The Role of Information Technology in Measuring Strategic Price Response in the Food & Beverage Manufacturing Industries: The Case of the Black and Herbal Tea Industry

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ABSTRACT

This paper develops a vector error correction model using weekly, point-of-purchase scanner data to investigate multivariate pricing relationships amongst brands competing in the domestic black and herbal tea industry. Johansen's likelihood ratio cointegration test established the existence of a long run equilibrium between the prices of Bigelow black tea, Twining black tea, and Celestial Seasonings herbal tea. The cointegrating vectors, speeds of adjustment, and impulse response function analysis corroborate the finding that Bigelow leads and both Twining and Celestial Seasonings follow. [L110, L200, L660]

1. INTRODUCTION

In a mature industry, pricing strategies take on a more prominent role in business strategy. Droves of business students are taught to mechanistically cut price to bolster share as a way of preserving or bettering market position is this stage of the product life cycle (Kotler, 1995). With increasing financial expectations in the world's unforgiving capital market, the pressure to do so is exacerbated. However, short-run gains in top-line sales may not translate into sustainable earnings growth to pacify the critical eye of Wall Street investment bankers and analysts.

The domestic food industry, exhibiting a growth rate of demand in the 1 to 3 percent range, has embraced, among other strategies, product and geographical diversification to help mitigate the temptation of price cuts (Standard & Poors, 1996). Economists have shown both theoretically (Bernheim and Whinston, 1990; Tirole, 1995) and empirically (Heggestad and Rhoades, 1978; Scott, 1982) that multimarket contact can increase the likelihood of cooperative industry pricing tactics. Intuitively, a player's short-sighted decision to cut price in one market would likely provoke a retaliatory price cut not only in that market but also in others in which it competes. This market discipline serves to heighten tacit price collusion.

The principal empirical objective of this paper is to estimate a vector error correction (VEC) model using 180 weeks of national-level point-of-purchase scanner data to investigate multivariate pricing relationships amongst brands competing in the black and herbal tea industry. For the 52 weeks ended May 12, 1996, the $2.24 billion industry exhibited a sales growth rate of only 3.11%, consistent with the notion of industry maturity. A structural oligopoly, the relative market shares of the six brands, Bigelow, Celestial Seasonings, Good Earth, Lipton, Stash, and

Twining, vary across the black and herbal tea market segments; Bigelow dominates the black tea market, while Celestial Seasonings dominates the herbal tea market.

Unit root tests are employed to determine, of the twelve price sequences, which are integrated processes of order (1) or I(1) series. These form the subset of eligible price series to be analyzed using Johansen's full information maximum likelihood cointegration test. That is, I determine which I(1) price series form a long-run industry pricing equilibrium. The cointegrating vectors, speeds of adjustment, and impulse response function analysis are used to characterize the nature of the long-run pricing equilibrium.

This study attempts to further the work of Vickner and Davies (2000) by relaxing the assumption of single-market contact. As is the case herein, their model departed from the oft-used assumption of one-shot play, but in the context of a single product market. This empirical inquiry also adds to the strategic management literature by formalizing the notion of an industry focal point (Schelling, 1960; Porter, 1980, 1985). Moreover, this model may be used to help firms avoid costly price wars attributable to misread, subtle pricing signals (Garda and Marn, 1993), as well as temporally forecast strategic price response both within and across interrelated product markets. Information from this model may also help game theorists develop more realistic supergames of pricing conduct, especially in a multimarket setting.

2. LITERATURE REVIEW

A popular approach to modeling strategic price response in the class of product-differentiated oligopolistic food and beverage markets is to combine information from each product's demand curve with supply-side behavior; Bertrand price reaction functions are used to endogenize price (Liang, 1989; Cotterill, 1994; Vickner and Davies, 1999). These studies followed the seminal residual demand work of Baker and Bresnahan (1985). The foregoing models have been applied to a wide variety of business and public policy issues such as vertical coordination in the food retailing industry (Cotterill and Putsis, 1998; Cotterill, Putsis, and Dhar, 1999). While econometric model specifications may vary slightly (i.e., linear versus LA/AIDS demand systems), a common feature that transcends each application is the assumption of repeated one-shot play. Using contemporary time series methods, Vickner and Davies (2000) relaxed this assumption for the canned pineapple industry by limiting their modeling effort to just the supply-side price reaction functions. Their VEC model of Dole and Del Monte's pricing strategies included two lagged price terms for each brand, a cointegrating equation, and a holiday dummy variable to capture the seasonal effects of Easter on pineapple pricing. I adopt their approach here, but further expand it for the case of multimarket contact of six brands in the black and herbal tea industry.

