Strategic Pricing Behavior under Asset Value Maximization

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Abstract

In this paper, we develop and estimate a model of strategic firm behavior in the product market after taking into account financial market uncertainty. We link product market oligopolistic competition with the financial market outcomes using capital asset pricing model (CAPM). An interesting feature of the model is that profit maximization enters as a nested component of the proposed general market value maximization (MVM) model. The model is tested using retail scanner data for margarine and butter from 1998-2002. The results show the MVM structure performs better than the traditional profit maximization model. Counterfactual simulations point toward significant biases in estimated Lerner indexes when capital market dimensions are ignored or if the wrong market structure is assumed.

Keywords: Market Value Maximization, Strategic Delegation, AIDS, FIML.

JEL Codes: D43, G12, L13, L21.

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1 Introduction

The majority of theoretical and empirical industrial organizational research is based on the premise that firms maximize profits. In practice, however, firm managers driven by pressure from shareholders and opportunities created by incentive packages may operate under an objective function only partially derived from short-term profitability. Indeed, a summary of Compustat data indicates that salaries and wages of CEOs in the U.S. food industry since 2000 represent only 40% of total compensation. The remaining 60% is comprised of bonuses, stock offerings and stock options.[1] Beginning with Vickers (1985), Fershtman and Judd (1987), and Sklivas (1987), a growing literature has addressed the concept of "strategic delegation", the notion that firm owners can provide incentives to managers that help align otherwise incongruous management-ownership objectives. In all three papers, the manager's objective function is based on a linear combination of profits and product revenue (or its variant, sales), which is derived from an owner's objective to maximize profits in an oligopoly setting. The incentive package represents the necessary precommitment device for a firm to shift rent from competitors and achieve Stackelberg leadership profits. However, as Fershtman and Judd (1987) point out, the owners are essentially joint Stackelberg leaders and thus obtain the prisoner's dilemma outcome in the sense that they would be better off not engaging in quantity games involving delegation of a revenue incentive. Ritz (2005) observes this as part of the structural problems plaguing the U.S. automobile industry. Not surprisingly, in the case of strategic complements, the delegated incentives work to increase the owner's profits (see also Eaton and Grossman, 1986, for similar conclusions in a strategic trade context).

The theory of strategic delegation has been used and/or evaluated in a variety

[1]Murphy (1999) and Prendergast (1999) provide comprehensive surveys on managerial compensation and incentive provisions in firms.

of empirical settings. Kovenock and Phillips (1995, 1997) and Chevalier (1995) assessed the role of debt and leveraged buyouts on market competition. Aggarwal and Samwick (1999) examined the importance of product market competition in manager compensation contracts. Fee and Hadlock (2000) investigated the relationship between management turnover and product market competition. Nickell (1996) and Berger and Hannan (1998) evaluated the link of imperfect competition and corporate performance. Sundaram et al. (1996) studied the effects of strategic behavior on a firm's stock price in the context of R&D competition. Kedia (2006) showed that the form of strategic interaction (substitutes or complements) affects CEO compensation in a manner predicted by Fershtman and Judd (1987). However, to our knowledge, no previous study has attempted to empirically validate the importance of delegation effects in imperfectly competitive final goods markets with firm value objectives.

While the delegation literature has, to date, focused primarily on the incentives provided managers, it has provided little guidance as to the proper specification of the owner's objective function. The common and straightforward assumption in most corporate finance textbooks and in much of the finance literature is, however, that shareholders would prefer that managers maximize the value of their common and/or preferred stock.[2] Recently, Wang and Stiegert (2007) developed a new model of strategic delegation in which shareholders maintain an objective of market value maximization (MVM) of the firm's assets as measured by a capital asset pricing model (CAPM). In this context, optimal delegation requires that managers maximize a linear combination of expected profits and shareholder equity values. An interesting feature of this model is that strategic delegation of the MVM objective mitigates competition in *both* price and quantity games. In the MVM model, the delegation

[2]Brealey and Myers (2002), page 22, ask the rhetorical question "How can the finance managers help the firm's stockholders?" with the subsequent answer: "There is only one way: by increasing the market value of each stockholder's stake in the firm."

instructs managers to consider market risk in product market decisions, which leads to greater market coordination, higher profits, and higher stock values. The purpose of the research in this paper is to empirically evaluate the MVM model to determine if financial market influences are significant in product market pricing behavior. The study is conducted using detailed scanner data of the U.S. butter and margarine retail market. As we will see, profit maximization in this paper is a nested component of the general MVM model, which allows for an easy and direct test of financial market influence on product markets.

The traditional CAPM was independently developed by Sharpe (1964), Lintner (1965), and Mossin (1966). Under the assumption of a risk-averse investor with a fully diversified portfolio, CAPM prescribes that the value of an individual firm be determined by its anticipated profits and systematic risk (i.e. correlated with the market). As pointed out in Frankfurter (1995), the CAPM remains an acceptable approach for evaluating and pricing financial assets when compared with all other methodologies. The basics of CAPM are widely taught as part of core graduate and executive business curriculums. Therefore it is plausible that firm managers may consider systematic risk in product market decisions using the CAPM framework. However, in rapidly advancing industries, opportunities for large profit payoffs have much to do with patent/R&D races, product innovation, and/or accumulating other future growth options. As Fama and French (2004) point out, the CAPM has had limited success in modeling equity values in these industries.[3] Managers in mature/stable industries (for example, margarine and butter) tend to observe stock cycles between

[3]See also Fama and French (1992), Black (1993a, 1993b), and Kothari, Shanken and Sloan (1995) for additional details. A parallel approach models the decisions of firms under uncertainty in which the firm is assumed to have a utility function and to maximize expected utility in the sense of von Neumann-Morgenstern, for example, Sandmo (1971), Leland (1972), and recent paper by Asplund (2002). This approach is justified in Sandmo (1971). However, it remains difficult to construct a utility function for a firm, especially for a publicly owned firm. See Fama and Miller (1972), pp. 67-68.

underpricing (low book value to market value) and correct values when hard times come and pass. For these industries, profit levels are an important but limited objective. Thus, managers seeking to enhance the value of firm equity may look to consistent and stable growth, and to creating perceptions about stable management governance structures and other factors that increase the actual/anticipated earnings of a firm while decreasing the actual/anticipated covariance of earnings with the market.

