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Market Concentration in the Grocery Retail Industry: Application of the Basic Prisoners' Dilemma Model

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Abstract

We assess spatial concentration ratios in the grocery retail industry across four regions of the country to determine whether there is evidence of covert collusion among the retail chains that can explain why we do not see more price competition among them. We apply a basic theory of the prisoners' dilemma game model, together with an empirical analysis that utilizes the price-concentration model (PCM) to test both the direction and size of the effect of concentration on prices, whilst controlling for other factors that affect the retail prices of the grocery retail firms. The work explores whether higher concentration does enable collusive behavior that leads to higher set prices of grocery products within and across given spatial locations, by estimating a PCM which allows us to verify the extent to which the grocery retail chains can manipulate and set prices uniformly among themselves in a quasi-collusive behavior.While the theory suggests that the degree of competition as opposed to cooperative collusive outcomes in the industry depends on the accuracy of rival conjectures about each other's moves, the empirical evidence indicates that the pricing patterns observed between the companies may be largely due to covert tacit collusion among these retail firms.

JEL classification numbers: L11, L13, C5, C7
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1 Introduction

Following Sexton *et al* (2003; 2002), we examine the pricing practices in the grocery retail industry to determine why there always seems to be price uniformity among the major retail chains. We assess spatial concentration ratios in the grocery retail industry across the country and determine whether there is evidence of covert collusion among the retail chains that can explain why we do not see more price competition among them. The aim is to verify the extent to which the price-concentration ratio model (PCM) can explain the apparent collusive pricing behavior that seems to exit in the grocery retail industry. Retailers in this industry have become dominant players since the 1990s when the industry began to experience unprecedented structural changes due to waves of mergers and acquisitions and new entries of such retail giants as Walmart and Target. It is estimated that the national market share of the four leading retailers rose from 23 percent in 1993 to 28 percent in 1999, 37 percent 2005, and43 percent in 2010, and further to 55 percent in 2014.[3]

As a classic oligopoly market game theoretic setting in which firms are assumed to be always resolved to seek their individual profits maximization over time, and in which each firm inherently adopts an inherently non-cooperative pricing strategy, how could it be that an apparent cooperative (collusive) solution seems to be apparent? This study addresses this question by applying a basic theory of the prisoners' dilemma game model, together with an empirical analysis that utilizes the PCM to test both the direction and size of the effect of concentration ratios on prices, whilst controlling for other factors that affect the retail prices of the grocery retail firms. The study is motivated by a recent work by Lazarou (2013), followed by an earlier finding by Hodson et al. (2012) as well as Fischer and Kamerschen (2003) for the airline industry, to the effect that collusive behavior among industry leaders in any market is consistent with higher prices and sustained profits in the industry; both of which result in economic distortions, market inefficiency, and dead-weight losses in the economy.

The traditional Cournot-Nash assumption of zero (inconsistent) conjectural variation among oligopolists does not adequately explain the grocery retail industry in the United States.[4] This is because its implications of an ongoing state of competition within an oligopoly industry has not been compatible with observed conditions in the industry. For this reason, collusive behavior of firms

[3]United States Department of Agriculture, Economic Research Service (USDA, ERS) calculations using data from U.S. Census Bureau, Economic Census of Retail Trade the top four grocery retailers in 2013 were Walmart Stores, Inc. (25% market share), Kroger (17% market share); Safeway (8% market share); and Supervalu (5% market share).

[4]The term *conjectural variation* is used to refer to the belief that each competitor has regarding how its rivals would react to its own unilateral actions and initiatives.

designed to limit competition and enable colluding members to set high prices and thereby earn profits above the normal competitive level seems to exist in the grocery retail industry. Although such practices are prohibited under both Federal and State statutes in order to protect consumers, and considerable resources are allocated each time to prosecute such antitrust violations, yet the very outcomes that are targeted for prevention appear to often emerge.

Leading research studies on market power and collusive pricing behavior such as Fischer and Kamerschen (2003),Baraji and Ye (2003), Baraji and Summers (2002), or Pesendorfer (2000), have established proof for the existence of monopoly power, and concluded that retail prices across most industries are also influenced by the particular region of the country under consideration at any time. Benson and Faminow (1985) had established the widely held fact that grocery retailing had always been essentially oligopolistic in terms of pricing behavior. More recent studies have stressed this finding; for example, Bajari and Ye (2003) carried out an analysis that computed the probabilities that observed outcomes in the industry are the result of competitive behaviors of firms that fail the tests for conditional market independence. In a study of the perishable fresh produce retail chains, using nation-wide data, Sexton et al. (2003) found that the structure of grocery retailing necessarily gives large retailers some degree of market power in terms of the ability to influence price; and concluded that to the extent that retailers exercise their market power in the sense of marking up prices in excess of full marginal costs, they exploit the unilateral monopoly power they possess through geographic and brand differentiation. Similarly, Binkley and Connor (1998)cited the work ofHoch et al. (1995) which developed four competitive variables to explain store-level price-elasticities of 18 branded grocery products. The authors examined the effects of warehouse-type stores within the given geographical location, and found that such presence resulted in increased elasticity of demand and therefore more competitive prices, while the distance from such stores (including those outside the immediate trading area) negatively affected the responsiveness of demand to price variations. The findings were supported by Drescher and Connor (1999) which also found that the presence of warehouse-type stores significantly reduced overall market grocery prices.

