviations from long-run equilibrium values.

Having described the model, we estimate equations (9) and (12) econometrically for the U.S. peanut butter industry, using nonlinear-three-stage-least-square (NL3SLS) procedure. In the following section, details about the data on peanut butter industry, results of the stationarity and cointegration tests, regression estimates of the two equations, and their interpretation are presented.

Data and Empirical Results

Our data requirements were based on the BL model specification as presented in equations (5) and (6). Quarterly data on variables was available from the third quarter of the 1984 marketing year to the second quarter of the 1995 marketing year[6]. For the demand equation, data on U.S. consumption of peanut butter (Q_t) was collected from the various issues of *Peanut Stocks and Processing* published by the U.S. Department of Agriculture (USDA). Data on peanut butter price (P_t), and price of substitute good, bologna (B_t) were collected from the various issues of the publication, *Average Retail Prices*, published by the U.S. Department of Labor (USDL). Data on U.S. personal disposable income (I_t) and U.S. population (Z_t) were collected from various issues of the publication, *Survey of Current Business*, published by U.S. Department of Commerce (USDC).

Similarly, for the first-order-condition equation, data on peanut price ($W_{1,t}$) was collected from the publication, *Peanut Marketing Summary* (USDA, 1996). Information on another cost item, employment cost index ($W_{2,t}$), was collected from the publication, *Compensation for Working Conditions*, published by USDL (February-March, 1996). In addition, data on consumer price index used to deflate nominal variables was collected from the publication, *CPI Detailed Report, Consumer Price Index* published by USDL (September 1996), where 1982-84 is considered to be the base year. The definitions of variables in levels, and their descriptive statistics are presented in Table 1. The income variable, I_t, was selected to rotate the demand function through the variable PI_t, because PI_t was integrated of order I(1), and was cointegrated with rest of the demand equation variables in levels. Moreover, I_t had more variability in terms of coefficient of variation, than the population variable, Z_t.

All the variables were tested for stationarity and cointegration. Using Weighted Symmetric and Phillips-Perron tests, we conclude that the variables were nonstationary in levels but stationary in first differences, i.e., variables were integrated of order I(1)[7]. Weighted Symmetric test was performed, because new evidence suggests that this test seems to dominate all other tests in terms of power (Pantula, Gonzalez-Farias, and Fuller). Moreover, using the Johansen trace test (Johansen and Juselius) we show that variables in each equation are cointegrated in levels. Further, the optimal number of lags were selected based on modified Q-statistics for the hypothesis that all autocorrelations of higher order are zero[8]. Seasonality was taken into account by using quarterly seasonal dummies, D_1, D_2, D_3 in the NL3SLS regression estimation. Another dummy variable, D_4, is used to account for the major drought during the 1990-1991 marketing year. The results of all the tests performed above are reported in Table 2, Table 3, and Table 4. Regression results are reported in Table 5 and Table 6.

As the results suggest, model specification fits the data well. The R^2 values for the demand equation and the first-order-condition equation were 0.82 and 0.87 respectively, and many coefficients are statistically significant at the 0.01 and 0.05 levels. Since the Durbin-Watson statistic is not applicable when explanatory variables contain lagged endogenous variable, we performed the Durbin's *m* test (Durbin). For both equations, the coefficients of the lagged error terms were statistically insignificant and we could not reject the null that the first-order autocorrelations are zero. In the demand equation, though one of the price coefficients, a_{01}, is positive, it must be noted that the short-run slope of the demand for one lag is given by $(a_{01}+a_{02}I_t)$ which negates the positive price coefficient.

Results of the first-order-condition equation indicate that the parameters that capture short-run degree of competition, θ_i, have a value of 0.01, and the parameter that captures the long-run degree of competition, θ, has a value of 0.02. We cannot reject the hypothesis that θ_1 is zero. However, the value of θ_2, though close to zero, is statistically different from zero at the 0.01 level. The value of the long-run parameter, θ, is even higher than θ_2, and it is also statistically different from zero at the 0.01 level. This indicates that the peanut butter industry is not perfectly competitive in the long-run, even though it is closer to a competitive structure than a collusive one. The short-run estimates suggest that at times the industry does behave in a perfectly competitive manner, however, in the long-run, it maintains a certain degree of imperfectly competitive behavior. The statistically significant value 0.66 of the adjustment parameter n_0 indicates that the short-run behavior is temporary, and, in the long-run, there is a gradual movement towards the imperfectly competitive behavior. This seems to suggest that periodically firms may go through phases of intense competition due to reciprocal aggressive marketing strategies, but this is not a permanent feature of the industry.

