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PRICES, DISTRIBUTION SERVICES AND SUPERMARKET COMPETITION

February, 1995

Roger R. Betancourt and Margaret Malanoski
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IRIS Report on "Prices, Distribution Sevices and Supermaket Competition"

An economic function of retail institutions is to provide consumers a set of distribution services together with the explicit goods and sevices purchased from these institutions. In this paper we specify empirically the mechanisms through which distribution services affect costs and competition in the case of supermarkets. We also specified empirically a concept of competition put forth by Bliss and extended by Betancourt and Gautschi. Finally, we show empirically the interaction between the prices charged and the distribution services offered by supermarkets while incorporating this view of competition. As a result we are able to evaluate quantitatively the welfare consequences for consumers of economic policies directed at this economic sector.

Empirical studies of supermarket competition have been criticized on four general grounds: inability to interpret empirical results for lack of a well specified theoretical model; failure to allow for changes in concentration to have different effects in different markets; need to control for differences in services; and need to control for differences in costs. We address each of these four criticisms in our empirical work.

Our data consist of observations that allow calculation of the average price charged by each store at three different times in a four month interval for a set of 616 supermarkets in 28 SMSA's in the US. A survey of store characteristics was carried out concurrently with the price surveys over the four month interval. The survey of store characteristics permitted the construction of an index of the distribution services provided by each store. This data was supplemented by public information on the SMSA's and by socioeconmic information on the zip code area where the supermarket was located.

First we estimated linear regressions for our three endogenous variables: quantity demanded, prices and distribution services. The results of our linear regression for price were as mixed as those available in earlier literature. The results for the other two variables also generated difficulties of interpretation. Secondly, we estimated the nonlinear equations corresponding to a model that explicitly incorporated distribution services and the BG adaptation of Bliss'concept of competition in retail markets. The anomalies of the linear equations were eliminated with one exception, which was shown to make no difference to the other results.

On the demand side our main results are: A 1% increase in distribution services increases quantity demanded by 0.3%; A 1% increase in price decreases quantity demanded by 2.8%; As the percentage of households without cars increases in the zip code area of a supermarket, demand becomes more inelastic with repect to price; As the socioeconomic status of the zip code area of a supermarket increases, demand becomes more inelastic with respect to distribution services.

On the cost side our main results are: store formats have important effects on costs, in particular traditional supermarkets experience an 11% (5%) increase in costs relative to warehouse stores (superstores) at the same level of output and distribution services. The presence of scanners decreases costs by about 3%. Marginal costs decline substantially as distribution

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services expand and marginally as output expands. Finally, there are positive interdependencies in the marginal costs of producing output and distribution services.

On the competition side our main results are: increases in concentration increase the marginal contribution to profits of lowering the competitive standard that the store must meet; increases in entry decrease the marginal contribution to profits of lowering the competitive standard that the store must meet; finally, the shadow price of distribution services, or what the representative consumer is willing to pay for a 1% increase in distribution services, is positive and substantial- about $135. over the course of a year.

Our results allow us to analyze the joint response of prices and distribution services to changes in exogenous variables and parameters. First on average increases in concentration lead to a lowering of prices and distribution services. On average welfare decreases because the negative welfare impact on consumer expenditures of the decrease in distribution services dominates the positive welfare impact of the decrease in prices. Nonetheless, there is considerable heterogeneity in the welfare consequences of an increase in concentration, for about 1/3 of the sample welfare increased. This subsample was characterized by a predominance of modern formats, the presence of scanners, high volumes of output, low prices and high distribution services.

Similar analyses for other exogeous variables and parameters show a similar pattern of heterogeneous responses either with respect to the welfare consequences or the pattern of movement of prices and distribution services. The characteristics of the stores mentioned previously continue to determine the differential response.

This paper provides empirical support for the view of retail institutions and their economic function adopted in earlier IRIS projects. Furthermore, and perhaps more importantly, it provides a methodology for implementing these views with other bodies of data that is quite flexible in accomodating different institutional mechanisms for performing this economic function. Hence, it can be applied to bodies of data from countries at very different stages of development.

Finally, we conclude by highlighting the principal implications of our analysis for competition policy in this sector: first, the impact of concentration on welfare is qualitatively different for the customers of different stores; second, compared to the effects of, for example, a 1% change in marginal costs or price elasticity of demand on welfare, the impact of a 1% change in concentration is quantitatively much smaller. These two implications are likely to hold in a broad variety of settings and the analysis in this project provides a methodology for ascertaining the validity of these conclusions in these settings.

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Prices, Distribution Services and Supermarket Competition*

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Comments Welcome
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1. Introduction

Often one finds statements in the trade literature emphasizing the importance of the services provided by institutions in the retail sector. For instance, in a 1987 survey of customers reported by the Progressive Grocer low prices were only one of 16 items that more than half of the sample considered important in selecting a food store. All of the other items are distribution services of various kinds, for example convenient store location, unit pricing on shelves, produce department, short wait for checkout, cleanliness, etc. In the empirical literature, one finds arguments that supermarket competition involves more than just price, for example Keith Anderson (1990) devotes a whole section of his survey paper to this topic. Nonetheless there is no explicit identification in this literature of the mechanisms through which distribution services affect costs and supermarket competition.

One aim of this paper is to identify in an empirical setting the mechanisms through which distribution services affect costs and supermarket competition. A second aim of this paper is to implement empirically the concept of retail competition put forth by Christopher Bliss (1988) and the recent extension of this concept by Roger Betancourt and David Gautschi (1993a), which explicitly incorporates distribution services into the analysis. Finally, a third aim of the paper is to demonstrate in an empirical setting the interaction between the prices charged and the distribution services offered by supermarkets in the context of this new view of competition in retail markets. In satisfying these aims we develop an approach for evaluating quantitatively the welfare consequences for consumers of economic policies frequently advocated for this industry, for example antitrust policies directed at lowering concentration or consumer policies aimed at protecting the poor from higher prices.

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To provide the context of our analysis it is useful to start with the empirical literature. Well known discussions of empirical analyses of the structure- performance paradigm and its problems are available in , for example, Richard Schmalensee (1988) and Frederick Scherer and David Ross (1990). More directly relevant for our purposes, however, is the survey of studies of this type for grocery retailing done by Anderson (1990) as a result of a congressional request and a response to the survey by a participant in some of the studies surveyed, Ronald Cotterill (1991). Both address the relation between profitability and market power and between prices and market power. We will concentrate on issues pertaining to the latter relationship, because it is the one directly relevant to our analysis, but some of the issues are the same or similar for both relationships.