Preceding studies focussing on how truly competitive the grocery retail industry is, and the impact of the degree of concentration on prices in the grocery retail industry, include Connor (2001), Yu and Connor (1999), Dobson and Waterson (1997), as well as Cotterill (1991, 1986).

Yu and Connor's (1999) study revealed that some price competition existed in the industry in terms of rivalry between the major industry leaders in the horizontal, vertical, and geographic dimensions. The study applied empirical cross-sectional analysis of retail price competition, and found that in the case of horizontal price competition, pricing was sensitive to different degrees of firm concentration in the industry; thus, differences in overall grocery prices across geographic markets in the industry existed in terms of competitive intensity as measured by market shares and/or market concentration.

Cotterill and Harper (1995), drawing upon an earlier study that applied highly aggregated retail food price indexes published for 18 large U.S. metropolitan areas by the Bureau of Labor Statistics (Lamm, 1981), which found that industry concentration was positively related to food prices, also verified and concluded that there existed a positive industry concentration-price relationship for a sample of 34 local markets in and around Arkansas. Connor (2001) cited a 1999 study (Drescher and Connor, 1999) in which, aided by a 1993 special survey of consumer prices across 50 German cities and a comprehensive commercial data base on grocery stores, they established a relationship between the industry 5-firm concentration ratio (CR_5) and grocery retail prices. The study found that as the industry's CR_5 increased toward the study's sample mean of 88 percent, prices declined in the amount of 1.6 percentage points; but when the CR_5 increased from 88 percent toward 100%, the resulting market power caused prices to increase by about 3.4 percentage points from their lowest levels.
Drawing from the Drescher-Connor approach of exploring causality between industry prices and concentration ratios, the present paper attempts to explain the basis of collusive pricing patterns in the grocery retail industry, whereby we investigate the impact of the industry's four-firm concentration ratio (CR_4)and pricing, and use it to establish evidence of collusive pricing behavior on the part of industry leaders. We apply the framework of basic prisoners' dilemma game theoretic analysis to explain grocery pricing in the context of oligopoly market rivalry in which a competitor's conjectural variation about rival moves is strictly non-zero with a probability of being either correct or incorrect. The analysis is used to determine whether grocery retail pricing is based on cooperative (quasi-collusive) or non-cooperative (competitive) strategies, depending on whether or not rival conjectures about each others' moves and responses turn out to be certain.[5]

2 Resolving the Prisoners' Dilemma in a System of Finite Repeated Games

Being a classic case of oligopoly market rivalry in which a competitor's conjectural variation about rival moves is strictly non-zero, the *Prisoners' Dilemma* model can be used to convey the central message of this paper, namely, the use of the probability that each competitor's conjectural variation could be either right or wrong in devising long term strategic dispositions. This is particularly so where the conjecture is about whether or not rivals would act cooperatively. Moreover, the grocery retail market involves a system where

[5]We assume that playing cooperatively would imply raising prices, while a non-cooperative play would imply a drastic price reduction.

competitors can (and do) choose to either cooperate or not cooperate with rivals -- a system of a *finite repeated game* setting. For this reason, the prisoner's dilemma framework lends itself for elucidating the main theme of the present study. In particular, it enables us apply a simple *Bayesian* comparative analysis of expected profits to explore what motivates competitors to either cooperate or not cooperate with their rivals.

We postulate that oligopolists would not choose the cooperative solution if they could not be more trusting of their rivals, and moreover such a trusting relationship must be necessary for any lasting cooperative outcome. Firms are rational and know that their rivals are also rational; and each competitor's conjecture about its rivals' moves is correct, but might be wrong; this is because each competitor needs not be perfectly rational (under circumstances of which its rival's conjectural variation would be wrong).

We depict the profit payoff of each competitor by π, and assuming just two competitors, Firm 1 and Firm 2, each of who adopt either of the two strategies of cooperative moves (coop) with possible payoff π^1 if rival adopts a similar strategy, or payoff π^{-1} (losses) if rival plays non-cooperatively (noncoop). Each firm receives payoff π^0 -- indicating a bare breakeven condition -- under a mutually aggressive (noncoop) setting, a competitive "warfare" setting. A firm reaps payoff π^2 should its rival play cooperatively while it plays aggressively. This payoff matrix is stated as follows:

		Firm 2	
		coop	noncoop
Firm 1	coop	π_1^1, π_2^1	π_1^{-1}, π_2^2
	noncoop	π_1^2, π_2^{-1}	π_1^0, π_2^0

(1)

Presumably, since the competitors are involved in their respective dominant (best) strategies, each having a profit level π^0, if and whenever a competitor's conjecture is wrong, that competitor realizes profits $\pi^2>\pi^0$ since its rival had failed to adopt the best strategy.