The long-run elasticity of demand is given by the formula: $\mu = (m_1 + m_2 I)\ (P/Q)$. Calculating the formula at the mean values of the variables provides us the elasticity of demand as –0.23. Thus, demand for peanut butter is inelastic. From equation (4), it is obvious that the Lerner Index, defined as the percent mark-up of price over marginal cost, is given by the formula: $[P\text{-}C'(\cdot)]/P = -\theta\ /\mu$. Substituting the values $\theta = 0.02$ and $\mu = -0.23$, we obtain the value of Lerner's Index as 0.087. This means that in the long-run, the peanut butter industry is getting a mark-up of about nine percent over marginal cost. The Lerner Indices for some other industries are: Tobacco, 0.65 (Appelbaum); Beef, 0.55 and Pork, 0.48 (Schroeter and Azzam); and Beef Packing, 0.036 for 1983 (Schroeter). Thus, in terms of price mark-up, peanut butter industry certainly seems to be much more competitive than the Tobacco and Meat industry, and little less competitive than Beef Packing industry.

Conclusion

Our objective was to estimate the degree of competition in the U.S. peanut butter market. So far, many studies have been conducted that estimate the degree of competition in a given market. These studies have used both static and dynamic techniques. However, with the exception of Steen and Salvanes who use dynamic ECM formulation, none of these studies have addressed the nonstationarity and cointegrating characteristics of the data. We use their methodology to estimate the degree of competition in the U.S. peanut butter industry. We augment their estimation procedure by employing NL3SLS procedure to estimate short-run and long-run degree of market power.

The estimated degree of competition parameters and the adjustment parameters not only were within the theoretical bounds, but were statistically significant. Based on the results, we conclude that in the long-run, the peanut butter industry is not perfectly competitive though it may be close to it. The industry shows perfectly competitive behavior in the short-run, but gradually moves to a long-run solution, which exhibits less than perfectly competitive behavior. Game theoretic explanation of oligopolistic market behavior suggests that in a given market with an infinite horizon, tacit cooperation can emerge among firms from their self-interested, non-cooperative behavior. If any firm deviates from the tacit cooperation, others might punish it by starting a price war[9]. The deviation and the punishment would be a short-run feature, and, eventually, firms will return to a noncompetitive solution in the long-run. In the peanut butter market, higher degree of market power in the long-run seems consistent with the argument in the game theory literature. However, the increase in the degree of market power from short-run to long-run is extremely small to be described as any tacit cooperation among firms that leads to a monopoly behavior.

Our findings have a baring on the assessment of economic effects of the elimination of U.S. peanut program. We reject the hypothesis of this industry being perfectly competitive in the long-run; therefore, any reductions in the peanut support prices will not be fully passed on to final consumers of peanut butter. However, the peanut butter industry is not collusive in structure either. In fact, market behavior, though imperfectly competitive in the long-run, is very close to the competitive solution. Therefore, price reduction will be passed on to final consumers to a great extent, and an increase in consumers' welfare will certainly be much higher than what it would have been if the market was collusive in structure.

Table 1. Descriptive Statistics

Variable	Description	Mean	Std. Deviation
Q_t	Quantity of Peanut Butter, thousand pounds.	193151.00	22095.00
P_t	Real Price of peanut butter, dollars/pound.	1.40	0.14
PI_t	Rotation variable, P_t times I_t.	4296.00	314.00
I_t	Real Disposable Personal Income, billion dollars.	3086.00	262.00
B_t	Real Price of Bologna, dollars/pound.	1.79	0.18
Z_t	U.S. population, millions	251.14	8.28
$W_{1,t}$	Real Price of Peanut, dollar/pound.	0.49	0.12
$W_{2,t}$	Employment Cost Index, Private Industry Workers, Manufacturing.	107.27	14.22

Table 2. Stationarity Tests for I(0)