Anderson (1990) criticizes earlier studies on the relation between price and market power on four general grounds. First, the lack of a well thought out model leads one to overlook possible interpretations of empirical findings. Second, a change in concentration may not have the same effect on prices in all markets. Third, it is necessary to control for differences in quality (what we have called distribution services above) to interpret any relation between prices and market power. Finally, the same consideration applies to differences in costs. Anderson uses these criticisms to question the antitrust implications of a common empirical finding in these studies: namely, with the exception of Phillip Kaufman and Charles Handy (1989) and Gerald Grinnell, et.al., (1977), they find a positive relation betwen prices and market power.

With respect to the last two criticisms, Cotterill (1991) offers a detailed reply. In the case of services he argues that higher services may lead to higher costs and higher prices but they do not necessarily imply that all of the

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difference in prices is due to the costs of the higher level of services. In the case of costs he points out, for example, that many of the studies controlled for various types of costs, especially labor costs; in addition, he questions the existence of economies of scale at the store level and their importance in the strategic plans of firms (p.8). More generally, he argues that the conclusion of more vigorous enforcement of antitrust implied by the earlier studies continues to be valid.

A separate strand of literature on retailing can be used to address the issues raised by Anderson (1990) and Cotterill (1991). Roger Betancourt and David Gautschi (1988) argue that the main economic function of retail firms is to provide a set of distribution services together or jointly with the goods or services actually bought by consumers. Empirical evidence on the importance of distribution services in determining retail margins is available in Roger Betancourt and David Gautschi (1993b). Walter Oi (1992) in a wide ranging analysis of the distributive trades identifies a similar set of distribution services as the output of a retail firm. He goes on to argue, among other things, for viewing stores as spatially separated entities that can vary the distribution services offered. These contributions identify five broad categories of distribution services as outputs of a retail firm: accessibility of location, breadth and depth of assortment, assurance of product delivery at the desired time or in the desired form, information and ambiance.

In a related development Christopher Bliss (1988) puts forth a theory of the retail firm as a multi product monopolist with market power limited by competition. He defines the latter concept in terms of offering the consumer "better value" for her money than at the next best alternative store. This concept is measured in terms of indirect utilities; he does not address the issue

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of the choice of distribution services. More recently Marshall Reinsdorf (1995) uses the existence of distribution services as an argument for viewing competition among stores in similar discrete fashion. Betancourt and Gautschi (1993a) adopt Bliss' concept of competition, but measure it in terms of the consumer's expenditure function, and extend it to incorporate formally distribution services in the analysis. The resulting model implies the joint determination of prices and distribution services by a retail institution in the presence of an exogenously given level of competition in the market where it operates. This model provides the theoretical basis for the empirical analysis in the paper.

More generally this study is part of a growing literature on "output measurement in the service sectors". Quoting from Zvi Griliches (1992) introduction to the volume with this title "Looking at a fruit store and measuring its output by the number of oranges sold ignores the effort that may go into their arranging and culling." (p.10). As a result of the existence of these other dimensions of output it becomes necessary, for instance, to control for quality dispersion in distribution services when explaining lower prices through outlet substitution in the CPI, Reinsdorf (1992); another consequence is that prices of food items in the CPI differ systematically across outlets with different mixes of distribution services, Mary Kokoski (1994). While our analysis focus exclusively on supermarkets, similar considerations are relevant for very different sectors, which can be seen in Ellen Hanak's (1992) analysis of retail banking, and at much higher levels of aggregation, which can be seen in Usree Bandyopadhyay's (1994) analysis of the role of the distribution sector in international trade.

In our empirical implementation the store or establishment is the focus of

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the analysis. From this perspective the store price indexes calculated by the ERS of USDA for 616 supermarkets across the United States, Kaufman and Handy (1989), are especially well suited for implementing store oriented models. They are designed to measure the average store unit price. Indeed, the index having this characteristic may be the only point of agreement between the USDA authors and their critics, Frederick Geithman and Bruce Marion (1993). Furthermore, these data provide sufficient information for constructing a similar store level index of the distribution services available in each establishment.

Our principal empirical findings with respect to positive economics are in three areas: demand, costs and market structure. Distribution services have a positive effect on the demand for the products of supermarkets. Indeed, a 1% increase in distribution services generates roughly a 0.3% increase in quantity demanded for the average supermarket. In contrast a 1% increase in average store price generates roughly a 2.4% decrease in quantity demanded for the average supermarket. Controlling for store formats and the presence of scanners, we find that there are slightly declining marginal costs with respect to the explicit output of supermarkets and substantially declining marginal costs with respect to their provision of distribution services. This finding helps explain the rapid growth of superstores in the 1980's. More generally, it helps explain the finding that stores with high levels of output, including superstores, charge slightly lower prices and offer significantly larger levels of distribution services than stores with low levels of output. Finally, with respect to market structure we find that at any level of competition facing a supermarket, an increase in concentration (potential entry) increases (decreases) the marginal contribution to profits of lowering the competitive standard by one unit.

With respect to normative economics our most important finding is the

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heterogeneity in the welfare consequences of changes in market structure. For instance, for most supermarkets (about 90% of the sample) an increase in concentration lowers prices and distribution services. When prices and distribution services decrease the effect on welfare depends on the relative strength of the two effects on the consumer's expenditures. While our estimates show that on average the net welfare effect is negative, for about one third of the sample the net welfare effect is positive. Interestingly enough, this third of the sample is characterized by a higher proportion of superstores and stores with scanners as well as an average level of output that is four times the size of the average level of output for the other two thirds of the sample.

The plan of the paper is as follows: in the next section (2) we present the theoretical model underlying the empirical analysis; subsequently (section 3) we discuss all the functional forms needed for implementing the theoretical model; in section 4 we discuss the details of the data; in section 5, we present the results of the nonlinear estimations implied by the specification of appropriate functional forms for the theoretical model; finally, in section 6, we conclude by analyzing the effects of changes in exogenous variables and parameters on prices, distribution services and consumer welfare.

2. The Theoretical Model.

Below we present an adaptation of the model in Betancourt and Gautschi (1993a), where a profit maximizing firm chooses retail prices and distribution services subject to the competitive constraint that it must offer the consumer as equally good value for money as any other establisment. Since in the empirical work we employ an aggregate index for prices and another for distribution services, we limit attention here to the single price, single distribution service case.

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Formally, we have as the objective function

$$L = p*Q - C(V,Q,D) - pQ + \mu[\bar{E} - E(p*,\bar{p},D,z^0)]$$

where μ is a Lagrange multiplier; p* is the level of retail prices; Q is the level of output, which is determined by the representative consumer's demand function; C is a neoclassical cost function describing the costs of supermarket activities as a function of input prices (V) and the two outputs of this retailing activity, explicit products and services (Q) and the implicit levels of distribution services (D); p is the purchase price of the explicit products and services purchased from suppliers; E is the representative consumer's expenditure function, which depends on the retail price and distribution services of the supermarket, other prices $\bar{p}$, and the optimal level of the representative consumer's consumption activities, z^0. $\bar{E}$ is the lowest cost to the representative consumer of attaining her maximum level of utility at any other establishment.