Based on the premise that managers in publicly owned firms care about market risk, their objectives will be to mirror the objectives of investors looking to add value to an efficient portfolio of assets under the CAPM. If the manager can limit risk through product market decisions while maintaining profit levels and subsequent stock values appreciate, he may be rewarded through stock holdings, options and/or job-security. Furthermore, lower CAPM beta values convert to greater access to capital at lower costs, thus creating a form of scale economies which can act to drive out smaller firms (see Sherer and Ross, 1990, page 129 for a discussion and listed citations), leading to increasing concentration, increased current and future period profits, and ever-increasing equity values. In this context, managers of firms in an industry face penalties for "rocking the boat" which implies that, to manage risk, firm pricing can be more collusive than standard industrial organization models (Wang and Stiegert, 2007).

The MVM model is tested using 4-week interval scanner data from 1998 to 2002 for the U.S. margarine and butter retail market. Demand is modeled using a nonlinear Almost Ideal Demand System (AIDS) under the assumption of price and expenditure endogeneity.[4] Full information maximum likelihood (FIML) is used to estimate AIDS

[4] A common alternative is the random coefficients discrete choice model. Although this model can reduce the number of parameters to be estimated, it often imposes restrictions that may not be implied by the general utility theory. See Bajari and Benkard (2003) for a discussion of this

along with the derived first order conditions to evaluate model fit, optimal pricing strategies, and investigate the degree of market power in this industry. We use both the Wald and the likelihood ratio tests, to test for the appropriateness of standard profit maximization against our proposed MVM model with risk considerations. In terms of pricing games among firms, the Vuong and Wald tests are used to select from a menu of benchmark equilibrium outcomes (i.e. Bertrand, Stackelberg, etc.) or a conjectural variations model. Our exhaustive battery of tests suggests the model of MVM pricing behavior performs better than that of standard profit maximization. Two counterfactual experiments assuming Bertrand pricing and profit maximization indicate that significant measurement errors of the standard Lerner index are associated with ignoring MVM or when assuming the wrong market structure.

The remainder of this paper is organized as follows. In the next section, the MVM model is presented followed by discussions of the empirical model and data used in this paper. Next, all estimation procedures and empirical results are discussed and reported. Finally, we provide our concluding remarks and suggestions for further research.

2 Conceptual Model

A model built on the concept of asset value maximization necessarily involves a framework for dealing with uncertainty. To model MVM, it is assumed that capital value is priced according to the one-period Sharpe-Lintner capital asset pricing model

point. Choice of demand system is also motivated by the fact that in the butter and margarine market, brands can either be complements or substitutes due to household purchasing behavior. Our extensive and detailed discussions with store and brand managers have led us to believe that households tend to buy assortment of butter and butter blends to meet various household demand. Due to the strong assumption of unit purchase in discrete choice models, this kind of complex complementary and substitutable brand relationship is difficult to capture (Dubé, 2004).

(CAPM).[5] The one-period CAPM appeared to be the best of the viable candidate models of financial pricing because the product market is analyzed using one-period benchmark equilibriums. Though the intertemporal CAPM (ICAPM) or arbitrage pricing theory (APT) models introduce greater flexibility in explaining risk and arguably provide greater accuracy in pricing assets, using them are computationally costly (Merton, 1973; Campbell, Lo, and MacKinlay, 1997). The CAPM has the important benefits of being simple and tractable both theoretically and empirically. Because it provides a clear normative signal about how financial markets can influence product markets under imperfect competition, it fits nicely with our objective of testing the hypothesis of profit maximization versus MVM.

By CAPM,

$$E(\tilde{r}_i) = r + \beta_i \left[E(\tilde{r}_m) - r \right], \tag{1}$$

where r is the risk-free interest rate, $E(\tilde{r}_i)$ and $E(\tilde{r}_m)$ are expected rates of return of asset i and market portfolio, respectively, while β_i is systematic risk defined by $Cov(\tilde{r}_i, \tilde{r}_m)/Var(\tilde{r}_m)$. The firm i's market value can be obtained by $V_i = E(\widetilde{\pi}_i)/(1 + E(\tilde{r}_i))$, where $E(\widetilde{\pi}_i)$ is the expected cash flow of net earnings. The firm value can be derived as follows.

$$\begin{aligned} \frac{E(\widetilde{\pi}_i)}{V_i} &= 1 + E(\tilde{r}_i) = 1 + r + \frac{Cov(\tilde{r}_i, \tilde{r}_m)}{Var(\tilde{r}_m)} \left[E(\tilde{r}_m) - r \right] \\ &= 1 + r + \left[\frac{E(\tilde{r}_m) - r}{Var(\tilde{r}_m)} \right] \frac{Cov(\widetilde{\pi}_i, \tilde{r}_m)}{V_i}. \end{aligned} \tag{2}$$

Rearranging (2) yields firm i's market value:

$$V_i = \frac{1}{1+r} \left[E(\widetilde{\pi}_i) - \lambda Cov(\widetilde{\pi}_i, \widetilde{r}_m) \right], \tag{3}$$

where λ is the equilibrium shadow price of market risk, defined by $[E(\widetilde{r}_m) - r]/\sigma_m^2$ and $\sigma_m^2 = Var(\tilde{r}_m)$.

[5]Similar approaches can be found in Subrahmanyam and Thomadakis (1980), Harris (1986), and Shaffer (1991).

For manager's incentive packages given by shareholders, we consider a weighted average of the firm's expected profits and the CAPM-styled values of equity. As a result, the MVM objective function facing managers is given by

$$MV_i = (1-\theta)E\Pi_i + \theta V_i, \tag{4}$$

where θ is an incentive parameter chosen by shareholders in the context of strategic delegation, $E\Pi_i = E(\widetilde{\pi}_i)/(1+r)$, and V_i is defined in (3).[6] Practically speaking, equation (4) shows that managers can receive the desired incentive using a simple combination of profit-sharing bonuses and managerial stock holdings held in escrow.