Variable	Weighted-Symmetric Statistic	Weighted-Symmetric P-value[a]	Phillips-Perron Statistic	Phillips-Perron P-value[a]
Q_t	-2.47	0.31	-9.19	0.49
P_t	-1.97	0.67	-5.66	0.77
PI_t	-1.84	0.75	-5.22	0.81
I_t	-1.50	0.89	-6.60	0.68
B_t	-1.91	0.70	-4.48	0.86
Z_t	0.75	0.99	-4.41	0.86
$W_{1,t}$	-3.17	0.05	-13.43	0.24
$W_{2,t}$	0.15	0.99	-7.43	0.63
Q^*_t	-2.51	0.29	-9.69	0.45

[a] P-values show the significance level required to reject the null hypothesis based on critical values of the two tests. Values higher than 0.05 indicate insignificance both at 1% and 5% level.

Table 3. Stationarity Tests for I(1)

	Weighted-Symmetric		Phillips-Perron	
Variable	Statistic	P-value[a]	Statistic	P-value[a]
Q_t	-5.84	0.0001	-43.30	0.0005
P_t	-3.92	0.006	-23.26	0.030
PI_t	-3.97	0.005	-23.96	0.030
I_t	-4.19	0.002	-34.11	0.004
B_t	-4.44	0.001	-33.18	0.004
Z_t	-2.76	0.150	-19.05	0.085
$W_{1,t}$	-4.65	0.0007	-31.07	0.007
$W_{2,t}$	-3.56	0.020	-33.48	0.004
Q^*_t	-5.84	0.0001	-42.72	0.0005

[a] P-values show the significance level required to reject the null hypothesis. Values lower than 0.01 indicate significance at 5% and 1% level, and values lower than 0.05 indicate significance at 5% level.

Table 4. Johansen Trace Test for Cointegration

	Demand Equation		First-Order-Condition	
Cointegrating vectors: r	λ_{trace}	P-value[a]	λ_{trace}	P-value[a]
H_0: r = 0	106.30	0.04	77.94	0.04
H_0: r ≤ 1	56.91	0.64	35.53	0.68
H_0: r ≤ 2	24.86	0.94	13.85	0.90
H_0: r ≤ 3	14.26	0.89	05.62	0.81
H_0: r ≤ 4	06.65	0.74	01.04	0.33
H_0: r ≤ 5	00.82	0.39	---	---

[a] P-values show the significance level required to reject the null hypothesis. Values lower than 0.05 indicate significance at 5% level.

Table 5. NL3SLS Regression Estimates: Demand Equation

Variable	Estimated Coefficient		t-statistic
Constant	a_{00}	2224150.00	1.91
ΔP_t	a_{01}	3288920.00[b]	2.17
ΔPI_t	a_{02}	-1172.12[b]	-2.38
ΔI_t	a_{03}	1737.92[a]	2.54
ΔB_t	a_{04}	42320.70	0.89
ΔZ_t	a_{05}	22143.90	1.10
ΔP_{t-1}	a_{11}	-1169750.00[c]	-1.77
ΔPI_{t-1}	a_{12}	332.00	1.46
ΔI_{t-1}	a_{13}	-384.40	-1.14
ΔB_{t-1}	a_{14}	49210.20	1.11
ΔZ_{t-1}	a_{15}	-5403.65	-0.28
ΔQ_{t-1}	a_{16}	-0.86[a]	-4.68
$-Q_{t-2}$	m_0	0.66[a]	3.05
P_{t-2}	m_1	-1387630.00[b]	-2.16
PI_{t-2}	m_2	439.46[b]	2.30
I_{t-2}	m_3	-430.32	1.65
B_{t-2}	m_4	252.39	0.003
Z_{t-2}	m_5	-7399.79[b]	-2.28
D_1	ad_1	16354.8[a]	3.63
D_2	ad_2	-2176.77	-0.33
D_3	ad_3	5030.05	1.03
D90-91	$ad_{90\text{-}91}$	11035.90	1.15

$R^2 = 0.82$, and coefficient of lagged error term, $\rho_1 = -0.39$, with t-statistic –0.46.

[a] Significant at 0.01 two-tail test, [b] significant at 0.05 two-tail test, [c] significant at 0.05 one-tail test.