The expected value of payoffs over the relevant time horizon for a firm adopting aggressive (non-coop) strategy, $E\pi_i^{nc}$, is:

$$E\pi_i^{nc} = [\rho_i\pi_i^0+(1-\rho_i)\pi_i^2]_1 + [\rho_i\pi_i^0 + (1-\rho_i)\pi_i^2]_2 + \ldots$$
$$\ldots + [\rho_i\pi_i^0+(1-\rho_i)\pi_i^2]_{k-1}+[\rho_i\pi_i^0+(1-\rho_i)\pi_i^2]_k \qquad (2)$$

where

ρ_i = probability that firm i's conjecture is correct,
π_i^0 = normal payoff under correct conjectures,

π_i^2 = payoff if conjecture is wrong,
and $\pi_i^2 > \pi_i^0, \pi_i^{-1} < 0$,
i = 1, 2,..n,
k = time period 1, 2, 3….k.

Expression (2) gives the sum of current and future profits weighted by the conjectural disposition probabilities. For a player adopting an aggressive (non-cooperative) strategy that would result in "warfare", the expected value of payoff would be less desirable than that obtained from a cooperative stance. The prospects of this outcome compels the competitor to adopt a cooperative stance in the game. However, a competitor's conjecture could be wrong (i.e. its rivals may not really match its strategic moves in a tit-for-tat fashion), in which case the player comes off with a larger payoff π_i^2. But since the game is a repetitive one, the player could be sure of the tit-for-tat reaction down the horizon should it play aggressively at any stage. It is this possibility that compels players to play cooperatively, resulting in a cooperative solution in an otherwise inherently non-cooperative game setting.
The expected payoff from cooperative play, $E\pi_i^c$, is

$$E\pi_i^c = [\rho_i\pi_i^1 + (1-\rho_i)\pi_i^{-1}]_1 + [\rho_i\pi_i^1 + (1-\rho_i\pi_i^{-1}]_2 + \ldots$$
$$\ldots + [\rho_i\pi_i^1 + (1-\rho_i)\pi_i^{-1}]_{k-1} + [\rho_i\pi_i^1 + (1-\rho_i)\pi_i^{-1}]_k, \qquad (3)$$

A player's disposition at any stage of the game over time can be found by comparing $E\pi_i^{nc}$ and $E\pi_i^c$ at that stage. This is given by:

$$\begin{aligned} E\pi_i^{nc} - E\pi_i^c &= \rho_i\pi_i^0 + (1-\rho_i)\pi_i^2 - [\rho_i\pi_i^1 + (1-\rho_i\pi_i^{-1})], \\ &= \rho_i\pi_i^0 + (\pi_i^2 - \pi_i^{-1}) + \rho_i(\pi_i^{-1} - \pi_i^2) - \pi_i\Pi_i^1 \\ &= (\pi_i^2 - \pi_i^{-1}) + \rho_i(\pi_i^0 - \pi_i^1) + \rho_i(\pi_i^{-1} - \pi_i^2) \\ &= \pi_i^2(1-\rho_i) + \rho_i\pi_i^0 - \pi_i^{-1}(1+\rho_i) - \pi_i^{-1} > 0 \qquad (4) \end{aligned}$$
since $\pi_i^{-1} < 0$

This indicates that under a given probability of the correctness of a firm's conjectures about rival behaviors, ρ_i (that is, firm iis not certain about the direction of rival responses to its own behavior), its expected payoff would be greater by adopting an aggressive play rather than a cooperative play. Therefore, the condition that ρ_i be an indicator of an ordinary chance event ($\rho_i < 1$) cannot explain the choice of cooperative solution among oligopolists. We must turn to an alternative condition surrounding ρ_i. Hence, cooperative behavior among oligopolists, a quasi-monopolistic outcome, involves a degree of certainty among the players regarding each other's expected actions and reactions. This rules out the uncertainty of rivals' behavior and therefore rules out the existence of the oligopolistic competition. This is to say that the probability of accuracy of firm is conjectures about rivals' behaviors, is one ($\rho_i = 1$). In this case equation (5) would turn out to be:

$$E\pi_i^{nc}\text{-}E\pi_i^{c} = \pi_i^{2}\text{-}\pi_i^{-1}+\pi_i^{0}\text{-}\pi_i^{1}+\pi_i^{-1}\text{-}\pi_i^{2}$$
$$= \pi^{i0}\text{-}\pi_i^{1} < 0. \qquad (5)$$

This demonstrates that only if a firm has correct conjectures about rival actions that it is profitable for it to adopt a cooperative play, under which it would have no incentive to deviate unilaterally. In fact, cooperative solution requires that the firm's conjectures be certain. A firm that opts out of the cooperative stance loses the certainty (assurance) about rivals' responses (ρ_i<1), and would have a lower (non-cooperative) expected profit.