By rearranging (4), we have

$$MV_i = \frac{1}{1+r}\left[E(\widetilde{\pi}_i) - \theta\lambda Cov(\widetilde{\pi}_i, \widetilde{r}_m)\right]. \tag{5}$$

In equations (4) and (5) we observe a full incorporation of the CAPM-styled financial objectives if $\theta = 1$. Therefore, θ may be interpreted as how the risk component $\lambda Cov(\widetilde{\pi}_i, \widetilde{r}_m)$ is perceived by shareholders relative to the standard CAPM benchmark. In the empirical setup, θ represents the "observed" outcome from the delegation scheme presented to managers, which allows for useful empirical tests about capital market influences on product market behavior. While we do not explicitly demonstrate θ as a strategic delegation variable in this paper, it can be shown how manager's incentives may be manipulated by properly arranging θ in a general MVM framework.[7]

Assuming that managers of each firm in a mature market know both the pricing strategies of other firms (i.e., market structure is known) and the prices of raw materials, uncertainty can enter the model in the form of unanticipated demand.[8] Thus,

[6]In general, the manager's objective function should be $A + B \times MV_i$, where A and B are constant and $B > 0$. Both A and B are irrelevant to the product market decisions.

[7]See Wang and Stiegert (2007) for more details.

[8]Obviously, the covariance of firm profits to market returns are complicated and involve perhaps

we assume that anticipated market demand is accurate up to a normally distributed error term and uncertainty is additively linear, i.e., firm i's demand is defined by $\tilde{X}_i = X_i + \widetilde{e}_i$, where random variable $\widetilde{e}_i$ is firm i's idiosyncratic shock and normally distributed, with a mean of zero and a variance of σ_e^2.[9] As a result, firm i's net earnings are given by

$$\widetilde{\pi}_i = (p_i - c_i)(X_i + \widetilde{e}_i) - U_i, \tag{6}$$

where p_i is price of goods X_i, c_i is a constant marginal cost, and U_i is firm i's fixed cost. Firm i faces demand function $\tilde{X}_i = X_i(p_i, p_{-i}) + \widetilde{e}_i$ and p_{-i} is the pricing strategy of all rivals of firm i. The assumption of constant marginal cost simplifies the supply of raw material and promotion expenditure used to determine marginal costs and subsequently the output-market's structural characteristics.

Therefore, from equations (5) and (6) the first-order conditions in price of MVM are given by

$$X_i - \theta\lambda Cov(\widetilde{e}_i, \widetilde{r}_m) = -(p_i - c_i)\sum_{j=1}^{n} \frac{\partial X_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}, \ \forall i. \tag{7}$$

The conjectural variation parameter of pricing $\tau_{ji} = \partial p_j / \partial p_i$ is given by firm i's conjecture of firm j's price response. Note that $\tau_{ji} = 0, \ \forall j \neq i$ under Bertrand competition and the difference between MVM and profit maximization is the risk component $\theta\lambda Cov(\widetilde{e}_i, \widetilde{r}_m)$ on the left side of the equation. As equation (7) makes obvious, θ, as an incentive parameter, measures financial market impacts on the product market in the framework of strategic delegation presented in equation (4).[10] A positive θ implies that the managers are instructed to consider financial market

multiproduct strategies, research and development outlays, mergers, spinoffs or other fixed costs facing the firm. Our analysis is constrained to consider only the uncertainty that product managers might face in pricing a good.

[9] See section 3.2 for specific details of $\widetilde{e}_i$.

[10] Note that we do not incorporate the leverage and tax issues in the estimation though we recognize their importance. The problem of addressing these issues empirically is one of properly measuring and introducing the firm's balance sheet and tax conditions when they reflect multi-product and/or multi-stage production and marketing activities.

risk when making product market decisions. Furthermore, equation (7) nests two benchmark objectives that firms could pursue: styled CAPM ($\theta = 1$) and pure profit maximization ($\theta = 0$). By restricting $\theta = 0$, we use a straightforward likelihood ratio test to evaluate the common presumption of profit maximization in oligopoly models.

3 Empirical Model Specification and Data Description

To build an empirical model capable of testing MVM, we begin by specifying a demand framework. In the New Empirical Industrial Organization (NEIO) literature, strategic behavior of firms is typically modeled by estimating demand and subsequently, the departure of demand from marginal costs. In many cases, researchers simplify the structural model by specifying ad-hoc or approximated demand specifications, and utilize reduced form conditions because of the prohibitive complexity of flexible demand and cost functions. However, ad-hoc demand specifications fail to satisfy all the requirements of consumer theory. Pioneered by Deaton and Muellbauer (1980a, b), the AIDS approach has been extensively used in the economics, marketing and agricultural economics literature.[11] Recently, Dhar, Chavas, and Gould (2003) estimated a NEIO pricing system for the U.S. carbonated soft drink industry and rejected the commonly applied assumption of expenditure exogeneity. We begin with the AIDS structure, which provides a fully flexible functional form for the purpose of demand estimations, and then incorporate risk concerns into the demand system. We also estimate expenditures as endogenous to the system.

Following the traditional Barten-Gorman AIDS model,[12] the modified AIDS model

[11]For example, Blanciforti and Green (1983), Alessie and Kapteyn (1991), Taube and MacDonald (1991), Browning (1991), Hunt-McCool, Kiker, and Ng (1994), and Cotterill, Putsis, and Dhar (2000).

[12]More discussions on the Barten-Gorman AIDS model can be found in Perali (2003).

can be specified as:

$$
\begin{aligned}
w_{ilt} &= \alpha_{0i} + \sum_{k=1}^{K} \lambda_{ik} Z_{klt} + \sum_{j=1}^{n} \gamma_{ij} \ln(p_{jlt}) + \left[\eta_i \ln(M_{lt}) - \eta_i \ln(P_{lt})\right], \\
& \quad i = 1, \ldots, n; l = 1, \ldots, L; t = 1, \ldots, T;
\end{aligned} \tag{8}
$$

where $w_{ilt} = p_{ilt} X_{ilt} / M_{lt}$ is the market share for the product of firm i consumed in city l at time t, X is consumer goods, p is goods price for X, and M is total expenditure on n goods. Z_{klt} is the k^{th} socio-demographic variable, and γ_{ij} is a cross-effect of firm j's price on the market share of firm i. η_i is the income effect, while P is a price index defined by

$$
\begin{aligned}
\ln(P_{lt}) &= \delta + \sum_{m=1}^{n} \alpha_m \ln(p_{mlt}) + \sum_{m=1}^{n} \sum_{k=1}^{K} \lambda_{mk} Z_{klt} \ln(p_{mlt}) \\
& \quad + \frac{1}{2} \sum_{m=1}^{n} \sum_{j=1}^{n} \gamma_{mj} \ln(p_{mlt}) \ln(p_{jlt}).
\end{aligned} \tag{9}
$$