The objective function above provides a useful setting in which to discuss the essential characteristics of supermarket competition embedded in the model. A lowering of the competitive standard that the store faces by one unit means a 1 $ increase in the lowest cost to the representative consumer of attaining her maximum level of utility at any other establisment. The Lagrange multiplier, μ, measures the marginal contribution to profits of such an experiment. For any level of competition faced by a supermarket one would expect this multiplier to have a higher value in a market with higher levels of concentration or lower levels of potential entry than in a market with opposite characteristics. Hence, exogenously given differences in market structure affect the behavior of establishments by generating different values of this multiplier in different markets.

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Optimal choices of retail prices and distribution services by the supermarket must satisfy the following first-order conditions.

Price equation

$$p*[1 - (1/\epsilon_p*)(1 - \mu)] = C_Q + p \qquad (1)$$

Distribution services equation

$$[p*]\partial Q/\partial D + \mu r = C_D + (C_Q + p)\partial Q/\partial D \qquad (2)$$

Constraint

$$\bar{E} - E(p*, \bar{p}, D, z^0) = 0 \qquad (3)$$

A new variable arises in these equations, namely $r = -(\partial E/\partial D)$. r is the shadow price of distribution services or what the consumer would be willing to pay for an additional unit of distribution services if it were available in the market at an explicit price. This interpretation results from viewing distribution services provided by retailers as fixed inputs in the (household) production activities of consumers, Betancourt and Gautschi (1992). ϵ_{p*}, a more familiar concept, is the price elasticity of demand for the explicit output of the supermarket.

This formulation of the first- order conditions facilitates the interpretation of the analysis. In the first two equations retail prices and distribution services are chosen to ensure that marginal revenues and marginal costs are equal in each equation, subject to the constraint represented by the third equation being satisfied. If distribution services are eliminated from the analysis, the second equation becomes irrelevant as well as any dependence of demand or marginal costs on these services. If in addition competition a la Bliss is eliminated from the analysis μ is identically zero, the first equation is the only relevant one and it yields the elementary result that a monopolist

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chooses prices such that marginal revenues equals marginal costs[1].

3. Empirical Implementation: Functional Forms

For empirical purposes, we view each supermarket as attaining a short run equilibrium by choosing prices and distribution services to maximize profits given the exogenous level of competition that it must meet and the (Marshallian) demand function of the representative consumer for that supermarket. These considerations lead to the following set of equations for estimation.

$$[p^* - C_Q - p]\partial Q/\partial p^* - Q(\mu - 1) = \epsilon_1 \qquad (4)$$

$$-C_D + [p^* - C_Q - p]\partial Q/\partial D + \mu r = \epsilon_2 \qquad (5)$$

$$Q - f(p^*, D, X_3) = \epsilon_3, \qquad (6)$$

where ϵ_i are independent and identically distributed error terms with $E(\epsilon_i) = 0$ and X_3 is a vector of exogenous variables shifting the demand function in different market areas[2]. In order to proceed, we need to specify functional forms for the demand function, the cost functions and competition a la Bliss.

3.1. Specification of the Demand Function

There are two alternative approaches to the specification of the demand function: The complete systems approach and the single equation approach. Since we only have information on quantity and prices for the products of each supermarket, the systems approach is not fruitful; therefore we follow the single

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[1]Incidentally, competition a la Bliss implies imperfectly competitive markets and thus $0<\mu<1$. Values greater than unity would violate the second-order conditions.

[2]The first-order conditions on the left hand side of (4) and (5) are simply a reformulation of (1) and (2) in the previous section that happens to be convenient for estimation.

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equation approach by specifying a 'double log' type of demand function[3] in its exponential form, i.e.,

$$Q = f(p*, D, X_3) = p*^{\delta_1} \cdot D^{\delta_2} \cdot X_3^{\delta_3}. \qquad (7)$$

Two modifications of (7) are useful in an empirical setting. First, the parameters affecting the endogenous variables need not be assumed constant, e.g., Betancourt (1981). Instead, they will be allowed to vary with characteristics of the households in the market area in which the supermarket is located, e.g.,

$$\delta_1 = \delta_{10} + \delta_{11}X_1 \qquad (8)$$

$$\text{and } \delta_2 = \delta_{20} + \delta_{21}X_2 \qquad (9)$$

Economic theory leads us to expect a negative price response and a positive distribution services response[4]. Thus, we would expect $\delta_{10} < 0$ and $\delta_{20} > 0$. The signs of δ_{11} and δ_{21}, however, would be determined by whether we expect the household characteristic to increase or decrease the sensitivity of demand to retail prices or distribution services. Second, any dummy exogenous variables in the vector X_3 were introduced in exponential form, e.g., as $e^{\delta_{31}X_{31}}$, to avoid the implication of having a zero response for zero values of the dummy.

Finally, this specification of the demand function implies the following for the price and distribution services equations (4) and (5), respectively.

$$\partial Q/\partial p* = \delta_1 Q/p* \leq 0 \qquad (10)$$

$$\partial Q/\partial D = \delta_2 Q/D \geq 0 \qquad (11)$$

These cross-equation restrictions will be imposed upon estimation and the

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[3]For a reconciliation of this type of demand function with the systems approach see Sato (1972); For applications of variants to the demand for supermarket products see Bode (1990).

[4]For a theoretical analysis of the role of distribution services in the household production model and its implications for retail demand see Betancourt and Gautschi (1992).

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consistency of the estimates with standard economic theory as incorporated in the model can be easily checked through the signs of δ_1 and δ_2.

3.2. Specification of Competition a la Bliss.

Just as indicated in the previous section, the Lagrange multiplier (μ) represents the marginal contribution to profits from relaxing the competitive constraint in any particular market. Hence, one would expect it to vary across the market areas where the supermarkets are located as characteristics of these market areas differ. In addition, the value that this variable can take on in any one market must lie between zero and unity. These considerations were incorporated into the empirical analysis by specifying the following logistic functional form,

$$\mu = e^{\gamma M}/(1+e^{\gamma M}), \qquad (12)$$

where M is a vector of variables describing the characteristics of the market.