Multimarket or multipoint contact is the condition in which two or more firms square-off in two or more markets. Porter (1985) argued that defection (a price cut) by one player may be met not only with retaliation (a reciprocal price cut) in the current contested market, but also with retaliation in the other contested markets as well. Thus, market discipline via the anticipated punishment strategy may increase the possibility of cooperative pricing in the multimarket setting relative to a single-market game. Porter further argues, in the presence of multimarket contact, firms are likely to find more industry "focal points" or so-called "natural equilibrium points for competition" and find them sooner than in the single-market case. Schelling (1960) is usually credited with developing the notion of an industry focal point.

Representative of the few empirical studies on the topic of multimarket contact, Heggestad and Rhoades (1978) and Scott (1982) used the structure-conduct-performance (SCP) paradigm to estimate cross-sectional regressions to isolate the relative effects of internal factors (concentration metrics, growth rate of demand, entry barriers) and external factors (multimarket contact) on industry-level performance. The results indicate that multimarket contact facilitates cooperative pricing. Bernheim and Whinston (1990) developed a game-theoretic model to formalize arguments of Porter and others. They argue that:

> "When markets are not inherently linked, it is easy to see that multimarket contact cannot reduce firms' abilities to collude. Since firms can always treat each market in isolation, the set of subgame perfect equilibria cannot be reduced by the introduction of multimarket contact. It is somewhat more difficult to understand the mechanism through which multimarket contact can increase collusion." (Bernheim and Whinston, 1990, p.3)

To avoid introducing cumbersome mathematical notation that is beyond the scope of this empirical paper, Bernheim and Whinston's "mechanism" amounts to altering assumptions about the markets, firms, and economies of scale in their static pricing model as these serve to "pool" or "relax binding incentive constraints" and hence increase the possibility of cooperative pricing.

3. DATA DESCRIPTION

Horizontal diversification strategies complicate empirical industrial organization analysis in the food industry. Often data is only available at a high level of aggregation, both temporally and across very general SIC codes. Cotterill (1994), recognizing the utility of syndicated point-of-purchase scanner data sets, has largely overcome these aggregation obstacles. Cotterill and Westgren (1994) also note that brand level or strategic business unit level of analysis permits a much cleaner assessment of competitive strategy and demand response. Thus, I use a weekly, brand level scanner data set of pricing to construct the VEC model in this paper.

Information Resources, Inc. assembled national-level, weekly point-of-purchase scanner data for price (dollars per equivalent unit) and expenditure for the six brands in both the black and herbal segments of the domestic tea industry. The 180-week time series spans December 6, 1992 to May12, 1996. Table 1 summarizes simple descriptive statistics of industry structure and price positioning of the six brands in each market segment. In the black tea segment, Bigelow commands the most dollar market share at 47.79 percent, followed by Twining and Lipton with 25.24 percent and 19.18 percent, respectively. The other brands each maintain less the 3.5 percent of the market. The structural landscape of the herbal tea segment is quite different; Celestial Seasonings garners 54.70 percent of segment expenditures, followed by Lipton and Bigelow having 19.65 percent and 18.32 percent, respectively. The other three brands each maintain less than 5 percent of the market. Porter (1985) raises an interesting point about asymmetrically distributed market shares under multimarket contact relative to an industry in which shares are uniformly distributed. He comments:

> "the high-share competitor will tend to have a clear advantage, and hence a small disturbance will be less likely to cause either firm to precipitate a war. Similarly, the asymmetry of positions reduces the chances that the high-share competitor in one industry will seek an even greater share, since it remains vulnerable to retaliation in the industry in which it is weak." (Porter, 1985, p.357)

Hence, asymmetry may further the chance of cooperative pricing in the multimarket setting. Unlike Porter's (1985) prescription to qualitatively analyze the competitive interaction of multipoint competitors across all of their markets, I employ a rigorous battery of nonstationary time series statistical methods to quantify the nature of a pricing focal point or long-run industry pricing equilibrium across both tea industry segments. Departing from earlier SCP cross-sectional empirical work of Heggestad and Rhoades (1978) and Scott (1982), I follow the New

Empirical Industrial Organization (NEIO) paradigm and track this multimarket industry through time.

4. ECONOMETRIC MODEL DEVELOPMENT AND EMPIRICAL RESULTS

4.1. Unit Root Tests

Following Vickner and Davies (2000), I first determine the order of integration of the natural logarithm of each price sequence $\{P_t\}$ using the augmented Dickey-Fuller (ADF) test. The ADF test statistic is the $\boldsymbol{a}_1$ parameter in the linear regression model

$\Delta P_t = \boldsymbol{a}_0 + \boldsymbol{a}_1 P_{t-1} + \sum_{j=1}^{n} \boldsymbol{b}_j \Delta P_{t-j} + \boldsymbol{u}_t$, where P_t is the natural logarithm of shelf price. This test was repeated 12 times, once for each of the six brands across the two market segments. Given the volume of specification diagnostic information assembled for each test, only those results for three price series present in the vector error correction model are catalogued.[1] The results prior to first differencing each price series (Bigelow and Twining black tea and Celestial Seasonings herbal tea) may be found in table 2.