Table 6. NL3SLS Regression Estimates: First-Order Condition Equation

Variable	Estimated Coefficient		t-statistic
Constant	b_{00}	1.63[a]	6.77
ΔQ_t	b_{01}	0.2E-5	1.37
$\Delta W_{1,t}$	b_{02}	-0.05	-0.92
$\Delta W_{2,t}$	b_{03}	0.01	1.41
$-\Delta Q^*_t$	θ_0	0.01	1.54
ΔQ_{t-1}	b_{11}	0.2E-5[a]	2.60
$\Delta W_{1,t-1}$	b_{12}	0.18[a]	3.80
$\Delta W_{2,t-1}$	b_{13}	0.01	0.78
ΔP_{t-1}	b_{14}	-0.80[a]	-5.25
$-\Delta Q^*_{t-1}$	θ_1	0.01[a]	2.80
$-P_{t-2}$	n_0	0.66[a]	6.50
Q_{t-2}	n_1	0.5E-5[a]	5.30
$W_{1,t-2}$	n_2	0.52[a]	6.22
$W_{2,t-2}$	n_3	-0.01[a]	-8.5
$-Q^*_{t-2}$	θ	0.02[a]	4.80
D_1	bd_1	0.01	0.74
D_2	bd_2	0.01	0.80
D_3	bd_3	-0.01	-0.70
D90-91	$bd_{90\text{-}91}$	0.05[a]	3.54

$R^2 = 0.87$, and coefficient of lagged error term, $\rho_2 = -0.01$, with t-statistic 0.03.

[a] Significant at 0.01 two-tail test, [b] significant at 0.05 two-tail test, [c] significant at 0.05 one-tail test.

Footnotes

1. The GAO's definition of consumers was the first buyers of peanuts, which would be shellers and manufacturers, and not households.

2. In the industrial organization literature, a commonly used term is: 'degree of market power,' which refers to the wedge between price and marginal cost.

3. For simplicity, at this stage, other exogenous variables are not introduced in the demand and cost function, and only one lag is considered. Later, appropriate number of lags and exogenous variables are selected for estimation purpose. Mathematical expressions (1) to (3), and (7) to (12) are originally presented by Steen and Salvanes.

4. This is interpreted as firms not being forward looking while making the production decisions. Also, the ECM formulation that we use for the econometric estimation of the first-order condition requires that we include only lagged values of the variables. Thus, for estimation purpose, we need to consider the terms as zero.

5. Why I_t is selected for rotation is explained at a later stage. For the moment, it is used as an illustration. A change in I_t will rotate the demand curve around the equilibrium point and trace out the supply relation, which allows calculation of the degree of market power. If the product term such as PI_t is not included in the demand equation, the coefficient of Q_t in equation (6) reduces to $(b_1\text{-}\theta/a_1)$, and hence, an identification problem occurs for θ as b1 and θ cannot be estimated separately.

6. It may be noted that the second quarter of the 1995 marketing year extends to January of 1996 calendar year. Monthly data was available for peanut butter price and quantity, however, quarterly data was constructed for these variables since only quarterly data was available for most of the other variables.

7. The population variable Z_t is integrated of order I(1) at 0.085 significance level using Phillips-Perron test.

8. For two lags in P_t and Q_t, the χ^2 values of the Q-statistic were 6.9 and 10.8 and we could not reject the hypothesis of zero higher order autocorrelations at 0.975 and 0.996

confidence levels respectively. We also ran regressions with one lag and three lags; however, lower R^2 and insignificant regression coefficients were reported as compared to the model with two lags.

9. The tacit cooperation among firms is possible only in an infinite period game with a credible threat of punishment and discount factor close to 1; profits earned by deviating from tacit cooperation must be less than the present value of profits earned by not deviating.

References

Appelbaum, E. "The Estimation of the Degree of Market Power," *Journal of Econometrics*, 19(1982): 287-299.

Bouffier, C.G. *Opportunities for Peanut Products Processing in South Georgia.* Atlanta, GA: Georgia Tech Research Corporation. (November) 1994.

Bresnahan, T.F. "The Oligopoly Solution Concept is Identified." *Economic Letters*. 10(1982): 87-92.

Bresnahan, T.F. "Empirical Studies of Industries with Market Power." *Handbook of Industrial Organization*. Edited by R. Schmalensee and R. Willig, Amsterdam: North Holland, 1989.