The theoretical structure implies symmetry restrictions (Equation (10a)) and homogeneity restrictions (Equation (10b)):

$$
\gamma_{ij} = \gamma_{ji}, \forall i \neq j. \tag{10a}
$$

$$
\sum_{i=1}^{n} \alpha_{0i} = 1; \;\; \sum_{i=1}^{n} \lambda_{ik} = 0, \forall k; \;\; \sum_{i=1}^{n} \gamma_{ij} = 0; \;\; \sum_{i=1}^{n} \eta_i = 0. \tag{10b}
$$

To maintain theoretical consistency with the AIDS model, additional restrictions are applied to the demographic translating parameters

$$
\alpha_{0i} = \sum_{r=1}^{9} \nu_{ir} D_r, \;\; \sum_{r=1}^{9} d_{ir} = 1, \;\; i = 1, \ldots, n, \tag{10c}
$$

where ν_{ir} is the parameter for firm i associated with the regional dummy variable D_r for region r. As a result, the demand equations have no intercept terms. The parameter δ may be difficult to estimate and is often set to some predetermined value. We follow the approach suggested by Moschini, Moro, and Green (1994) and set $\delta = 0$.

3.1 Marginal Cost and Expenditure Endogeneity

Estimating the nonlinear AIDS specification presents serious computational challenges. Because uncertainty enters the model on the demand side, it becomes practical to specify costs linearly. Furthermore, the assumption of constant marginal costs is common and has performed well in the past structural market analysis (for example Vilcassim, Kadiyali, and Chintagunta, 1999). Marginal cost c_i is assumed observable and is specified as

$$c_i = \mu_0 + \mu_1 UPV_i + \sum_{j=1}^{2} \mu_{2j} MCH_{ij}, \tag{11}$$

where UPV_i is the unit per volume and represents the average size of the purchase, and MCH_{ij} is in-store marketing, including price reductions and all other merchandising components (display and feature). This setting differs from that in the model with no cost information, for example, Nevo (2001). Nevo (2001) presumes Bertrand competition and uses demand side parameters to recover marginal costs. Our approach allows for evaluation and selection of the correct market structure using the menu approach developed by Gasmi, Laffont and Vuong (1992).

Although demand systems are regularly estimated assuming that expenditures are exogenous, recent finding by Blundell and Robin (2000) and Dhar, Chavas, and Gould (2003) have shown this may not hold. To control for expenditure endogeneity, the reduced form expenditure equation is specified as

$$\begin{aligned} M_{lt} &= f(\text{time trend, income}) \\ &= \xi Trend_t + \sum_{r=1}^{9} \zeta_r D_r + \psi_1 INC_{lt} + \psi_2 INC_{lt}^2,\ t = 1, \ldots, T, \end{aligned} \tag{12}$$

where $Trend_t$ is a linear time trend, capturing any time-specific unobservable effect on consumers' expenditures. The variable INC_{lt} is median household income in city l at time t, and is used to capture the effect of income differences on purchases.

3.2 Simulation of Uncertainty Term

The uncertainty term, $\widetilde{e}_i$ is central to our efforts and requires a detailed explanation. The firms we study in this paper produce multiple products, including those other than margarine and butter. Therefore, it is almost impossible to compute specific β's for the margarine and butter sector only. As such, we simulate the uncertainty term and use the simulation results in subsequent calculations. Because we adopted a scaling technique on all relevant variables throughout the empirical implementations, we define $\Psi = \lambda Cov(\widetilde{e}_i, \widetilde{r}_m)$ and a normalized random variable $\widetilde{\phi}_i = [\widetilde{e}_i - E(\widetilde{e}_i)]/\sigma_e$. By the scaling technique, we define scaled Ψ_s as $\Psi/E(\Psi)$. It turns out that

$$\Psi_s = \frac{\lambda Cov(\widetilde{e}_i, \widetilde{r}_m)}{E\left[\lambda Cov(\widetilde{e}_i, \widetilde{r}_m)\right]} = \frac{\lambda \sigma_e Cov(\widetilde{\phi}_i, \widetilde{r}_m)}{\lambda \sigma_e E\left[Cov(\widetilde{\phi}_i, \widetilde{r}_m)\right]} = \frac{Cov(\widetilde{\phi}_i, \widetilde{r}_m)}{E\left[Cov(\widetilde{\phi}_i, \widetilde{r}_m)\right]}.$$

Thus, the assumption that $\tilde{e}$ is a normally distributed random variable allows us to present uncertainty using $\widetilde{\phi}_i$, which is randomly drawn from a standard normal distribution $N(0,1)$.[13] The normalized samples $\widetilde{\phi}_i$ are used for all calculations. As a result, the covariance term $Cov(\widetilde{\phi}_i, \widetilde{r}_m)$ used in the estimation can be computed from $\widetilde{\phi}_i$ and $\widetilde{r}_m$.[14]

[13] The moment matching technique is usually used to adjust the samples so that the adjusted samples have a correct mean of zero and a correct standard deviation of 1. However, the technique is not needed here. The reason is simple. To match the first and second moments, let us define the mean of samples, m_ϕ, and the standard error of the samples, s_ϕ. The adjusted samples $\widetilde{\phi'}_i$ can be obtained by $(\widetilde{\phi}_i - m_\phi)/s_\phi$, $i = 1, 2, \ldots N$, where N is the sample size. Equation (13) shows why $\Psi'_s = \Psi_s$.

$$\Psi'_s = \frac{Cov(\widetilde{\phi'}_i, \widetilde{r}_m)}{E\left[Cov(\widetilde{\phi'}_i, \widetilde{r}_m)\right]} = \frac{Cov((\widetilde{\phi}_i - m_\phi)/s_\phi, \widetilde{r}_m)}{E\left[Cov((\widetilde{\phi}_i - m_\phi)/s_\phi, \widetilde{r}_m)\right]} = \frac{Cov(\widetilde{\phi}_i, \widetilde{r}_m)}{E\left[Cov(\widetilde{\phi}_i, \widetilde{r}_m)\right]} = \Psi_s. \quad (13)$$

[14] The conclusions of hypothesis tests for $\theta = 0$ are the same (same t-values) with and without the scaling technique we selected. However, we face a tradeoff between these two approaches. Without applying our scaling technique, the assumed level of σ_e plays a crucial role in determining θ. If a large σ_e is assumed, θ is expected to be underestimated, and vice versa. With our scaling technique, on the other hand, we avoid the issue of the magnitude of σ_e, but have no test for $\theta = 1$. We decided to adopt the scaling approach and, therefore, focused principally on the hypothesis test $\theta = 0$: i.e., whether the financial market influences product market decisions.