In the black tea segment, given the MacKinnon (1991) critical value of 2.58, I failed to reject the null hypothesis of a unit root at the 10 percent level of significance for each price series except for Celestial Seasonings and Good Earth. However, with a MacKinnon (1991) critical value of 3.47, I failed to reject the null hypothesis of a unit root at the 1 percent level of significance. Upon first differencing of those five series, I rejected the null of a unit root. Thus, I conclude the black tea price series for Bigelow, Celestial Seasonings, Lipton, Stash, and Twining are I(1) processes and thus eligible for consideration in a long-run industry pricing equilibrium or focal point.

In the herbal tea segment, given the MacKinnon (1991) critical value of 2.58, I failed to reject the null hypothesis of a unit root at the 10 percent level of significance for each price series except for Good Earth and Twining. Upon first differencing of those four series, I rejected the null of a unit root. Thus, I conclude the black tea price series for Bigelow, Celestial Seasonings, Lipton, and Stash are I(1) processes and so are candidates for a long-run industry pricing equilibrium.

Employing Enders' (1995) and Hendry's (1986) General to Specific modeling paradigm, I began with an overspecified model and worked toward a parsimonious specification. Standard lag length diagnostic tests were used to determine the appropriate specification for the number of price terms in the ADF test. Ultimately, a specification with $n = 1$ was used. The partial *t*-statistics on second and third order lagged prices were not statistically significant (p>0.10). The Durbin Watson statistic indicated no first order autocorrelation existed. Sixty weeks of Ljung-Box *Q*-statistics showed higher order autocorrelation did not exist either in the empirical residual series. Although usually biased toward parsimonious models, loss functions, such as AIC and Schwarz Criterion, were roughly minimized in the neighborhood of $n = 1$. The F-test showed that all parameter estimates in the ADF regression were not simultaneously equal to zero at the one percent level of significance.

4.2. Cointegration and the Vector Error Correction Model

Among the set of nine I(1) price processes may exist a long-run industry pricing equilibrium (Enders, 1995). Johansen's (1991) full information maximum likelihood ratio test is designed to find such an equilibrium if it exists. At most, the cointegrating rank of the system may be one less the number of endogenous I(1) processes; in this case, the number of cointegrating price

[1] The unit root test results are available upon request from the author.

vectors may be at most eight. The task of finding such an equilibrium is not trivial in a system this large and the time series econometrics literature offers no general guidance in this search beyond specification testing.

In this paper, the brands were sorted from largest to smallest by market share within each segment. Next, I tested if the largest player's price was cointegrated with that of the next largest player. For black tea, I found that prices for Bigelow and Twining were cointegrated at the 10 percent level of significance. However, no other black tea price series was cointegrated with that pair of prices. For herbal tea, none of the other price series were cointegrated with Celestial Seasonings. Then I tested if Celestial Seasonings herbal tea price series was cointegrated with the black tea price series for Bigelow and Twining. This indeed was the case, supporting the multimarket cooperative pricing hypothesis. So as to rule out the possibility that the focal point in pricing was not simply an artifact of the order in which the cointegration tests were conducted, I repeated the testing in the opposite order; that is, I ranked the firms from smallest to largest within each segment and repeated the testing. The same focal point emerged. Finally, all the price series regardless of segment were ranked by share. Again, testing from largest to smallest player, the focal point with Bigelow's and Twining's black tea prices and Celestial Seasonings' herbal tea price persisted. The results of this final industry pricing equilibrium are summarized in tables 3 and 4a.

Following Johansen (1992), the cointegration specification presumes a linear stochastic trend in the price series, but the cointegrating equations contain an intercept only; neither cointegrating equation contains a trend. In table 3, with a likelihood ratio statistic of 31.15, I rejected the null hypothesis that the cointegrating rank of the system was zero ($r = 0$). Similarly, with a likelihood ratio statistic of 13.58, I rejected the null hypothesis that the cointegrating rank of the system was at most one ($r \leq 1$). However, I failed to reject the null hypothesis that the cointegrating rank of the system was at most two at the 10 percent level of significance. Thus, there exists a stationary, linear combination of Bigelow's black tea price, Twining's black tea price, and Celestial Seasonings' herbal tea price. The specific nature of this long-run pricing equilibrium is captured by the normalized cointegrating vectors in table 4a and is described next in the model specification.