In practice, the extent of collusion between independent firms is limited by laws on restrictive practices. Clearly, this points to a policy question concerning the operation of the country's *Competition Act* under the *Anti-Trust Laws*. But if the profit gains from collusion are substantially high relative to the costs of operating the collusive agreement (including fines and any other types of punitive liabilities), then the companies have incentives to operate the collusive agreements. We examine this question in the empirical section below by estimating a price-concentration model for the grocery industry across four regions in the U.S., which allows us to verify the extent to which the grocery retail chains can manipulate and set prices uniformly among themselves in a quasi-collusive behavior. The PCM is applied to explore whether higher concentration does enable collusive behavior that leads to higher set prices of grocery products within and across given spatial locations.

One central message from the preceding game theoretic analysis is that collusive behavior within an oligopoly industry such as grocery retail, results in high concentration; and since the payoffs in the theoretical model represent profits of the retail firms, which are correlated with the prices, it implies that firms tend to adopt cooperative play (collusion) because they obtain higher profit payoffs from doing so. Thus, since prices determine profits, we apply the profit-concentration model that uses cross-sectional data on a mix of explanatory variables such as store-level information, market characteristics, and geographical location, to estimate an equation system that enables us to better understand the pattern of pricing behavior in the grocery retail industry in the empirical analysis that follows.

3 Empirical Analysis

3.1 Model specification and estimation

For several decades various economic and business theories have been propounded to analyze the relationships between profits, prices and market concentration. The profit-concentration studies found a weak positive correlation between market concentration and profits. This finding was interpreted as an evidence of collusion among leading/dominant firms in highly concentrated industry. This assertion by the profit-concentration studies has been criticized on the grounds that efficient firms can be expected to earn both high market shares and high profits (efficiency rents) thereby suggesting a more benign explanation for the observed correlation (Woodrow, 1995). This superiority or efficiency critique expressed by Demsetz (1973) and other profit-concentration problems have given rise to price-concentration studies. There are several advantages of using prices as op- posed to profits. First, prices are easier to obtain than economic profits. Second, prices are not subject to accounting conventions that complicate the study of profits. Third, price-concentration studies are not subject to the efficiency or the competitive superiority criticism since prices are determined in the market.[6]

In this paper we apply price-concentration relationship model (PCM) in our analysis to the grocery retail industry. Our major objective is to analyze how price-concentration relationship explains the collusive pricing behavior that exits in the grocery retail industry.

The PCM seeks to test both the direction and size of the effect of concentration on prices, whilst controlling for other factors that affect the price of the firm.

Let the structural (primary) equation of the price-concentration relationship be:

$$y = \alpha z + \beta x + \varepsilon \tag{6a}$$

where:

y = the price of the firm,
z = the market concentration,
x = other exogenous variables in the price equation,
α,β, = the coefficients to be estimated,
ε = the disturbance term in the price and concentration equation.

There are two estimation issues/problems in equation (1). First the selection of the retail stores in our sample is non-random. They were selected based on the availability of information for the stores. Exclusion of stores in the sample due to lack of data leads to a sample selection bias and OLS estimates will be biased and inconsistent. Second, it has also been pointed out that there exits a potential endogeneity in the market concentration measure. For example, grocery stores in small cities, where concentration tends to be higher, may have high costs because they are unable to attain economies of scale. Thus, the estimated relationship between price and concentration will be biased (Schmalensee, 1989; Bresnahan, 1989). Therefore, there is simultaneity issue in price-concentration models since market concentration is endogenous. In this paper, we estimate a price-

[6]For a large range of price-concentration studies that overcome the efficiency or market superiority criticism, see Weiss (1989).

concentration model that addresses both the sample selection and the endogeneity of the covariate (z).
In order to address the sample selection bias and the endogeneity of the covariate (concentration) variable, we specify the model as:

$$y = \alpha z + \beta x + \varepsilon \tag{6b}$$

$$z = \delta m + v \tag{7}$$

$$d = \theta w + u \tag{8}$$

and

$$d = \begin{cases} 1 \ \ if \ \ \theta w + u \geq 0 \\ 0 \ \ if \ \ \theta w + u < 0 \end{cases} \tag{9}$$

where *m* is the exogenous variable in equation (7), *d* is an indicator function, *w* is the exogenous variable in equation (8), and *v,u* are disturbance terms in equations (7) and (8), respectively. The first equation (6b) is the structural equation of interest and it is the same as equation (6a). The second equation is the endogenous concentration equation. It is the reduced form equation for the endogenous variable z. The third equation is the selection equation; it is the *probit* equation that represents the probability of being in the market or the propensity for the firm to sell or the probability of being in the sample. The explanatory variables (*w*) in equation (8) include most of the explanatory variables in equation (1a) plus other explanatory variables that determine *d*. We assume that (i) (*w, d*) are always observed, (ii) (*y*, *z*) are observed when *d* = 1, (iii) (ε, *u*) is independent of w with zero mean $[E(\varepsilon,u) = 0]$, (iv) $u \sim N(0,1)$, (v) $E(w,u) = 0$. Assumption (v) indicates that we need an instrument that is correlated with *z* but is not correlated with or orthogonal to the disturbance term (*v*). Assuming a joint multinormal distribution, the conditional disturbance terms in equations (6b)-(8) for the entire population is given by (ε, v, u) $\sim N\ (0, \Sigma)$ and the variance-covariance matrix of the disturbance term is:

$$\sum = Cov(\mathcal{E}, v, u) = \begin{pmatrix} \sigma_\varepsilon^2 \rho_{\varepsilon v} \rho_{\varepsilon u} \\ \rho_{v\varepsilon} \sigma_v^2 \rho_{vu} \\ \rho_{u\varepsilon} \ \rho_{uv} \quad\quad 1 \end{pmatrix}$$