It is worthwhile to recall that $\widetilde{e}_i$ is an idiosyncratic demand shock facing each firm i. The covariance term $Cov(\widetilde{e}_i, \widetilde{r}_m)$ or its counterpart $Cov(\widetilde{\phi}_i, \widetilde{r}_m)$ is not specified to be within any certain range, but determined by the random drawing and the rate of return of the market portfolio. To be robust, we estimate each model 30 times with different draws of $\widetilde{\phi}_i$ and assume this approach is sufficient to eliminate any noticeable error.

3.3 Data

The data sets for this study are from Information Resources, Inc. (IRI), Current Population Survey (CPS), and Center for Research in Security Prices (CRSP). Table 1 contains appropriate descriptive statistics for all the data used in this study.

The data set from IRI includes different measures of sales and prices, and in-store marketing activities. The information contains all UPC-coded products in the margarine and butter category from retail store scanners for 28 cities/markets[15] across the United States. It measures 58 periods based on 4-week intervals from January 25, 1998[16] to June 9, 2002. As a result, there are 13 periods in each of 1998-2001 and 6 periods in 2002.

For branded products, market shares of top three firms are 37.5%, 15.66%, and 9.6% while the remaining is 13.29% with which the market share is less than 3% for the fourth ranking firm. Therefore, the estimation involved the top three firms, an aggregate "all others" group, and private labels. Both private labels and all others are treated as two individual firms. That is, firms of private labels and all others are

[15] They are Atlanta, Baltimore/Washington, Boston, Buffalo/Rochester, Chicago, Columbus, Dallas/Ft Worth, Denver, Des Moines, Detroit, Indianapolis, Jacksonville, Kansas City, Little Rock, Memphis, Milwaukee, New Orleans/Mobile, New York City, Oklahoma City, Philadelphia, Portland (OR), Raleigh/Greensboro, Richmond/Norfolk, Salt Lake City, San Diego, San Francisco/Oakland, Seattle/Tacoma, and Tampa/St. Petersburg.

[16] The first period runs from December 29, 1997 to January 25, 1998.

assumed to behave in coordination, with the same pricing and marketing strategies within their own categories. This assumption was made for the following reasons. First, our IRI database only provides aggregated private label data and the "all others" category is created to control for the large number of residual brands in the market place with small market share for each brand. Given non-trivial computational demand of our proposed model, it was not feasible to incorporate each of these residual brands in the present model. Second, our preliminary exploratory data analysis of the market share also implied stable market shares in most weeks for all aggregate firms and private labels. The market appears quite mature in its overall structure. Twelve dummy variables ($Season$) were added to adjust for seasonality across the 13 4-week intervals. Firm 3 charges relatively high prices because its major product is pure butter. We add a dummy variable ($Butter$) to control for this quality difference.

We estimate our model using data from 28 major cities with 58 periods for each city, each firm has 1624 (=58×28) complete data observations. The variables used in the analysis include price, volume sales, dollar sales, unit sales, volume per unit, in-store marketing variables such as price reduction, and all other merchandising components (feature and display).

For the demographic data, we use the following three sources: (1) 9 division binaries are from Census Bureau Geography,[17] (2) variable POPU (overall population) is from IRI, and (3) 6 other demographic variables are from the Current Population Survey – Annual Demographic Survey (March CPS Supplement) for 1998-2002, which include PERLT10K (percentage of households earning less than $10,000), PERGT50K (percentage of households earning more than $50,000), HUNDER15 (average number of people under age 15), H_NUMBER (average household size), A_AGE (median

[17]See Reference Resources for Understanding Census Bureau Geography available at: http://www.census.gov/geo/www/reference.html.

household age), and FSPANISH (percentage of Hispanics).

We merged the CPS data with IRI data by using the GMMSA variable (Geography - MSA or PMSA FIPS Code) in the CPS database. The areas covered by CPS and IRI are approximately the same. Furthermore, because the March CPS Supplement database is annual, linear projection is used to obtain the 4-week interval data.

For the financial components of the model, the annual rate of return of the market portfolio ($\widetilde{r}_m$) and the annual risk-free rate (r) were available from the Center for Research in Security Prices (CRSP). The annual rate of return of the market portfolio is computed from CRSP Indices on the S&P 500. The annual risk-free rate is based on actual 90-Day Bill Returns reported by the U.S. Treasury.

4 Estimations and Results

The estimating model included four sets of equations: AIDS demand (8), expenditure (12), MVM first order condition (7), and marginal cost (11). The system was estimated in GAUSS using the maximum likelihood module. The structural model essentially measures the wedge between price and marginal costs while simultaneously accounting for revenue uncertainty through the CAPM structure. As described earlier, the estimation is run for 3 firms, an aggregate category for all other firms, and a final category for private label firms, in which firms 1 and 2 produce margarine and firm 3 produces butter only, while All Others and Private Labels produce both butter and margarine.

Note that, by definition, $\sum_{i=1}^{5} w_i = 1$, where w_i is the expenditure share of good i. Thus, the dependent variables are linearly dependent, implying the singularity of the variance of the error terms. This singularity problem can be handled by dropping one equation, thus estimating the remaining four demand equations. The parameters from the equation dropped can be recovered from the homogeneity restrictions. As a result, the full information maximum likelihood (FIML) estimation in this study consists of 10 equations in the system, including 4 demand equations, 5 first-order conditions, and 1 equation to control for expenditure endogeneity.

With regard to the number of parameters in the estimation, there are 91 demand-related parameters from equation (8), 12 expenditure endogeneity parameters from equation (12), and 20 marginal cost parameters from equation (11). For equation (7) the parameters include one parameter capturing financial market impact and the conjectural variation of price parameters (CV) whose numbers depend on the market structure specified in each competing model. Table 2 contains details about each set of equations estimated and descriptions and numbers of the parameters.