The VEC model is a vector autoregression model in first-difference form that includes cointegration. It underscores the fact that the variables are I(1) and must be first-differenced to obtain stationary residuals. In the VEC, the price sequence $\{\Delta P_t\}$ for each brand is represented as a function of own lagged prices, the two rival's lagged prices, and two cointegrating equations. The VEC is given by

(1a) $$\Delta P_t^{CS\_H} = \sum_{j=1}^{k} \left(\boldsymbol{a}_{1j} \Delta P_{t-j}^{CS\_H} + \boldsymbol{b}_{1j} \Delta P_{t-j}^{TW\_B} + \boldsymbol{f}_{1j} \Delta P_{t-j}^{BG\_B} \right) + \boldsymbol{l}_{11}(\tilde{\boldsymbol{e}}_{1t-1}) + \boldsymbol{l}_{12}(\tilde{\boldsymbol{e}}_{2t-1}) + \boldsymbol{e}_{1t}$$

(1b) $$\Delta P_t^{TW\_B} = \sum_{j=1}^{k} \left(\boldsymbol{a}_{2j} \Delta P_{t-j}^{CS\_H} + \boldsymbol{b}_{2j} \Delta P_{t-j}^{TW\_B} + \boldsymbol{f}_{2j} \Delta P_{t-j}^{BG\_B} \right) + \boldsymbol{l}_{21}(\tilde{\boldsymbol{e}}_{1t-1}) + \boldsymbol{l}_{22}(\tilde{\boldsymbol{e}}_{2t-1}) + \boldsymbol{e}_{2t},$$

(1c) $$\Delta P_t^{BG\_B} = \sum_{j=1}^{k} \left(\boldsymbol{a}_{3j} \Delta P_{t-j}^{CS\_H} + \boldsymbol{b}_{3j} \Delta P_{t-j}^{TW\_B} + \boldsymbol{f}_{3j} \Delta P_{t-j}^{BG\_B} \right) + \boldsymbol{l}_{31}(\tilde{\boldsymbol{e}}_{1t-1}) + \boldsymbol{l}_{32}(\tilde{\boldsymbol{e}}_{2t-1}) + \boldsymbol{e}_{3t},$$

where the superscripts CS_H, TW_B, and BG_B represent Celestial Seasonings (herbal), Twining (black), and Bigelow (black), respectively; ΔP is the change in the natural logarithm of price; $\tilde{\boldsymbol{e}}_{1t-1} = P_{t-1}^{CS\_H} - \boldsymbol{p}_1 - \boldsymbol{q}_1 P_{t-1}^{BG\_B}$ and $\tilde{\boldsymbol{e}}_{2t-1} = P_{t-1}^{TW\_B} - \boldsymbol{p}_2 - \boldsymbol{q}_2 P_{t-1}^{BG\_B}$ are the one-week lagged 'disequilibrium residuals' from the respective cointegrating equations; $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{f}$, $\boldsymbol{l}$, $\boldsymbol{p}$, and $\boldsymbol{q}$ are unknown parameters to be estimated; and $\boldsymbol{e}$ represents a vector of stochastic errors, or innovations. A priori, in a VEC system like this it is very difficult to qualitatively characterize the expected signs of $\boldsymbol{a}$, $\boldsymbol{b}$, and $\boldsymbol{f}$ on the lagged endogenous variables.

The nature of the cointegrating equations is intuitive. From the unit root tests, I found $\{P_t^{CS-H}\}$, $\{P_t^{TW-B}\}$, and $\{P_t^{BG-B}\}$ to be I(1) processes. Thus, $\{\Delta P_t^{CS-H}\}$, $\{\Delta P_t^{TW-B}\}$, and $\{\Delta P_t^{BG-B}\}$ are I(0). Also, e_{1t}, e_{2t}, and e_{3t} are I(0) by definition. Thus, $\tilde{e}_{1t-1} = P_{t-1}^{CS-H} - p_1 - q_1 P_{t-1}^{BG-B}$ and $\tilde{e}_{2t-1} = P_{t-1}^{TW-B} - p_2 - q_2 P_{t-1}^{BG-B}$ must be I(0) since $\{P_t^{CS-H}\}$, $\{P_t^{TW-B}\}$, and $\{P_t^{BG-B}\}$ are cointegrated. Moreover, $\tilde{e}_{1t-1}$ represents pertubations in the cointegrating equation between one-week lagged prices of Celestial Seasonings herbal tea and Bigelow black tea (i.e., disequilibrium in respective prices one week ago). If the prices are on the long-run pricing equilibrium, $\tilde{e}_{1t-1} = 0$ so that $P_{t-1}^{CS-H} = p_1 + q_1 P_{t-1}^{BG-B}$. If $q_1 > 0$ then Celestial Seasonings' herbal tea price follows Bigelow's black tea price, and hence supports the multimarket, cooperative pricing hypothesis (Bernheim and Whinston, 1990; Porter, 1985). A similar interpretation applies to $\tilde{e}_{2t-1}$, but within the black tea segment only. That case closely parallels the single market, canned pineapple model developed by Vickner and Davies (2000).