Suppose that two market areas differ with repect to a market characteristic such as the level of concentration, M_1. We would expect, in general, that the marginal contribution to profits of relaxing the competitive standard would be higher in the more concentrated market. Of course, one can always find exceptions. For instance, if oligopolists in a more concentrated market are engaged in predatory pricing whereas those in a less concentrated market are not, it would no longer follow that we would expect to observe this relationship. If retail markets are monopolistically competitive, these anomalies due to variations in strategic behavior across markets are less likely to arise. In any event, the qualitative effect of a market characteristic on μ will be determined by the sign of γ, i.e.,

$$\partial\mu/\partial M_j = \gamma_j \mu (1 - \mu) \ . \qquad (13)$$

Thus, in the case of concentration we would expect γ to be positive. Notice that

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this need not imply that the effect of concentration on prices is positive. This second effect depends on the simultaneous adjustment of prices and distribution services to the increase in μ generated by the higher level of concentration. Of course, the parameters of μ will be restricted to be the same in the two equations where they appear.

3.3. The marginal cost functions and the wholesale price.

In order to complete the specification of the model, we need to specify functional forms for the marginal cost functions for explicit products, C_Q, and distribution services, C_D, as well as the wholesale price. We specified a slight generalization of a quadratic cost function, which generates the following marginal cost functions,

$$C_Q = (\exp(\theta S))\,[\alpha_1 + \alpha_{11}\beta_1 Q^{\beta_1}/Q + \alpha_{12}D]\,[v_1^{\pi_1} v_2^{\pi_2}] \qquad (14)$$

$$C_D = (\exp(\theta S))\,[\alpha_2 + \alpha_{22}\beta_2 D^{\beta_2}/D + \alpha_{12}Q]\,[v_1^{\pi_1} v_2^{\pi_2}] \qquad (15)$$

where v_1 is occupancy cost and v_2 is labor compensation. S is a vector of shift variables that lead to differences in the levels of costs, for example store type (S_1 is a dummy for superstores and S_2 is a dummy for traditional supermarkets with warehouses as the residual category) or the existence of a scanner at the store (S_3). θ is a vector of corresponding coefficients.

This specification is a slight generalization of the standard quadratic. That is, if $\beta_1 = 2 = \beta_2$, it collapses to the quadratic. Given our interest in distribution services as an output, it seemed useful to allow for richer behavior in terms of multiproduct returns to scale and the shape of marginal costs than permitted by the standard quadratic. For instance, with these functions marginal costs can increase at either an increasing or a decreasing rate with distribution

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services or output as β_i is greater or less than one.

Finally, the last component of cost to be specified is the wholesale price. The latter was assumed to be a function of whether or not the supermarket belonged to a chain as follows : $p = \sigma_0 + \sigma_1 S_4$, where S_4 takes on the value of unity if the store belongs to a chain and zero otherwise. σ_0 is expected to be positive and σ_1 is expected to be negative, i.e., one of the benefits of belonging to a chain is to secure products at advantageous prices.

4. The Data.

This study is based on two primary data sources. The first one is a 1982 survey of 616 supermarkets and their characteristics conducted on behalf of the Economic Research Service for a study of supermarket prices. The survey was supplemented by information on the 28 SMSA's where the supermarkets were located. The latter consisted primarily of items such as market growth, which was constructed from various issues of The Progressive Grocer for the same year. A detailed description of this data is available in the study by Kaufman and Handy (1989). The second primary data source was purchased by ERS from Claritas Corporation (Rezide, 1980) and it contains socioeconomic and demographic information on each of the zip code areas where a supermarket is located. This information is derived from the 1980 Census.

A heated debate on the first data source has taken place.[5] One of the essential points of contention, if not the essential one, is whether the price index constructed should try to measure the average price level at a store, firm or SMSA in contrast to the average price level of the same basket of market goods for all stores, firms or SMSA's. There is agreement that the procedure used by

[5]The critique of the data is in Geithman and Marion (1993); the defense of the procedures is in Kaufman and Handy (1993).

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Kaufman and Handy (1989, Appendix D) aims to measure the former concept. This is the concept that is suitable for our analysis, because it is the one consistent with the theoretical discussion in the previous sections. Of course, this does not imply that it is the one most suitable for all other analyses.

p* is a weighted average of indices of price relatives for each store. For each brand type in a product subcategory an all SMSA average of the unit price for the brand and subcategory was constructed[6]. For each item in a brand and product subcategory a price relative index was constructed through division of the unit price by the all SMSA average unit price and multiplying by 100. These indices of price relatives were aggregated into a single store index of price relatives, usually employing the share of sales as weights. This variable was taken directly from the ERS data set.

Data on prices of items were collected for three independent random samples for each supermarket. The surveys were taken about six weeks apart. The index of price relatives for each store ranges from 66 to 135 over the three samples. After cleaning up the data this generates 461 price observations for the first wave, 498 for the second wave and 494 for the third wave. The number of supermarkets for which we have three observations on prices, however, is lower, since the overlap in the three waves is far from perfect. For instance, 430 observations are the same in all three waves; 487 are the same in waves 2 and 3; 434 are the same in waves 1 and 3 and 438 are the same in waves 1 and 2.

D is an index of distribution services. Each store was asked to indicate whether or not it provided each of 20 possible services: a 1 was recorded if it

[6]Four brand type categories were used: advertised brands, private labels, generics and unbranded items.

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did and a zero otherwise.[7] One of these 20 services was the existence of a front end scanner. We deleted this one from the index on the grounds that it measured an input that made possible other services rather than an output. By the same logic we used information on store hours to construct an additional service. If a store operates before 7 a.m. or after 10 p.m. and more than 15 hours per day, we assign it a value of 1 and if not a zero. Thus, the range of possible services goes from 1 to 20. This variable was divided by its average value over all SMSA's and multiplied by 100 to generate an index commensurate with the index of price relatives.

Distribution services can be classified into five broad categories, as noted in the introduction. The components of the index described above capture four of these categories. Assortment is captured in the index by four questions on the existence of an area with employee assistance for bakery, deli, meat and fish as well as a question on whether the store accepts utility payments and another one on whether the store offers contests or games. Information is captured in the form of one question on whether product prices are marked and another on the use of unit pricing. Most of the services included can be viewed as providing assurance of product delivery in the desired form or at the desired time. That is, produce wrapping, check cashing, coupon redemption, express checkout, bagging service, carry out service, trading stamps, the extended hours dummy discussed previously and continuity programs. Finally, ambiance is captured by a question on the use of employee uniforms and another on the availability of music in the store. The only category of services not

[7]See Kaufman and Handy (1989) Appendix B for a detailed description of each of these services.

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represented in the index is accessibility of location.[8]

Q is a quantity index of output obtained by dividing annual store sales in hundreds of 1982 $ by the store index of price relatives. These three variables comprise the set of endogenous variables in our analysis.

We took most of our independent variables from the store survey in the ERS data set. That is, v_2 is labor compensation, measured as the average hourly wage rate per employee plus employee fringe benefits valued as a cost to the employer; S_1, S_2, S_3 and S_4, are the store format, scanner and chain store dummies, respectively, which were defined in Section 3.3; X_{31} is a shopping center dummy variable which takes on the value of 1 if the store is located with other retail stores in a shopping center complex or mall and zero otherwise; and X_{34} is the selling area of the store in per thousand square feet.