From these assumptions the Heckman's inverse Mill's ratio (λ) can be written as:

$$\lambda(\theta w) = \frac{\phi(\theta w)}{\Phi(\theta)} \tag{10}$$

where ϕ is the density function for standard normal distribution and Φ is the cumulative
distribution for standard normal variable.
After adjusting for sample selection bias and using instrument for the endogenous variable, the equation of interest is specified as:

$$y = \alpha\hat{z} + \beta x + \rho\hat{\lambda} + \varepsilon \tag{11}$$

The ρ is the coefficient of λ and it measures the covariance between the two residuals ε and u. Under the null hypothesis that there is no selectivity bias, we have $\rho = 0$. This can be tested by means of a conventional t-test.

3.2 Data source and description

The estimation of the model discussed in section 3.1 requires store level information, market characteristics, geographical, and other socio-economic indicators. The model was estimated using cross-section data from different sources. The bulk of the individual grocery retail data come from the "Chain Store Guide (CSG)." The CSG is a private owned U.S. company that collects information on about 3000 grocery, supermarket and C-stores retailers across the United States. The database has in-depth information with sales and unit history, areas of operation, the number of employees, sales for different items, wages, cost of operation, store location, postal area, prices of different items, and many more variables for each grocery retail store in the database. The C-stores include Publix, Safeway, Walmart, 7 Eleven, Costco and Whole foods. For a store to be included in the grocery retailers and supermarket chain database, a food retailer must operate two or more locations that generate at least 2 million dollars in grocery sales. And for convenience stores retailer leads must operate two or more stores, usually between 2,000-5,000 square feet with emphasis on high sales volume and fast moving products. This indicates that the sample does not include small stores that are unknown nationally. The regional, state and local variables such as unemployment rate, population, and population growth were obtained from Occupational Employment Statistics by the Bureau of Labor Statistics. The NAICS 445100–Grocery Stores provides data for both metropolitan and non-metropolitan areas. Other variables such as household income and household expenditures in different areas are taken from the US Census of Retail Trade (CRT).
Our sample consists of major grocery retail stores that operate in the United States and that sold similar items in 2009. We selected grocery stores that operate in the four regions. The division of states into regions is based on the Bureau of the Census Classification-Northeast, Midwest, South and West. Each region is

represented by some selected cities.[7] Seven parent stores are selected from each region. We then select twenty stores from each of the seven parent stores located in each region. This gives a total of 140 stores in each region. The selection of the twenty stores in each region is based on the availability of information on the variables in the model. Stores that did not have most the variables in the model were not selected. In the Northeast and the West, many stores have a lot of information for the variables in the model, compared to other regions, but to be consistent with the number of firms in each region, we selected only twenty stores. Three parent retail stores are ubiquitous in the country. These are Walmart, Target and Sam Club. These parents stores are part of the seven parent stores in each region. The parent grocery retail stores in each region are: (i) Northeast (Pathmark, B.J stores, Giants, Shop Rite, Walmart, Sam Club, and Target); (ii) Midwest (Acme, Kroger, Aldi, Save-a- lot, Walmart, Sam Club, Target); (iii) South (Publix, Winn-Dixie, Piggly-Wiggly, Food Lion, Walmart, Sam Club, and Target); (iv) West (Albertsons, Safeway, Costco, Whole Foods, Walmart, Sam Club, and Target). We concentrate on two items: Food items andnon-food items of the same brand. Food items include cereals products; Diary products; meat, poultry, and eggs, while non-food items comprise laundry and cleaning products.

The two most important variables in the model are the prices of the grocery retail items selected, and the market concentration. The measurement of concentration pro- vides the empirical evidence necessary for assessing the status of competition in a market. The Herfindahl-Hirschman (HH) is used to measure market concentration. This index is calculated as:

$$HH = \sum_{i=1}^{n} S_i^2 \tag{12}$$

whereS_i= the percentage share of the *i*th grocery store in the market; *n*= the number of firms in the industry and market participants. The *HH* index has an upper bound of 10,000 percent where there is only one firm in the industry. According to the US Department of Justice (USDOJ 1997), a market is not concentrated when the HH is less than 1000 percent, is deemed highly concentrated when HH is greater than 1800 percent, and moderately concentrated when HH lies between 1000 and 1800 percent. The description of the rest of the variables in model is presented in Table 1.