Table 4a summarizes the parameter estimates in the normalized cointegrating vectors. The parameter estimates were obtained using EViews (1995). Indeed $q_1 > 0$ $(-q_1 = -0.908)$ and the relationship was statistically significant at the 1 percent level. Thus, empirical evidence suggests that multimarket cooperative pricing does exist between the respective herbal and black tea market leaders, Celestial Seasonings and Bigelow. Within the black tea segment, cooperative pricing appears to also exist between the market leader, Bigelow, and the next largest player, Twining. Specifically $q_2 > 0$ $(-q_2 = -1.141)$ and the relationship was statistically significant at the 1 percent level. Vickner and Davies (2000) found a similar relationship between Dole and Del Monte in the domestic canned pineapple duopoly. In their model, the appropriate parameter in the cointegrating equation was equal to 1.318 and was statistically significant at the 1 percent level.

The speed of adjustment coefficients, the λ parameters in the VEC, further characterize the nature of the industry focal point in pricing. In particular, the λ_{11} and λ_{22} parameters show how quickly Celestial Seasonings' herbal tea prices and Twining's black tea prices return to the long-run equilibrium in response to any short-run departure or shock. Recall, short-run departures from the pricing focal point are non-zero values in the series $\{\tilde{\varepsilon}_{1t-1}\}$ and $\{\tilde{\varepsilon}_{2t-1}\}$. If $\tilde{\varepsilon}_{1t-1} > 0$, then Celestial Seasonings' herbal tea price exceeds the long-run equilibrium path ($P_{t-1}^{CS-H} > \pi_1 + \theta_1 P_{t-1}^{BG-B}$) and must necessarily fall in line with the black tea market leader to restore equilibrium. Thus, λ_{11} is expected to be negative. Table 4b summarizes all the parameter estimates in the VEC. It is the case that λ_{11} is negative; the parameter estimate of –0.126 is statistically significant at the 5 percent level. This is further evidence that supports a multimarket cooperative pricing regime in the black and herbal tea industry. Using similar reasoning, λ_{22} is expected to be negative too. In fact, the parameter estimate is –0.183 and is statistically significant at the 1 percent level. Vickner and Davies (2000) found a similar result in the single-market domestic canned pineapple industry. If Del Monte's price exceeded the long-run pricing equilibrium with the market leader Dole, it's price had to fall; the speed of adjustment parameter was –0.238 and was statistically significant at the 1 percent level. The speed of adjustment parameters in the Bigelow VEC equation were not statistically significant ($p>0.10$). This result is consistent with Granger (1991); if two variables are cointegrated, they must show causality in at least one direction.

The parameter estimates on own lagged price terms in the VEC were all negative and statistically significant ($p<0.05$). In the Bigelow black tea price response function, the parameter estimate on Celestial Seasonings' herbal, lagged price term was positive and statistically significant ($p<0.05$). None of the rival price terms were statistically significant in the final VEC model. Consistent with other similar cointegration studies built on weekly point-of-purchase scanner data, the R^2 values were reasonable; these were 0.12, 0.15, and 0.19, respectively, for Celestial Seasonings, Twining, and Bigelow. As noted in Vickner and Davies (2000) the relatively small R^2 values were not surprising given differenced data used in a VEC system. Again using the Hendry's (1986) General to Specific procedure, specification diagnostics indicated that the parsimonious VEC was appropriate. First, partial *t*-statistics on higher order lagged price terms were statistically insignificant ($p>0.10$) beyond a single lag. The AIC and Schwarz Criterion loss functions achieved a minimum in the neighborhood of the final model. The Durbin Watson statistics showed no evidence of first-order autocorrelation. Finally, the Ljung-Box *Q*-statistics for 60 weeks of lags were statistically insignificant ($p>0.10$) indicating higher order autocorrelation was not present in the empirical residuals.

The impulse response functions (IRFs) in figures 1a, 1b, and 1c show the effect of a one unit standard deviation shock in the recursive innovations obtained using Choleski decomposition on the prices of Celestial Seasonings, Bigelow, and Twining, respectively (Bessler, 1984; Hamilton, 1994). In figure 1a, with respect to a Bigelow innovational shock, Celestial Seasonings' herbal tea price rose considerably as expected throughout the three month summary period reaching a new and higher equilibrium. As seen in figure 1b, a Celestial Seasonings shock did not materially affect Bigelow's black tea equilibrium price. The result corroborates the early findings that in the multimarket setting, Bigelow leads and Celestial Seasonings follows; that is, Celestial Seasonings' pricing decisions must promote the long-run equilibrium or focal point. In figure 1c, Twinings' black tea price rose precipitously as expected in response to Bigelow's price shock. The response was not reciprocal as seen in figure 1b; the response by Bigelow to an innovation of Twining was as muted as its response to a Celestial Seasonings innovation. This result is consistent with the single-market IRF analysis for Dole and Del Monte in the canned pineapple industry (Vickner and Davies, 2000). Del Monte, the much smaller rival, responded to a Dole shock by substantially raising prices. However, Del Monte's influence over Dole was negligible. The IRF analysis results were robust with respect to the ordering of the price series. Similar to the Vickner and Davies (2000) study, responses to pricing shocks in the system dissipated very rapidly and suggest that aggregate time series pricing data may mask micro-level strategic price response.