4.1 Model Selection I: MVM vs. Profit Maximization

Our first goal was to evaluate the general MVM model versus a restricted version that assumes profit maximization. The general MVM presentation in equation (7) nests pure MVM and profit maximization. We use both likelihood ratio and Wald tests to demonstrate the robustness of the model selection results. At this stage, because the correct market structure had not been identified, the LR and Wald tests were performed across the entire menu of structures (see below for details). Although not reported, the MVM-profit test did not depend on any specific market structure. That is, by hypothesizing different market structures from the menu, the MVM-profit tests lead to the same qualitative conclusions.

Results of the LR and Wald tests from the best-fitted model (see below) are presented in Table 3. The range of estimated θ was from 0.3252 to 0.3751, while the mean was estimated at 0.3456. As mentioned in footnote 14, we developed a scaling approach that eliminated the need to measure σ_e and λ. Because the scaling method divides the financial component through by its mean, the specific estimated value of θ is not interpretable as to the level of delegation of MVM provided to managers from shareholders. Although this is a limitation, the hypothesis test of $\theta = 0$ remains valid. The Wald and LR statistics demonstrate the statistical significance of the financial component. Thus, a significant finding is that financial market risk (as perceived through the CAPM) has an important role in shaping the strategic interaction among firms in the margarine and butter market. This is a crucial finding because we reject traditional profit maximization models in favor of the unrestricted MVM model.

4.2 Model Selection II: Market Structure

Our second goal is to statistically select the best-fitted model from four benchmark oligopoly outcomes (Stackelberg Leadership, Stackelberg followership, non-cooperative Nash-Bertrand, and collusion), or an unrestricted conjectural variations (CV) model. It turns out that there are 4^5 possible combinations of benchmark pricing strategies that could be investigated. The procedure for choosing the best-fitted model is greatly simplified by the fact that all of the pure strategy equilibriums except for collusion are nested in an unrestricted CV model. Thus, we first choose from the unrestricted CV models with five possible collusion schemes using the Vuong test (VT) and augmented with tests using Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC).

The non-nested test results are presented in Table 4. Five possible market conditions were considered, including C0 (each firm operates non-collusively), C1 (firm 1 and firm 2 collude), C2 (firm 1 and firm 3 collude), C3 (firm 2 and firm 3 collude), and C4 (firm 1, firm 2, and firm 3 collude). We assume that those firms outside the collusion play CV strategies since the CV model is unrestricted and convenient for nesting most pure strategy games. We should further note that in order to simplify the analysis we assume that only one coalition can exist. That is, we do not deal with cases where more than two coalitions exist in the market. Because the statistics all exceed 1.96, the Vuong test and its adjustments (AIC and SIC) indicate that model C0 is the best-fitted model, in which each firm operates non-collusively in price.

Having eliminated all collusive schemes that seemed unreasonable, we turn to the tests of pure strategy equilibriums nested in the general CV model. We use the Wald test to test for Bertrand pricing, Stackelberg leadership for the top three firms, the All Others, the Private Labels, and consistent conjectures in pricing strategies. For the Stackelberg and consistent conjectures games, the slopes of reaction functions must be estimated before the Wald test can be implemented.

Though not reported here, the Wald tests show that all various combinations of Bertrand, Stackelberg leadership, and consistent conjectures for the pricing strategies are rejected. This result implies that the CV model for pricing strategies in model C0, where each firm operates non-collusively in price, is the final winner. After the best-fitted model is determined, we then work on the price and expenditure elasticities[18] derived from this model, as presented in Tables 5 and 6.

4.3 Elasticities

In Table 5, all own price elasticities are significantly negative. Since All Others and Private Labels are aggregated from many of differentiated niche-type products, it is not surprising that this group of products is relatively inelastic in price. Firm 1 is more inelastic than firms 2 and 3, which supports the notion that this dominant firm may have strong customer loyalty and strategies to differentiate these lines have been successful. Firms 2 and 3 are relatively more price sensitive than the other

[18] The elasticity estimates can be derived from the AIDS model. They are all computed at the means of relevant variables and the associated standard errors are obtained by the delta method.

firms in the study. This may signal relatively lower firm loyalty, poor differentiation strategies, and/or other factors that limit these firms from improving their market position relative to firm 1 or private labels.

Moving to cross elasticities, firms 1 and 2 are found to be substitutes, which was not surprising given that both are margarine product lines. Meanwhile, there exist no clear relationships between either firms 1 and 3 or firms 2 and 3. The negative cross elasticities of the rest of the products imply that they are roughly complements of each other. The result is consistent with Gould, Cox, and Perali (1991), where different food fats and oils, including butter, margarine, short, cooking, and lard are generally complements. Alternatively, the negative cross elasticities might emerge because retail firms control final prices and have no true complementary relationship. For example, when branded products are offered at lower prices, supermarkets can instantaneously react by lowering the price of their own private labels.

The expenditure elasticities are reported in Table 6. All are positive and statistically significant. Recall that firm 3, All Others, and Private Labels all have significant butter components aggregated within, while firms 1 and 2 are lower priced, margarine firms. Private Labels, All Others, and firm 3 are above unity, consistent with the fact that these items contain butter products and generally charge relatively higher prices.

4.4 Lerner Indexes

Table 7 provides a key set of results with respect to Lerner indexes. The Lerner indexes for the best-fitted model (MVM-conjectural variations) are presented in column 1. The Lerner indexes range from 0.0092 and no statistical significance (All Others) to 0.2821 (firm 3). The lowest Lerner index of All Others is consistent with the smaller market shares of these firms and possible fringe market positioning. The major firms (firms 1, 2, and 3) all operate with considerably higher margins indicating superior levels of market power. Private labels also have a high Lerner index and similar to the major firms. This is consistent with the growing concerns about market power of supermarkets.

To examine the importance of model specification, two added experiments are presented in terms of Lerner indexes. Because Bertrand pricing is oftentimes an operational assumption of retail market studies, Column 2 contains the MVM-Bertrand result and column 4 shows, in percentage terms, the difference between Lerner indexes between column 2 and column 1. While Bertrand pricing is a stable benchmark, the cost of imposing this restriction emerges in the form of higher Lerner indexes. In all cases except the All Others category, the error is around 35% and in a range of 25% to 45%. These results underscore the importance of getting the correct model assumptions in place and cast doubt on using a Bertrand-pricing assumption without a formal statistical test of its validity. What is particularly troubling is the estimated Lerner index for the All Others category. The Bertrand assumption leads to a result that the All Others category operates with a statistically significant Lerner index of 0.4, an egregious 99% error versus the correct model and generating a Type I error. In this case, the Bertrand assumption leads the researchers to believe that this is the most troubling category though it is usually not perceived so.