A number of other variables in the ERS data set were constructed on the basis of other published sources. From these we took v_1 or an occupancy cost proxy which is an index of rental rates and utility costs relative to the 28 SMSA sample average; M_1 or a concentration proxy, measured by the four firm partial Herfindahl index for each of the 28 SMSA's; M_2 or a potential entry proxy, measured by the average annual real growth of foodstore sales in an SMSA during the five years preceding the price survey and referred to as market growth.

Finally, we took four variables from the Claritas data set. X_1 is the percentage of households without cars in the zip code area where a supermarket is located. X_2 is an index of socioeconomic level of the zip code area in which

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[8]In the ERS version of the index the first four assortment services were weighted twice as much as the other sixteen on the grounds that they were more expensive to produce. Since no one has accurate information on relative costs, it seemed preferable not to prejudge the issue and use an index with equal weights. Preliminary experiments with linear regressions indicated that it may no difference to the results.

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a supermarket is located. It is based on four dimensions: household income, educational attainment, occupational status and home value. The index ranges from 1 to 100 and scores between 40 and 60 indicate middle class status. Fifty-five % of the zip codes in the U. S. have scores between 40 and 60. Fifty % of our zip codes have scores between 47 and 61. X_{32} is the median income of households in the zip code area where a store is located. X_{33} is the population in the zip code area where a store is located.

In Table 1 of the Appendix we present the sample means of all the variables used in subsequent analyses and previously described for the set of observations corresponding to each price wave. The characteristics of the samples are very similar across the waves. As a reference point for our investigation we estimated linear equations for all the endogenous variables, i.e., the retail price, distribution services and the quantity of output demanded. Since each equation contains the other two endogenous variables as explanatory variables, we used both OLS and 2SLS. The results for wave 2 are presented in Table 1.[9]

The most striking characteristic of the results is their sensitivity to corrections for endogeneity with 2SLS. For instance, distribution services become 'statistically insignificant' in the demand equation; distribution services and quantity demanded become 'statistically insignificant' in the price equation; and prices acquire a negative and 'statistically significant' effect in the distribution services equation. Some variables expected to matter do so

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[9]For completeness, we estimated the same price equation with store level data that Kaufman and Handy estimated with firm level data. Of 12 independent variables in both equations 11 had the same sign and the one that did not had a t-ratio less than .7 in both equations. The main difference in results was that market share was statistically significant with store level data but not with firm level data and the sum of market shares of those leading firms entering the market in the previous five years was statistically significant with the firm level data but not with the store level data (it had a t-ratio of 0.167).

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with both estimation methods. For instance, price, population and selling area in the demand equation; store formats, market growth and the percentage of households without cars in the price equation; and six of the nine exogenous variables in the distribution services equation. Finally, some variables expected to matter fail to have a 'statistically significant' effect with both estimation methods. For instance, median income in the demand equation; labor cost, the scan dummy and the Herfindahl index in the price equation; and the two market structure variables (the Herfindahl index and market growth) in the distribution services equation.

In order to see the robustness of these results, we estimated the same equations using waves 1 and 3. Table 2 presents the results of the 2SLS estimation for all three waves. The results are identical for the demand equation and almost identical for the price and distribution services equation. Indeed, the coefficient of the chain dummy is the only one to exhibit sensitivity to the choice of wave in terms of whether or not it is statistically significant at the 5 % level for both equations. Summing up, the linear estimation results are a thoroughly mixed bag. They lead to the acceptance and rejection of elementary tenets of economic theory (for example, quantity demanded negatively affected by price but not affected by income), of the economic model presented earlier (for example, distribution services being positively affected by quantity demanded but having no effect on price or quantity demanded), and of simple empirical intuition (for example, the superstore format having a positive effect on prices and distribution services and concentration, as measured by the Herfindahl, having no effect on prices and distribution services).

5. Nonlinear Estimation Results

By incorporating information from the theory and prior experience through

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the functional forms, we are able to address all the issues raised by the linear estimation results. We estimated the demand equation in (7) by nonlinear two stage least squares (NL2S).[10] In addition to the change in functional form from the linear case, we also allowed the coefficient of price to depend on the percentage of households without cars, as specified in (8), and the coefficient of distribution services to depend on the index of socioeconomic level, as specified in (9). The results are presented for all three waves in Table 3.

First, the two main anomalies of the linear case are eliminated. That is, the parameter estimates for median income (δ_{32}) and distribution services (δ_{20}) are positive and statistically significant at the 1% level in all three waves. This is in sharp contrast to the linear 2SLS results. Second, the coefficients of price δ_{10} and selling area (δ_{34}) have the expected sign and are statistically significant at the 1 % level in all three waves. Finally, the coefficients of the shopping center dummy (δ_{31}) and population (δ_{33}) show some instability across the waves. The former is statistically insignificant at the 5% level in wave 3; the latter is statistically insignificant at the 1 % level in wave 1.

Of special interest in the demand estimation for the nonlinear case are the results for the two coefficients that allow the elasticities to be variable (δ_{11} and δ_{21}). They have the expected sign and are statistically significant at the

[10]Initially we tried to estimate all three equations simultaneously but ran into a number of problems. First, it was difficult to attain convergence. Second, in the cases where convergence was attained, the results for the demand equation overwhelmed the other results, in the sense that the estimates for the demand equation were very close to the NL2S estimates and the estimates for the coefficients in the other two equations were statistically insignificant. The source of the problem seems to be that the standard error in the demand equation is 5 to 6 times the standard error in the price equation and 16 to 17 times the standard error in the distribution services equation.

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1% level in all three waves. Consider first the price response.[11] As the percentage of households without cars (X_1) increases our estimate implies that the price response of demand will decrease in absolute value, because of the lack of access to competing alternatives by the consumer. Incidentally, note that no restriction was imposed forcing the price response to remain negative as the percentage of households without cars increased. This provided an opportunity for the data to reject the analysis by generating coefficient estimates leading to positive price responses. The first three rows of the bottom half of the table demonstrate that the data did not take advantage of this opportunity for any of the more than 461 observations in each of the three waves. This is comparable to the satisfaction of monotonicity conditions in the usual demand and cost framework associated, for example, with the translog.