4.3. Modeling Assumptions

Consistent with Vickner and Davies (2000) two modeling assumptions were maintained throughout the analysis to make it tractable. First, all variation in price was attributed to strategic response. Detailed marginal cost data on a weekly basis were unavailable. It is unlikely though that the cost structure would change over such a short analysis period. Cost data, if available, could be included in the VEC as a conditioning variable. Second, the principal agent problem was dismissed. Given the availability of syndicated scanner data sets, food manufacturers such as Bigelow and Celestial Seasonings can monitor food retailers to ensure that pricing strategies are being implemented as planned. Food retailers also have an incentive to partner with upstream food manufacturers to better manage shelf space. The Efficient Consumer Response paradigm is recent evidence of this (Kinsey and Senauer, 1997).

5. SUMMARY AND MANAGEMENT IMPLICATIONS

This paper develops a VEC model of strategic price response in the presence of multimarket contact. In particular, I analyze the pricing conduct of six brands competing in the domestic black and herbal tea industry using weekly, point-of-purchase scanner. Augmented Dickey-Fuller tests identified the subset of I(1) prices eligible for consideration in the long-run industry pricing equilibrium. Johansen's full information maximum likelihood ratio test of cointegration established an industry pricing focal point or equilibrium between Celestial Seasonings' herbal tea price, Bigelow's black tea price, and Twining's black tea price. The cointegrating vectors, speeds of adjustment, and impulse response function analysis corroborate the finding that Bigelow leads and both Twining and Celestial Seasonings follow.

The strategic management implications of this research are far reaching. Garda and Marn (1993) caution senior management against misreading subtle pricing signals to avoid costly price wars yet provide no systematic guidance in statistically determining an industry pricing focal point. Too often, qualitative methods and heuristics, such as those prescribed by Porter (1985), are used in place of rigorous econometric analysis. Absent a battery of unit root tests, it is unclear what players' prices even matter in the competitive strategy analysis. Moreover, subsequent cointegration tests and an associated VEC model can identify a pricing focal point and the nature of it. At that point the analyst can meaningfully discuss Porter's (1985) notion of a "small disturbance" to the industry long-run pricing equilibrium or identify Garda and Marn's (1993) nebulous pricing signals.

Both Porter (1985) and Bernheim and Whinston (1990) discuss the merits of horizontal diversification from the point of view of increasing the likelihood of cooperative pricing due to the multimarket or multipoint setting. Juxtaposing this result with Garda and Marn's (1993) warning underscores the need for a thorough econometric analysis of an industry's long-run pricing equilibrium. Even though cooperative pricing is more likely to emerge in a multimarket setting, the single greatest risk associated with misread signals is that of starting a multimarket price war. The present value of the cost of such a war and restoring the industry pricing equilibrium may not be easily or quickly recouped. In this dawn of corporate accountability, the unforgiving global capital market may further penalize those careless oversights of the firm's professional management, especially in the mature food industries.

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TABLE 1. Descriptive Statistics of Market Shares and Prices by Brand in the Domestic Black and Herbal Tea Industry[a]

Brand	Mean	Standard Deviation	Minimum	Maximum
	Black Tea Dollar Market Share (%)			
Bigelow	47.79	1.63	43.53	52.13
Celestial Seasonings	3.27	0.98	1.81	5.67
Good Earth	1.86	0.27	1.29	2.54
Lipton	19.18	1.36	16.94	23.88
Stash	2.66	1.15	1.46	6.03
Twining	25.24	1.85	21.60	29.23
	Herbal Tea Dollar Market Share (%)			
Bigelow	18.32	1.43	14.96	21.02
Celestial Seasonings	54.70	1.54	51.09	58.98
Good Earth	4.53	0.50	3.43	5.94
Lipton	19.65	1.86	16.33	26.19
Stash	2.32	0.92	1.18	5.39
Twining	0.47	0.30	0.14	2.33
	Black Tea Price ($/equivalent unit)			
Bigelow	2.41	0.06	2.30	2.53
Celestial Seasonings	2.27	0.11	1.93	2.42
Good Earth	2.62	0.08	2.37	2.75
Lipton	2.28	0.07	2.11	2.40
Stash	2.20	0.21	1.76	2.49
Twining	2.44	0.08	2.26	2.63
	Herbal Tea Price ($/equivalent unit)			
Bigelow	2.32	0.07	2.16	2.46
Celestial Seasonings	2.45	0.06	2.30	2.58
Good Earth	2.58	0.07	2.29	2.75
Lipton	2.24	0.10	1.85	2.38
Stash	2.18	0.22	1.72	2.46
Twining	2.50	0.14	1.90	2.79

[a] Based on 180 weeks of observations from December 6, 1992 to May 12, 1996.