3.3 Estimation results

We estimated the model using five samples. The first sample or the national sample con- sists of all the regional samples (the pooled sample). The other four

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[7]For a detailed information on regional classification, see Census Bureau Regions and Divisions with State Federal Information Processing Standards (FIPS) Codes.

samples are the regional samples. Equations (6b) to (10) were estimated using the following steps: First, we estimate a *probit* model using equation (8) with d as the dependent variable and w as the explanatory variables. The estimates of the *probit* model ($\hat{\theta}$) are used to calculate the inverse Mill's ratio (λ) for each observation. Second, using a two stage least squares approach (2SLS), we estimate the concentration equation (7) with the exogenous variables (m) and the sample selection variable ($\hat{\lambda}$).[8]

Using the mean values of the explanatory variables in equation (7), we predict a value for the concentration variable (z) and replace the concentration variable by its corresponding predicted value.[9] This imputed concentration variable ($\hat{z}$) serves as an instrument for the concentration variable (z). It must be noted that the instrumental variable technique is justified if appropriate instrument can be found. The correlation between the actual concentration variable (HH) and the imputed concentration variable ($\hat{z}$) was about 0.72. Third, we estimate the price equation (11) by including the predicted value for the concentration variable ($\hat{z}$), and the inverse Mill's ratio ($\hat{\lambda}$) as explanatory variables.[10]

3.4 The Probit and Concentration Equations Estimates Results

Table 2 presents the probit and the concentration estimates for the national sample.[11] With the exception of the number of stores located in a particular area, all the variables in the *probit* equation are statistically significant. We observe that the population growth, the mean household income, the metropolitan area, past profit and the market price are more likely to encourage a grocery store to engage or be part of the grocery chain. However, past market concentration of a locality, the entry condition, the unemployment rate may discourage a participation in the grocery retail market. We noticed that market concentration depends positively on

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[8]Both the order and rank conditions for identification indicates that equation (7) is over-identified, and hence using 2SLS estimation approach is justified.

[9]The dependent variable of the *probit* equation takes a value of 1 if the firm's profit is greater than or equal to zero, and zero if the form's profit is less than zero. The argument here is that a firm will consider participating in the selling of a product in the market if existing firms are making some profit.

[10]If the instrumental variable technique is to produce consistent parameter estimate, care must be taken in selecting instruments. First, the instruments selected must be strongly correlated with the variable to be instrumented. In most cases, it is difficult to find such variables. Secondly, it is also almost impossible to check the assumption that the instrumental variables are independent of the error term in the equation in which the instrumental variables become regressors. Thirdly, one cannot be sure that the chosen variables will yield the minimum asymptotic variance. Thus the instrumental variable technique gives priority to consistency, and pays less attention to the possibility of high standard errors which the instrumental variables may produce. Therefore the best instrument for a variable is the predicted value of that variable.

[11]The *probit* and concentration results for other samples are available upon request.

the size of the store, population and population growth, the mean household income, past profits of stores, and the metropolitan areas. The sample selection bias variable is also positive and significant.

3.5 The Price Equation Estimates Results

We estimated the price equation for two groups of products -- food and non-food items. In Table 3, the average price of the selected food is a function of some covariates that are deemed likely to influence the prices of food. In the national sample, the coefficient of the concentration variable is positive and significant. A higher concentration retail food market leads to a higher average price of food. This seems to suggest that a high concentration food market may lead to collusion. A few grocery retail stores in a locality are more likely to collude in order to increase the price of food in that locality. The results indicate that an increase in population and population growth in the locality where these stores operate leads to an increase in food prices. A plausible explanation is that an increase in the population growth increases the demand for food and all things being equal, food prices will rise in response to the increase in demand. Similarly, as the income of households rise, the demand for food rises and food prices rise. We note that as the number of stores increases in an area, the price of food decreases, probably due to either an increase in supply of food or an increase in competition. Also stores located in metropolitan areas have lower prices compared to non-metropolitan areas. As expected all the cost variables have the expected signs. An increase in rent and wages increases the cost of the stores that is likely to be passed on to consumers in the form of higher prices. Similarly, as the store employs more workers, the cost of the store goes up and the stores are likely to increase food prices. The sample selection bias term is positive and significant. This means there would have been a positive sample selection bias in the price equation if the selection bias term was ignored.

There is a consistent result for the price-concentration relationship in all the regions. The result indicates that as the market become more concentrated, prices of food rise. The largest price increase is in the West as evidenced by the size of the coefficient of the concentration variable. With the exception of the South, a larger store size reduces food prices. Similar to the national results, an increase in population or population growth tends to increase food prices in the Northeast, Midwest and the South. However, the store size has an opposite effect in the West. A larger store size reduces food prices in the West.

We observed that the magnitude of the household income, the number of stores and the store expenditures variables (rent, wages) are quite similar to the national results. The difference lies in the sizes of the estimated coefficients. For example, the number of stores has the largest impact on food prices in the Midwest and least impact in the West. Similarly, the Midwest region experiences the most price declining effect as result of an increase in the number of stores operating in a metropolitan area. We also found that, with the exception in the South, there was a positive sample selection bias in the regional price equations.

Table 4 shows the price equation results for non-food items. The estimates of the non- food items are quite similar to the food items results, but there are a few differences. First, while the number of stores has mostly an inverse relationship with the price of food, the relationship is direct in the non-food price equation. The population variable is positive in the West region equation. Second, the size of the coefficient of the concentration variable is larger in the non-food equations than in the food equations for all regions. That is, market concentration has more impact on the prices of non-food than food prices. A plausible explanation may be that the demand for food may be price-inelastic compared to non-food items. Third, with the exception in the Northeast, there is a negative sample selection bias in regional price equations.