Buschena, D.E. and J.M. Perloff. "The Creation of Dominant Firm Market Power in the Coconut Oil Export Market." *Amer. J. of Agr. Econ.* 73(1991): 1000-1008.

Business Trend Analysts, Inc. *The Peanut Butter Market.* Commack, NY: 1996.

Davidson, R. and J.G. Mackinnon. *Estimation and Inference in Econometrics.* New York, NY: Oxford University Press, 1993.

Dixit, A. "Anti-Dumping and Countervailing Duties under Oligopoly." *European Economic Review.* 32(1988): 55-68.

Dixit, A. "Optimal Trade and Industrial Policy for the U.S. Automobile Industry." in *Empirical Methods in International Trade*, edited by R.C. Feenstra, Cambridge, MA: MIT Press, 1987.

Durbin, J. "Testing for Serial Correlation in Least-Squares Regression When Some of the Regressors are Lagged Dependent Variables." *Econometrica*, 38(May 1970): 410-421.

Gallup Organization. *Peanut User Study Findings: Final Report.* Princeton, NJ: (January) 1997.

GAO. *Peanut Program: Changes are Needed to Make the Program Responsive to Market Forces*, Washington, D.C.: U.S. General Accounting Office, (February 8) 1993.

Johansen, S. and K. Juselius. "Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money." *Oxford Bulletin of Economics and Statistics*. (1990):169-210.

Karp, L. and J.M. Perloff. "Oligopoly in the Rice Export Market." *Review of Economics and Statistics*. 71(1989): 462-470.

Karp, L. and J.M. Perloff. "A Dynamic Model of Oligopoly in the Coffee Export Market." *American Journal of Agricultural Economics.* 75(1993): 448-457.

Lau, L.J. "On Identifying the Degree of Competitiveness from Industry Price and Output Data." *Economic Letters*. 10(1982): 93-99.

McCorriston, S., and I.M. Sheldon. "Trade Reform with Vertically-Related Markets." Regional Research Project NC-194, *Occasional Paper Series* # OP49. Aug. 1993.

Pantula, S.G., G. Gonzalez-Farias, and W.A. Fuller. "A Comparison of Unit-Root Test Criteria." *J. of Bus. & Econ. Stat.* 12 (October 1994): 449-459.

Schmalensee, R. "Inter-Industry Studies of Structure and Performance." *Handbook of Industrial Organization*. Edited by R. Schmalensee and R. Willig, Amsterdam: North Holland, 1989.

Schroeter, J.R. "Estimating the Degree of Market Power in the Beef Packing Industry." *Rev. of Econ. and Stat.* 70(1988): 158-162.

Schroeter, J.R. and A. Azzam. "Measuring Market Power in Multi-Product Oligopolies: The U.S. Meat Industry." *Applied Economics*, 22(1990): 1365-1376.

Singh, N. and X. Vives. "Price and Quantity Competition in a Differentiated Duopoly." *Rand Journal of Economics.* 15(1984): 546-551.

Slade, M.E. "Empirical Games: The Oligopoly Case." *Canadian Journal of Economics.* 28 (May 1995): 368-402.

Steen, F. and K.G. Salvanes. "Testing for Market Power using a Dynamic Oligopoly Model." Working paper, Institute of Economics, Norwegian School of Economics and Business Administration, Norway, 1996. Forthcoming in *Intl. J. of Ind. Org.*

NPC. "Peanut Industry Guide." *The Peanut Farmer*. 32(April 1996).

The Peanut Grower. Tifton, GA: Vance Publishing Corporation, July 1994.

Tirole, J. *The Theory of Industrial Organization.* Cambridge, MA: MIT Press, 1990.

USDA. Federal-State Market News Service. *Peanut Marketing Summary*, 1996.

USDA. "Commodity Marketing and Programs." in *1995 Farm Bill: Guidance of the Administration*, Washington, D.C., May, 1995.

USDA. "Peanut Stock and Processing." *National Agricultural Statistical Service*. Annual Issues.

USDC. Bureau of Economic Analysis. *Survey of Current Business*, various issues.

USDL. Bureau of Labor Statistics. *Average Retail Prices*, various issues.

_____. *Compensation for Working Conditions*, February-March 1996.

_____. *CPI Detailed Report, Consumer Price Index*. September 1996.