TABLE 2. Augmented Dickey-Fuller (ADF) Test Results

Statistic/Diagnostic	$P_t^{BG\_B}$	$P_t^{CS\_H}$	$P_t^{TW\_B}$
ADF Test[a]	-1.58	-2.11	-2.33
F Test	15.04***	8.50***	9.07***
AIC	-9.51	-9.30	-8.89
Schwarz Criterion	-9.46	-9.25	-8.84
Durbin Watson	2.04	1.95	1.96

Note: *** 1% significance level, ** 5% significance level, * 10% significance level.
[a] In absolute value and compared to MacKinnon (1991) critical values.

TABLE 3. Johansen Cointegration Test Results

Null Hypothesis[a]	Likelihood Ratio Statistic	10% Critical Value	Eigenvalue
$r = 0$	31.15	26.79	0.094
$r \leq 1$	13.58	13.34	0.062
$r \leq 2$	2.10	2.82	0.012

[a] r is the cointegrating rank.

TABLE 4A. Parameter Estimates for Normalized Cointegrating Vectors

Variable	$\tilde{e}_{1t-1}$ [a]	$\tilde{e}_{2t-1}$
One-Week Lag of Price [b]		
Celestial Seasonings - Herbal	1	0
Twining - Black	0	1
Bigelow - Black	-0.908***	-1.141***
	(0.223)[c]	(0.250)
Intercept	-0.097	0.110

Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

[a] The variable $\tilde{e}_{1t-1} = P_{t-1}^{CS\_H} - p_1 - q_1 P_{t-1}^{BG\_B}$. Thus, $\tilde{e}_{1t-1}$ represents pertubations in the cointegrating equation between one-week lagged prices of Celestial Seasonings and Bigelow, and $-q_1 = -0.908$. A similar interpretation applies to $\tilde{e}_{2t-1}$.

[b] Natural logarithm of price.

[c] Standard errors in parentheses.

TABLE 4B. Vector Error Correction Model Parameter Estimates and Diagnostics

Variable	Dependent Variable: Change in Price [a]		
	Celestial Seasonings (Herbal Tea)	Twining (Black Tea)	Bigelow (Black Tea)
$\tilde{e}_{1t-1}$ [b]	-0.126**	0.142**	0.022
	(0.048)[c]	(0.059)	(0.043)
$\tilde{e}_{2t-1}$	0.012	-0.183***	0.035
	(0.040)	(0.048)	(0.036)
Change in One-Week Lagged Price [a]			
Celestial Seasonings	-0.195**	0.006	0.137**
	(0.076)	(0.092)	(0.069)
Twining	0.067	-0.188**	0.020
	(0.061)	(0.074)	(0.055)
Bigelow	-0.073	0.034	-0.351***
	(0.081)	(0.098)	(0.073)
Intercept	0.001	0.001	0.0005
	(0.001)	(0.001)	(0.001)
Model Diagnostics			
R^2	0.12	0.15	0.19
AIC	-9.30	-8.92	-9.51
Schwarz Criterion	-9.19	-8.81	-9.41
Durbin Watson	1.95	1.97	2.09

Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

[a] Natural logarithm of price.

[b] The variable $\tilde{e}_{1t-1} = P_{t-1}^{CS\_H} - p_1 - q_1 P_{t-1}^{BG\_B}$ from Table 4A; $\tilde{e}_{1t-1}$ represents pertubations in the cointegrating equation between one-week lagged prices of Celestial Seasonings and Bigelow. A similar interpretation applies to $\tilde{e}_{2t-1}$.

[c] Standard errors are in parentheses.