Columns 3 and 5 present a similar comparison as columns 2 and 4, but here, we impose the restriction that firms maximize profits. In all cases except the All Others category, the restriction of profit maximization causes Lerner Indexes to rise by about 4.74% with a range of 1.10%-7.39%. These results are consistent with the theoretical findings in Wang and Stiegert (2007) which suggest that Lerner indexes are overstated under profit maximization. For the All Others category, assuming profit maximization generates a very large error (51.09%) relative to MVM, but it was not statistically different from zero (thus, no Type I error). While the restriction of profit maximization generated some errors in precision relative to MVM, they are far less problematic than in the case of presuming the wrong market structure.

5 Concluding Remarks

Industrial organization research has a major focus of trying to determine how prices are formed when only a few competitors exist in defined markets. Usually, the operational assumption is that firms try to maximize profits. However, it is readily apparent that not all managers are compensated in ways consistent with simply increasing profits. In this paper, we investigate an objective function of (equity) market value maximization (MVM) in product market behavior for the U.S. margarine and butter retail market. We develop and implement a model of oligopoly pricing using a nonlinear Almost Ideal Demand Systems and structural first-order conditions derived from a CAPM based objective function. The data included retail scanner data from 1998-2002 over 28 demographic market areas in the U.S.

Two key objectives of the study were met. First and foremost, the model was constructed to incorporate a simple likelihood ratio or Wald test to determine if a restricted profit maximization version of the model was appropriate. The restricted model was rejected and we concluded that MVM factors have an important role in determining the pricing behavior of firms in this industry. The results regarding our MVM parameter value should be viewed with some caution. The firms in this industry may not have the incentives structured to fully incorporate a CAPM objective and indeed may offer management only an approximation to the objective that our theory suggests in section 2. Nevertheless, the implications are clear that MVM factors are present in product market behavior. Second, a menu approach was used to search for the market structure that best describes the data. The MVM model using a general conjectural variations assumption was selected over several benchmark oligopoly structures such as Bertrand pricing, various Stackelberg leadership models, and various forms of collusion. This is not an overly surprising result. While static benchmark results are useful theoretical guides, they are hard to sustain over long periods of time and across different cities.

The best-fitted MVM model was also used to compare Lerner indexes when incorrect assumptions were used. In the case of assuming firms maximize profits, Lerner indexes were slightly higher for four of the firms with an average overstatement of about 4.74%. For the aggregated All Others category, the overstatement was much larger, but neither the MVM nor the profit maximization Lerner indexes were different from zero. Many retail oligopoly studies simply presume a Bertrand market structure. When the MVM model was restricted to Bertrand pricing, the results pointed to a much larger problem. In this case, the restriction generated 25% to 45% errors for top three firms and Private Labels, but a 99% error for the All Others. Further, the MVM-Bertrand model generated a Type I error for the All Others where the Lerner index was found to be statistically different from zero. This result underscores the importance of statistically validating the market structure before moving forward with studies of imperfect competition.

The research in this study provides several important additions and extensions to the literature. To the best of our knowledge, this is the first attempt to estimate a flexible demand system under imperfect competition and financial market risk. We believe the modeling approach proposed here pushes the literature toward a richer model of firm behavior that links financial market objectives and product market behavior. Future research should attempt to consider similar linkages to the equity markets. For example, a better understanding of financial leverage and tax effects could prove important in an oligopoly context. Moreover, it is usually presumed that firms vertically integrate and/or vertically contract to gain efficiencies and improve profitability, but an additional factor may lie in managerial incentives to stabilize profit streams and increase the value of equity when such structures are under consideration. The research in this paper also points to a reconsideration of how supra-normal profits are measured in an antitrust context. While the discipline of finance has a long tradition in normalizing returns against risk exposure, the industrial organization field has struggled to define a clear or easy way to make this normalization process tractable for antitrust enforcement. Doing so would be a major advancement in the merger analysis.

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Table 1 Descriptive Statistics

Firms	Price ($/lb)		Market Share (%)		Expenditure share (%)		Total Revenue ($M/city)	
F1 (M)	1.18	(0.17)	37.50	(6.85)	29.81	(6.26)	40.75	(29.64)
F2 (M)	1.05	(0.22)	15.66	(9.69)	13.66	(7.48)	15.06	(8.99)
F3 (B)	3.40	(0.62)	9.60	(4.46)	16.43	(7.62)	29.69	(37.94)
AO (M&B)	2.19	(0.51)	13.29	(8.80)	14.59	(10.59)	26.87	(42.01)
PL (M&B)	1.85	(0.52)	23.95	(6.64)	25.51	(7.38)	41.11	(37.14)

Firms	Unit Per Volume		All Merchandising (%)		Price Reduction (%)		All Others (%) [Display & Feature]	
F1 (M)	0.77	(0.07)	24.37	(9.03)	9.57	(6.90)	14.80	(8.32)
F2 (M)	0.91	(0.06)	31.21	(13.75)	12.56	(8.74)	18.65	(12.66)
F3 (B)	1.13	(0.06)	36.89	(23.42)	17.50	(16.04)	19.39	(20.49)
AO (M&B)	1.06	(0.08)	24.45	(15.42)	13.17	(9.84)	11.28	(12.60)
PL (M&B)	0.90	(0.09)	38.53	(21.41)	16.20	(13.97)	22.33	(17.73)

Mean Values of Other Explanatory Variables

Variables	Units	Mean		Variables	Units	Mean	
PERLT10K	%	8.64	(3.22)	Median Income	$	44317.32	(6484.37)
PERGT50K	%	44.03	(6.63)	Per Capita Expenditure	$	0.72	(0.19)
HUNDER15	#	0.58	(0.09)	r_m	%	7.35	(18.80)
H_NUMBER	#	2.57	(0.16)	r_f	%	5.23	(0.78)
A_AGE	Years	34.01	(2.42)				
FSPANISH	%	13.40	(10.74)				
POPU	#	3651213	(3361325)				

Note:

(1) Product produced: M=margarine; B=butter.

(2) Standard errors are in parentheses.

(3) F1~F3: Firm 1~Firm 3, AO: All Others, PL: Private Labels.