5 Conclusion

This paper has applied the prisoners' dilemma game model together with an empirical analysis that utilizes the price-concentration model (PCM) to determine whether higher concentration does enable collusive behavior that leads to higher set prices of grocery products within and across regional locations in the U.S. We estimated a system of PCM equations to verify the extent to which the grocery retail chains can manipulate and set prices uniformly among themselves in a quasi-collusive behavior.The theory suggests that the degree of competition as opposed to cooperative collusive behavior in the industry depends on the accuracy of rival conjectures about each other's moves because oligopoly firms are less likely to adopt any aggressive strategies that might lead to accelerated competition that might jeopardize chances of higher profits; although, if firms believe that rivals are less than perfectly rational (and such a belief turns out to be rightly so), then they may resort to aggressive postures that result in non-cooperative strategies and quasi-competitive outcomes.

The empirical analysis shows a consistent result for the price-concentration relationship in all the regions. It indicates that as the market become more concentrated, prices of grocery products rise, with the largest price increase occurring in the West as evidenced by the magnitude of the coefficient of the concentration variable; while, with the exception of the South, a larger store size reduces grocery prices. These results may suggest that the pricing patterns observed between the retail companies in the grocery industry may be largely due to covert tacit collusion among these retail firms, whereby each firm seems to adopt a strategy that results in a cooperative solution in an otherwise inherently non-cooperative game setting. This appears to bear out evidence of a general tendency for quasi-price fixing at best, and outright tacit collusion at worse.

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Table- 1
Description of variables

HH	The market concentration variable. It is the Herfindahl-Hirschman index calculated for firms in a chosen locality—region, or geographical location
HH-PREDICT ($\hat{Z}$)	This is the predicted variable from the concentration equation (2)
HH-1	This variable is the past concentration of the area in which a store belongs
STORESIZE	This based on the Gross Leasable Area (GLA) definition. It is the amount of floor space designed for tenant occupancy, expressed in square feet. This is different from the Building Owners and managers Association (BOMA) definition.
METRO=1	This is a dummy variable. METRO=1 if the store is located in a metropolitan area, and zero otherwise.
NUMSTORE	The number of grocery retail chains within the chosen locality.
POP-1	The previous year's population of the county or area in which the store is located.
POPGROWTH	The population growth of the area within which the chosen stores are located.
HHINCOME	The median household income of the locality of the chosen stores.
TOTSALES	The total sales of the store in 2009.
GRSALES	This is the growth rate of sales. It is the percentage change in sales from one year to another. It is calculated as: Sales in 2008-sales in 2007 divided by sales in 2007 multiplied by 100.
REVENUE	The total revenue of the store in 2009.
PROFIT	The profit of the firm in 2009.
PTPROFIT	This is the previous year's profit of the store (previous year is 2008).
TOTWAGES	The total wages paid to employees
RENT	This is the amount of rent paid by the store to the municipality or the county for occupying the space.
NWORKERS	The number of workers employed in the 2009. This includes all categories of workers—full-time and part-time.
AVPRICE	This is the average price of all the items selected from the stores.
URATE	The unemployment rate of the area within which the chosen store is located.
ENTRY=1	This is the entry condition variable. It measures how difficult for a store to enter the market in a particular location. It is a dummy that takes a value 1 if the HH in the area/locality is less than 1000 percent (low concentration), and zero if HH is greater than or equal to 1000 percent.
SELECTIVITY (λ)	This is the calculated sample selection bias term

Table 2
Probit and Concentration Equations Estimates for National Sample. Food items

	Probit	Concentration
Constant	0.098^{c} (0.055)	0.139^{b} (0.066)
STORSIZE	0.012 (0.088)	0.105^{b} (0.048)
POP-1	0.219^{a} (0.064)	0.312^{b} (0.157)
POPGROWTH	0.477^{a} (0.126)	0.339^{b} (0.136)
HHINCOME	0.198^{b} (0.094)	0.022 (0.014)
NUMSTORE	0.208^{b} (0.099)	-0.088^{c} (0.046)
RENT	-0.026^{c} (0.013)	-0.011 (0.008)
TOTWAGES	-----	-0.145c (0.077)
NWORKERS	-----	0.041 (0.025)
MSA=1	0.221b (0.096)	0.177^{c} (0.089)
GRSALES	-----	0.102^{b} (0.049)
PTPROFIT	0.268^{a} (0.077)	0.031^{b} (0.015)
HH	-0.036^{b} (0.016)	-----
HH-1	-0.027^{b} (0.012)	-0.016^{c} (0.009)
URATE	-0.015^{c} (0.008)	-----
ENTRY=1	-0.146^{b} (0.063)	-0.166^{b} (0.075)
REVENUE	0.182^{b} (0.079)	-----
PRICE-1	0.152^{b} (0.057)	-----
N	560	560
F; R^2	-----	4.88; 0.54
LOG L	507.2	-----