Consider now the distribution services response. As the socioeconomic level of the area where a supermarket is located (X_2) increases the distribution services response decreases, because households in this area expect a high level of distribution services. No restriction was imposed forcing this response to remain positive, which once again provided an opportunity for the data to reject the analysis. The last three rows of the Table present the relevant evidence. No violations occurred in any of the three waves. More generally, it should be noted that these results represent the first time the distribution services demand response or elasticity has been estimated. Hence, they provide corroborating evidence in favor of one of the basic concepts underlying the

[11]We do the analysis in terms of the price response because it is what enters into the first- order condition. All statements about signs are equally applicable to the price elasticities, i. e., $\partial Q/\partial p^* = \delta_1(Q/p^*)$. The elasticities (δ_1 and δ_2) are presented in the bottom half of Table 3.

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analysis of retail institutions in Betancourt and Gautschi (1993a).[12]

Turning to the estimation of the two first-order conditions underlying the choices of prices and distribution services, we did our experimentation with wave 2 and used the other two waves to check the consistency of our results. These two equations, (4) and (5), were estimated by nonlinear three stage least squares (NL3S) using the same instruments as in the demand equation and imposing the functional forms developed in Section 3. Thus, we used (10) and (11) from Section 3.1, (12) from Section 3.2, and (14) and (15) together with the specification of p from Section 3.3. In addition, we treated the estimates of δ_1 and δ_2 from the demand equation as given in the estimation of these two equations. Finally, there were two intercept parameters in the specification of costs that were taken as given for purposes of the estimation:[13] Namely, α_1 and α_2. For the reader's convenience we present all the equations estimated together in Table 2 of the Appendix.

In Table 4 we present the results for wave 2. The base 1 results allow all the variables suggested by the theory to enter into the analysis in the form specified in Section 3. The only disappointing result is that the coefficient of labor compensation has the wrong sign although it is 'statiscally insignificant', just as in the linear case or in Kaufman and Handy's results. Since the null hypothesis that it is greater than or equal to zero can not be rejected at the 1% level, we imposed the restriction that this coefficient was

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[12]While the mean of the distribution services elasticity is considerably lower (almost one tenth) than the absolute value of the mean price elasticity in all three waves, the economic implication of these magnitudes requires identifying the economic meaning of a 1% increase in these indexes.

[13] Allowing these two parameters to be estimated generated convergence problems. Hence, we fixed their values and performed a sensitivity analysis of the results which will be discussed below.

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equal to zero and reestimated the two equations with the restriction imposed.[14] These results are labelled base 2 in Table 4 and provide the basic results of our analysis. The first point to be made is that imposing the restriction makes very little difference to the results. The only substantive change is that the effect of the chain dummy on the price paid to suppliers (σ_1) becomes 'statistically significant' in the base 2 case. There are no changes in sign among the coefficients. There are no changes in statistical significance using a one sided test at the 1% level among the other coefficients. Furthermore, even the magnitude of the coefficients remains similar in most cases. For instance, all of the 11 statistically significant coefficients in base 1 experience a change in magnitude of less than 20% in base 2, and many of them change by less than 5%.[15]

What are the main economic implications of our results. Store formats are important in affecting costs. While this result is not unexpected given the linear estimation results, it is now possible to be more precise about the effects of store formats. In particular traditional supermarkets experience an 11% increase in costs (θ_2) and superstores a 6% increase in costs (θ_1) relative to warehouses at the same level of output and with the provision of the same

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[14]We alsc considered a different functional form for the cost function, namely the one employed by Pulley and Braunstein (1984). This function is the standard quadratic with interaction terms between prices and output added to allow for heterotheticity. The results deteriorated and we abandoned experimentation with alternative functional forms.

[15]Incidentally, a comparison of the results with and without the labor compensation variable for waves 1 and 3 leads to the same conclusion. Namely, labor compensation also has the wrong sign and is 'statistically insignificant" in these two waves; moreover, removing this variable has no effect on the results for wave 1 and its effect on wave 3 is very similar to wave 2. For instance, the most noticeable effect in wave 3 is that the coefficient of the chain dummy becomes statistically significant at the 1% level rather than at the 5% level as a result of removing this variable.

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level of distribution services. This may be one of the factors leading to the severe contraction in the number of traditional supermarkets during the 1980's.[16] The presence of scanners (θ_3) decreases costs by about 3%. Not surprisingly this technology spread rapidly during the 1980's. Slightly less than a fourth of our 1982 sample had scanners. Marginal costs decline substantially as distribution services expand (β_2) and marginally as output expands (β_1). This is one of the factors that explains the ability of superstores to expand rapidly during the 1980's despite their cost disadvantage with respect to warehouses. Finally, there are positive interdependencies in the marginal costs of producing output and distribution services (α_{12}).

Our specification of competition a la Bliss generates the expected results. That is high levels of concentration (γ_1) increase the marginal contribution to profits of lessening competition[17] and rapid market growth (γ_2), which is a proxy for potential entry, lowers the marginal contribution to profits of lessening competition. Hence, they correct the anomalies generated by the linear specification of these variables. Finally, the shadow price of distribution services (r) is positive and substantial. A one unit increase in the distribution services index saves the consumer about $ 135 in distribution costs over the course of the year.[18] The bottom of Table 4 provides a useful

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[16] For instance, the number of traditional supermarkets declined from about 21,000 to about 12,000 during the 1980's, Betancourt (1992).

[17]While the coefficient of concentration is statistically insignificant using 2 as the critical value, it has the correct sign, in contrast to the linear case, and it is stastistically significant at the 5 % level using a one sided test.

[18]More generally, if a family patronizes a store every week and spends $200 per week at the store, the estimated yearly savings in distribution costs from adding a distribution service represent roughly 13.4 % of the family's yearly expenditures at the store.

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check on our specifications. It presents the results of calculating the profit margin for each store. In none of the 498 possible cases is this margin negative. This corresponds to satisfaction of the concavity conditions in the estimation of cost functions with flexible forms.

How robust are these results to the assumptions made? Table 3 in the Appendix presents the results of estimating the base 2 model for alternative values of the intercept for the marginal cost of output equation and for the marginal cost of distribution services equation. For values of α_1 equal to .5 and 1.5 the results are identical to the ones for base 2, which use a value of 1. Similarly, for values of α_2 equal to .5 and 1.5 the results are identical to the base 2 value of 1. Indeed, the change in the magnitude of any coefficient is less than 10 % of the base 2 estimate in all possible cases and less than 2% in the overwhelming majority of cases.

Another set of parameters taken as given were the estimates from the demand equation for the price and distribution services response. Since these estimates differ for the three waves, a comparison of the results for the three waves provides an initial sensitivity analysis to changes in these parameters. Of course, this experiment will also capture the effects of sampling differences in the drawing of a new set of prices and of variations in the set of observations included in each sample. The results are presented in Table 5.