Table 2 Numbers of Parameters in FIML Estimation

Equation	Parameter	Number	Note
8	ν_r	36	division binary, $r = 1 \ldots 9$.
	λ_k	28	socio-demographic variable, $k = 1 \ldots 7$.
	η	4	income term in AIDS
	γ	10	cross price effect in AIDS
	$Season$	12	seasonality dummy
	$Butter$	1	butter dummy
12	ζ_r	9	regional dummy in income, $r = 1 \ldots 9$.
	ξ, ψ_1, ψ_2	3	time trend, median income and its square
11	μ_0	5	intercept term
	μ_1	5	unit per volume
	μ_{21}	5	all other merchandising
	μ_{22}	5	price reduction
7	τ	*	CV in price
	θ	1	finance component

* Numbers depend on the market structure. See column (4) in Table 4.

Table 3 Wald Test and Likelihood Ratio Test for Financial Component (MVM versus Profit Maximization)

Draw	Estimates	Standard Error	Wald statistic	LR statistic
1	0.3569	0.0098	1338.04	354.49
2	0.3527	0.0087	1630.99	365.42
3	0.3458	0.0075	2142.03	355.11
4	0.3330	0.0082	1654.55	381.26
5	0.3783	0.0063	3633.31	252.00
6	0.3690	0.0079	2178.67	289.22
7	0.3669	0.0103	1258.21	442.44
8	0.3208	0.0078	1698.22	395.88
9	0.3451	0.0083	1712.88	355.79
10	0.3301	0.0082	1611.63	367.73
11	0.3676	0.0095	1503.89	462.89
12	0.3346	0.0078	1820.77	392.40
13	0.3442	0.0076	2054.92	366.42
14	0.3467	0.0090	1468.48	432.95
15	0.3517	0.0074	2230.45	327.26
16	0.3336	0.0070	2245.63	382.20
17	0.3510	0.0096	1344.35	365.03
18	0.3751	0.0101	1387.73	287.55
19	0.3573	0.0073	2365.81	356.31
20	0.3480	0.0091	1468.77	429.54
21	0.3255	0.0083	1536.45	391.12
22	0.3458	0.0080	1863.96	383.16
23	0.3372	0.0077	1922.31	384.77
24	0.3322	0.0071	2187.97	369.22
25	0.3408	0.0083	1681.56	403.32
26	0.3252	0.0076	1807.23	379.63
27	0.3472	0.0081	1854.66	445.08
28	0.3348	0.0073	2102.72	385.18
29	0.3385	0.0106	1028.39	387.52
30	0.3331	0.0091	1339.98	361.41

Note: The critical values at the 5% level of significance are 3.84 for both the Wald test and the LR test.

Table 4 Vuong Test (Model C0 versus Others)

Model	(1) VT	(2) AIC	(3) SIC	(4) # of CV
C0	0.0000	0.0000	0.0000	20
C1	19.1853	19.1520	19.0624	18
C2	17.6805	17.6580	17.5975	18
C3	20.3314	20.3031	20.2267	18
C4	26.6616	26.6105	26.4730	14

Note:

(1) C0: each brand operates non-collusively
C1: Firm 1+Firm 2
C2: Firm 1+Firm 3
C3: Firm 2+Firm 3
C4: Firm 1+Firm 2+Firm 3

(2) The numbers in columns (1)-(3) indicate the Vuong statistics under the different criteria, which measure how mode1 C0 is superior to the others. For example, the three entries of model C1 indicate that model C0 is better than model C1 by those amounts. The critical values for the 5% level of significance are -1.96 and 1.96.

Table 5 Price Elasticity Matrix

Firms	F1	F2	F3	AO	PL
F1	**-0.5561**	**0.1327**	**0.0425**	**-0.0348**	**-0.2733**
	(0.0096)	(0.0033)	(0.0027)	(0.0036)	(0.0097)
F2	**0.3329**	**-0.7873**	**0.1086**	**-0.1183**	**-0.0734**
	(0.0081)	(0.0055)	(0.0045)	(0.0073)	(0.0115)
F3	**-0.0714**	-0.0013	**-0.8383**	**-0.0524**	**-0.1868**
	(0.0030)	(0.0023)	(0.0064)	(0.0025)	(0.0075)
AO	**-0.2514**	**-0.2169**	**-0.0800**	**-0.0925**	**-0.6212**
	(0.0063)	(0.0059)	(0.0032)	(0.0242)	(0.0250)
PL	**-0.5071**	**-0.1441**	**-0.1662**	**-0.3811**	**-0.1659**
	(0.0119)	(0.0059)	(0.0057)	(0.0144)	(0.0188)

Note:
(1) Standard errors are in parentheses.
(2) Highlighted numbers are significant at the 5% level of significance.
(3) F1~F3: Firm 1~Firm 3, AO: All Others, PL: Private Labels.

Table 6 Expenditure Elasticity Matrix

Firms	Estimates
F1	**0.6872** (0.0105)
F2	**0.6315** (0.0162)
F3	**1.2220** (0.0057)
AO	**1.2711** (0.0170)
PL	**1.2648** (0.0160)

Note:
(1) Standard errors are in parentheses.
(2) Highlighted numbers are significant at the 5% level of significance.
(3) F1~F3: Firm 1~Firm 3, AO: All Others, PL: Private Labels.

Table 7 Comparisons of Estimated Lerner Indexes

Firms	(1) MVM	(2) MVM Bertrand	(3) Profit Maximization	(4) [(2)-(1)]/(1)*100%	(5) [(3)-(1)]/(1)*100%
F1	0.2694 (0.0165)	0.3492 (0.0140)	0.2893 (0.0129)	29.62	7.39
F2	0.2471 (0.0252)	0.3095 (0.0234)	0.2621 (0.0214)	25.25	6.07
F3	0.2821 (0.0088)	0.4084 (0.0097)	0.2852 (0.0077)	44.77	1.10
AO	0.0092* (0.0983)	0.4001 (0.0382)	0.0139* (0.1232)	4248.91	51.09
PL	0.2478 (0.0172)	0.3527 (0.0186)	0.2587 (0.0136)	42.33	4.40

Note:
(1) Standard errors are in parentheses.
(2) '*' indicates 'not significant'.
(3) F1~F3: Firm 1~Firm 3, AO: All Others, PL: Private Labels.