Standard error in parentheses
^{a} Significant at 1% level
^{b} Significant at 5% level
^{c} Significant at 10% level

Table 3 Estimation results of the price equation. Dependent variable is logarithm of the price of the firm Product = Food items. The price variable is the average price of food items					
Variable	National	Northeast	Midwest	South	West
Constant	0.068 (0.324)	-0.176 (0.321)	-0.014[c] (0.008)	0.298 (0.192)	-0.172 (0.104)
Imputed concentration ($\hat{Z}$)	0.862[b] (0.418)	0.336[b] (0.176)	0.268 (0.143)	0.156[b] (0.078)	0.502 (0.139)
STORSIZE	-0.059[c] (0.031)	-0.051 (0.032)	-0.016 (0.010)	0.142[c] (0.078)	-0.036 (0.023)
POPULATION	0.178[c] (0.098)	0.011[c] (0.006)	0.032[c] (0.019)	0.013 (0.008)	-0.082 (0.047)
POPGROWTH	0.238[b] (0.116)	0.024[c] (0.013)	0.177[b] (0.084)	0.262[b] (0.132)	-0.073[b] (0.037)
HHINCOME	0.077[c] (0.045)	0.048 (0.046)	0.132 (0.081)	0.053 (0.033)	0.027 (0.018)
NUMSTORE	-0.586[a] (0.189)	-0.322[b] (0.124)	-0.413[c] (0.216)	-0.264[b] (0.133)	-0.194 (0.054)
MSA=1	-0.238[a] (0.121)	-0.326[b] (0.125)	-0.411[a] (0.111)	-0.268[b] (0.128)	-0.195 (0.048)
RENT	0.036[c] (0.019)	0.131[c] (0.069)	0.092[c] (0.054)	0.041[b] (0.019)	0.024 (0.013)
NWORKERS	0.316[b] (0.109)	0.277[a] (0.087)	0.136[b] (0.054)	0.096[c] (0.055)	0.171[b] (0.071)
TOTWAGES	0.142[b] (0.072)	0.042[b] (0.021)	0.027[c] (0.016)	0.106[c] (0.055)	0.065[b] (0.033)
SELECTIVITY (λ)	0.028[b] (0.014)	0.103[c] (0.052)	0.082[a] (0.026)	-0.015[c] (0.009)	0.044[b] (0.018)
Adjusted R^2	0.241	0.526	0.182	0.174	0.169
F	6.10	7.22	5.98	6.77	5.76
N	560	140	140	140	140

Standard errors in parentheses

[a] Significant at 1% level

[b] Significant at 5% level

[c] Significant at 10% level

Table 4

Estimation results of the price equation. Dependent variable is logarithm of the price of the firm
Product = Non-Food items. The price variable is the average price of food items

Variable	National	Northeast	Midwest	South	West
Constant	2.634[c] (1.330)	0.638[c] (0.321)	-0.608 (0.422)	-0.076[c] (0.040)	0.073 (0.059)
Imputed concentration ($\hat{Z}$)	0.216 (0.110)	0.419[b] (0.880)	0.316[b] (0.142)	0.266 (0.074)	0.624[b] (0.271)
STORSIZE	0.009[c] (0.005)	0.036[b] (0.015)	0.008 (0.006)	0.087 (0.060)	0.008 (0.004)
POPULATION	0.258[c] (0.155)	0.031 (0.019)	0.071 (0.053)	0.037 (0.028)	0.017 (0.009)
POPGROWTH	0.039[b] (0.016)	0.156[c] (0.083)	0.216[b] (0.098)	0.076[b] (0.039)	0.026[b] (0.014)
HHINCOME	0.046[b] (0.023)	0.032[c] (0.018)	0.074[b] (0.037)	0.102[b] (0.051)	0.031 (0.010)
NUMSTORE	0.975[b] (0.278)	-1.036[c] (0.523)	-0.281[a] (0.781)	-0.318[a] (0.091)	-0.216[b] (0.098)
MSA=1	-0.098[b] (0.049)	-0.143[c] (0.075)	-0.296[b] (0.133)	-0.365[a] (0.104)	0.212[b] (0.092)
RENT	0.059[b] (0.038)	0.076[b] (0.034)	0.066[c] (0.039)	0.027[c] (0.016)	0.046 (0.024)
NWORKERS	0.253[c] (0.132)	0.521[b] (0.248)	0.099[b] (0.045)	0.124[b] (0.054)	0.098[b] (0.047)
TOTWAGES	0.216[c] (0.114)	0.042[c] (0.025)	0.136[b] (0.061)	0.217[b] (0.090)	0.046 (0.024)
SELECTIVITY (λ)	0.019[c] (0.011)	0.096[b] (0.044)	-0.038[c] (0.081)	-0.066[b] (0.029)	-0.131 (0.079)
Adjusted R^2	0.314	0.466	0.618	0.296	0.518
F	8.14	5.99	6.72	5.20	5.11
N	560	140	140	140	140

Standard errors in parentheses
[a] Significant at 1% level
[b] Significant at 5% level
[c] Significant at 10% level