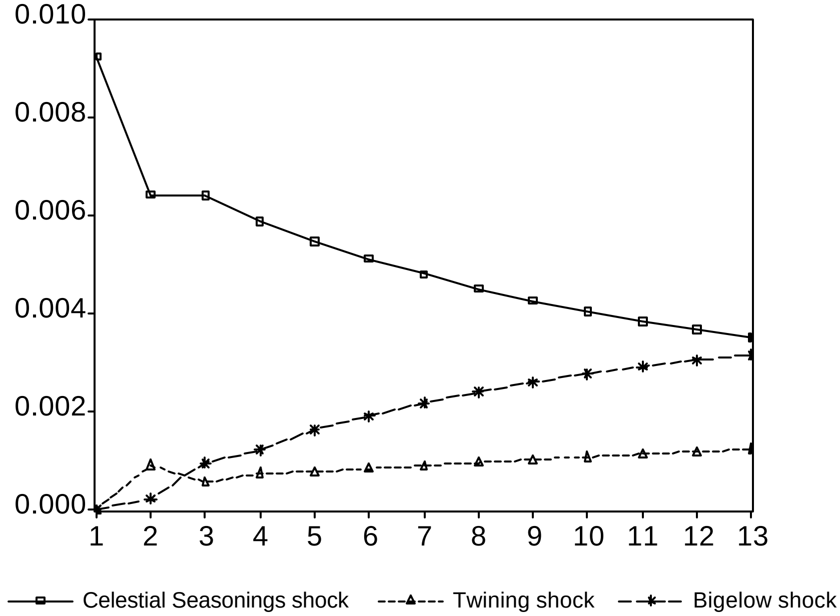

Figure 1a. Vector error correction impulse response function of Celestial Seasonings' herbal tea price given respective shocks - 13 week summary.

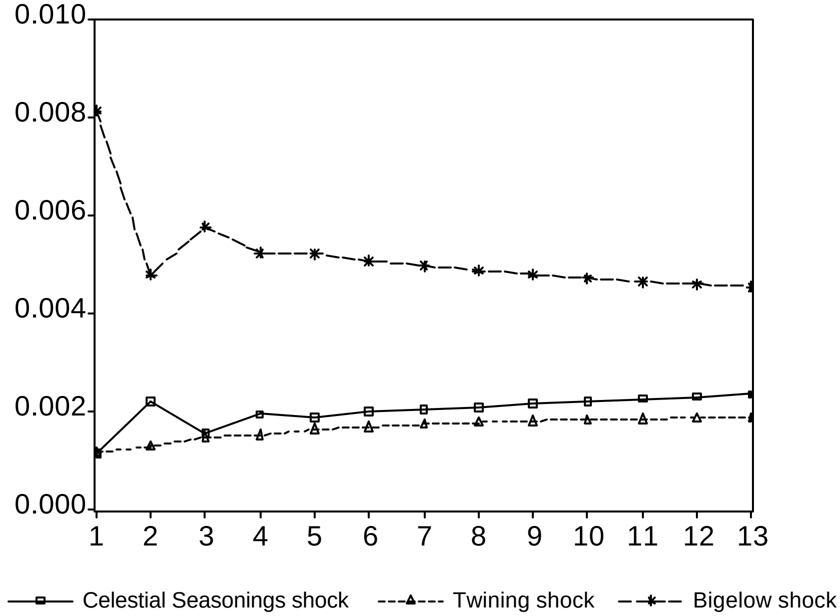

Figure 1b. Vector error correction impulse response function of Bigelow's black tea price given respective shocks - 13 week summary.

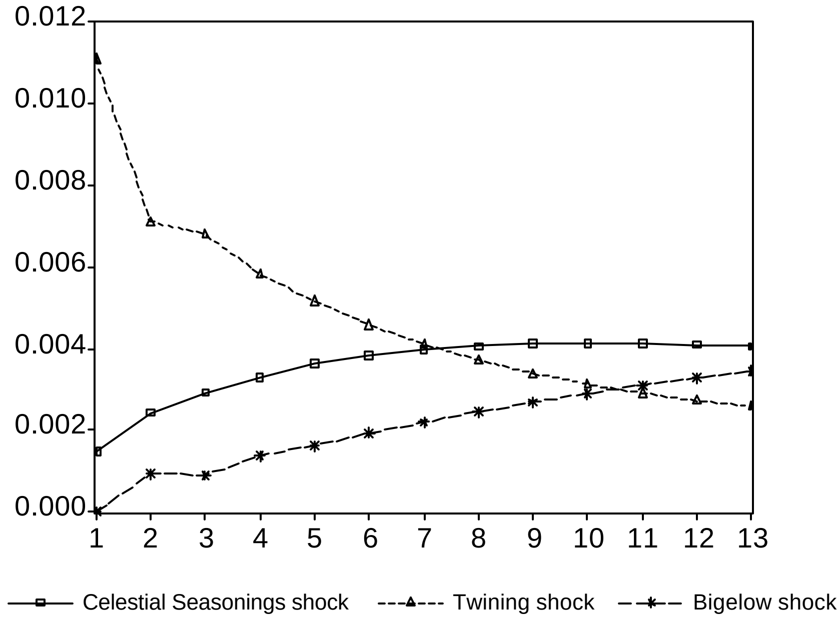

Figure 1c. Vector error correction impulse response function of Twining's black tea price given respective shocks - 13 week summary.