The results are very similar in waves 2 and 3. The main difference in results between these two waves is that concentration is not statistically significant at the 5 % level in wave 3. The differences with wave 1 are somewhat more noticeable. In particular the effect of store formats in wave 1 is substantially different from the other two waves in that there are no 'statistically significant' differences in costs between superstores and

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warehouses; similarly, the coefficient of of occupancy costs is statistically insignificant at the 5 % level in wave 1 but not in the other two waves. Interestingly, three observations violate the nonnegativity condition in wave 1. Perhaps most importantly, however, the results about the existence of declining marginal costs and costs complementarities are the same across the three waves. Similarly, the results with respect to the value of the shadow price of distribution services and the effect of potential entry on competition a la Bliss are the same across the three waves.

To complete our analysis we present an additional set of results in Tables 4A and 4b of the Appendix. These tables contain the results of reestimating the model for all three waves using only the set of 430 observations that are common to all waves. In Table 4a we present the results of estimating the demand equation by NL2S with the common set of observations for all three waves. This table is comparable to Table 3 in the text. The substantive results across the three waves are identical! This means that the very minor differences across the three waves in Table 3 were entirely due to the use of a different set of observations rather than to sampling differences across the waves.

In Table 4b of the Appendix we present the results of estimating the two first-order conditions by NL3S for the common subset of observations. This table is comparable to Table 5 in the text. A comparison of the corresponding columns in the two Tables shows the sensitivity of the results to eliminating the observations that are not common to all three waves. Using a one sided test at the 5% level of significance, there are no substantive changes in wave 2 and the only substantive change in wave 3 (1) is that the coefficient of concentration (occupancy cost) becomes 'statistically significant' for the reduced sample. A comparison across the columns of Table 3b shows the sensitivity of the results

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to sampling variations, including changes in the magnitudes of the demand elasticities estimates, using the same set of observations. Using a one sided test at the 5% level of significance there is only one result that differs across the three waves. Namely, in wave 1 there are no costs differences between superstores and warehouses.

To conclude our main results are invariant to changes in the number of observations, assumptions about the fixed parameters, sampling variability over the three price waves, and the inclusion of labor compensation.

6. The Effects of Changes in Exogenous Variables and Parameters.

In this section we use the estimated model to answer a number of relevant questions in the context of grocery retailing. We consider the effect of changes in the determinants of market structure, demand conditions and costs characteristics on the prices charged and the distribution services offered by supermarkets as well as on consumer welfare.

Our procedure is to obtain a base prediction for each observation by solving the two equation system for the predicted values of prices and distribution services. The effect of changes in the exogenous variables or parameters on the predicted values of prices and distribution services is obtained by solving the two equation system again for each observation using the new values of the parameters or exogenous variables.

A general consequence of the nonlinearity in the system is the need to calculate the expected change in the predicted value of the endogenous variables as the mean of the changes for each individual observation. A particular feature of our specific model is that the welfare consequences of these predicted changes depend on whether the two endogenous variables move in the same or opposite

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directions. If they move in opposite directions the welfare consequences are unambiguous. If they move in the same direction, the welfare consequences depend on the magnitudes of the changes in prices and distribution services. In addition, there is the numerical issue of whether or not there is a solution to the nonlinear equations for the predicted values of the endogenous variables.

In reporting the results we address the above issues by using the following procedure: first, we restrict the analysis to those observations where there is a numerical solution to the base simulation for the predicted value of the two endogenous variables.[19] Second, we report separately the results for those observations where price and distribution services move in the same and opposite directions. Finally, we estimate the net welfare gain or loss in monetary terms for each observation and report the results separately for those that improve and for those that deteriorate.

Net welfare gain was calculated for each supermarket by subtracting the change in consumer expenditures due to the change in prices from the change in consumer expenditures due to the change in distribution services. The change in the price relative index is multiplied by the quantity index for each supermarket. This is an estimate of the change in consumer expenditures due to the price change. The change in the distribution services index is multiplied by the shadow price of a unit change in the distribution services index for each supermarket. This is an estimate of the change in consumer expenditures due to the change in distribution services.

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[19]We also eliminated from the analysis any observation with a predicted value for distribution services more than 2.5 times the average value. About a dozen observations were eliminated on this criterion.

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In Table 6 we present the results of changes in concentration[20] as well as the means of each characteristic for the complete sample and for the sample used in the simulations. The two samples are quite similar.[21] A 1% increase in concentration leads to an average decrease in prices and distribution services. The average net welfare change is negative because the decrease in distribution services dominates the decrease in price.[22] Splitting the sample by the direction of change in the endogenous variables reveals that for a subset of observations (21) there was an improvement in welfare since prices decreased and distribution services increased. A more revealing split, however, is to compare those observations where welfare increased with those where it decreased. For the 210 observations where welfare decreased, we find that prices and distribution services decrease and, consequently, the latter change dominates the net welfare effect for each observation. This subsample is characterized by firms with higher prices, lower distribution services and levels of output, and fewer warehouses, superstores and scanners than the subsample where welfare increases.

Summing up, both for changes in concentration and potential entry, the welfare effects of changes in market structure depend crucially on the characteristics of the supermarket. This result brings out the pitfalls in arriving at conclusions about antitrust policy on the basis of relationships

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[20]We did the same analysis for a 1% increase in entry and found the pattern of results to be the same with opposite signs.

[21]A test of the differences in means fails to reject the null hypothesis of equality at the 10% level for all characteristics but one. The mean of the distribution services index in the simulated sample is lower than the mean in the complete sample.

[22]For a few observations (8) where distribution services and prices move in the same direction, they both increase rather than decrease. Since they are few and do not change the average results we will not discuss them specifically.

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between prices and concentration, which have been the focus of the literature cited in the introduction.

Table 7 contains the results of a similar experiment for a demand characteristic, the price elasticity of demand.[23] A 1 % increase in the price elasticity, i.e., demand becoming more elastic, leads to lower prices and distribution services on average. The average net welfare change is positive since the price effect dominates.[24] Splitting the sample by the direction of change in endogenous variables, however, reveals that almost half the sample responds by lowering prices and increasing distribution services. The most pronounced feature of this result is that the stores that respond in this fashion have low levels of output, high prices and low levels of distribution services. They operate in markets with higher level of concentration, have fewer scanners and fewer of them are superstores than those in the other subsample. Splitting the sample by the direction of welfare change reveals that for a small proportion of the sample (about 11%) welfare decreased. This subsample exhibits a lowering of prices, distribution services and welfare for each observation.

Once again a striking feature of the results is the dependence of the response to changes in demand conditions on the characteristics of the supermarkets. In this case, however, it is with respect to distribution services that this dependence is most visible. In particular supermarkets that charge high prices, provide low levels of distribution services and have low volumes of output respond to an increase in the price elasticity of demand by increasing

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[23]We performed a similar experiment with respect to an upward shit in demand, for example due to a 1% increase in median income. The pattern of results was the same as for the price elasticity.

[24]Of the 176 responses in the same direction (48) experience an increase in prices and distribution services and the net welfare change for each of these observations is positive because the distribution services effect dominates.

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distribution services. This subsample is characterized also by containing fewer superstores and stores with scanners than the subsample where prices and distribution services move in the same direction. Our results on the price elasticity are consistent with those of James MacDonald and Paul Nelson (1991). They found that the poor pay more because they reside in neighborhoods with a high percentage of households without cars and explained this result in terms of a reduction in their price elasticity (in absolute value). Our analysis also shows, however, that if the poor reside in neighborhoods with stores which provide low volumes of output, as they argue, their welfare is further reduced because these stores will lower the distribution services they provide in the face of a more inelastic demand.

In Table 8 we present the results of a similar experiment with respect to a cost characteristic, the slope of the marginal cost function with respect to output.[25] A 1% increase in this parameter (α_{11}) leads on average to higher prices and distribution services. The average welfare change is negative. Splitting the sample by the direction of change of the endogenous variables is also revealing in this case. For about two thirds of the observations prices increase and distribution services decrease. Once again this subsample has very definite characteristics: high prices, low distribution services and output; and a high proportion of warehouses, superstores and stores with scanners.[26] In the other subsample prices increase and distribution services also increase but the former effect dominates on average, leading to a decrease in welfare. Splitting the sample by the direction of change in welfare shows that only 7 observations

[25]The pattern of results for this experiment is identical to the one obtained for a 1 % increase in σ_0.

[26]Incidentally of the 130 observations in the other subsample only 2 experienced a decrease in prices and distribution services.

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experienced an increase in welfare.

Changes in demand and costs characteristics discussed thus far generate subsamples with more heterogeneous responses (in the sense of different responses that are more equally balanced in number of observations) with respect to prices and distribution services and less heterogeneous responses with respect to welfare than changes in market structure. In addition, the magnitude of the changes in welfare as a result of changes in cost and demand characteristics is substantially larger than the magnitude of the welfare changes as a result of changes in market structure.

Our last experiment was to increase the slope of the marginal cost function for distribution services.[27] There are no observations for which prices and distribution services move in opposite directions. The average response is an increase in prices and distributions services. The distribution services effect dominates in that the net welfare change is positive. We split the sample by the direction of the welfare change and found that for every observation in the subsample where welfare decreased prices and distribution services decreased and the latter effect dominated. In the other subsample 212 of the observations experienced an increase in prices and distribution services and in each case the welfare change was positive due to the domination of the latter effect. Hence, the average result is being driven by distribution services. Finally, the subsample that generates the increase in welfare is characterized by low volumes of output, high prices and low levels of distribution services as well as a low proportion of warehouses, superstores and stores with scanners. Note that in the analysis of the previous experiment this type of subsample generated a decrease

[27]We also performed the experiment of a 1% increase in the elasticity of demand for distribution services. The pattern of results is very similar to the one for this cost experiment but with opposite signs.

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in welfare by decreasing the levels of distribution services.

A common thread through all four experiments is the importance of the characteristics of supermarkets in determining the response to changes in demand, costs and market structure. This heterogeneity manifests itself in two different ways. For changes in the demand or cost characteristics associated with the explicit output of supermarkets, the responses are heterogeneous with respect to whether or not prices and distribution services move in the same direction. Nevertheless for changes in market structure or demand and cost conditions associated with the provision of distribution services, the responses are heterogeneous with respect to the welfare consequences of these changes. In all four cases, however, supermarkets with low prices and high levels of output and distribution services behave differently than those with high prices and low levels of output and distribution services. Since the former have been gaining a substantial share of the market in recent years, one would expect their responses to dominate average behavior in the future.

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TABLE 1: COMPARISON OF OLS AND 2SLS RESULTS - WAVE 2

Variables	Price (Wave 2)				Distribution Services			
	OLS Estimates		2SLS Estimates		OLS Estimates		2SLS Estimates	
	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic
Intercept	84.5460*	49.319	89.3829*	24.552	27.3754	1.538	226.4293*	3.632
Services	.0265*	2.486	-.0563	1.044				
Price (Wave 2)					.3148**	1.670	-2.0170*	2.792
Quantity	-.0025*	5.550	-.0009	0.935	.0094*	4.906	.0071**	1.786
Labor Cost	-.0023	0.284	-.0015	0.166	.0579**	1.745	.0265	0.664
Occupancy Cost	.0513*	4.387	.0290	1.601	-.3003*	6.110	-.1817*	2.693
Chain Dummy	-1.6892*	3.220	-1.0379	1.423	8.4632*	3.837	5.2771**	1.949
Superstore	8.9019*	7.308	13.5269*	4.068	54.3673*	11.110	78.0613*	8.580
Traditional Mkt	9.9008*	9.071	14.2910*	4.819	46.7202*	10.215	74.3296*	7.693
Scan Dummy	-.6943	1.355	-.2272	0.306	9.2939*	4.301	8.7624*	2.450
Herfindahl	-1.7812	0.480	-.8183	0.154	17.1770	1.086	11.6005	.635
Market Growth	39.7770*	5.944	38.5554*	5.237	-33.5108	1.151	48.8410	1.183
% Households w/o Cars	.0789*	5.067	.0626*	3.163				
Zip Quality Index					.1071	1.336	.1592**	1.705
R^2		.39		.34		.43		.36

Variables	Demand (Q2)			
	OLS Estimates		2SLS Estimates	
	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic
Intercept	1873.5531*	5.556	1719.7374*	2.971
Price (Wave 2)	-20.6146*	6.271	-16.3136*	2.695
Services	2.2664*	2.816	-1.1378	0.732
Shopping Center	-72.4474**	1.922	-38.5527	0.944
Median Income	.0038	1.228	.0040	1.272
Population	.0041*	3.919	.0037*	3.415
Selling Area	2.7104*	15.134	3.0161*	13.296
R^2		.47		.45

* |t| > 2
** |t| > 1.645

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TABLE 2: COMPARISON OF 2SLS RESULTS - WAVE 1,2,3

Variables	Price Equation					
	Wave 1		Wave 2		Wave 3	
	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic
Intercept	90.7949*	20.181	89.3829*	24.552	89.1205*	21.608
Services	-.0265	0.383	-.0563	1.044	-.0553	0.897
Quantity	-.0009	0.727	-.0009	0.935	-.0006	0.476
Labor Cost	-.0015	0.157	-.0015	0.166	.0037	0.370
Occupancy Cost	.0096	0.425	.0290	1.601	.0298	1.402
Chain Dummy	-1.6933**	1.998	-1.0379	1.423	-1.4044	1.624
Superstore	11.7162*	2.581	13.5269*	4.068	13.7542*	3.544
Traditional Mkt	12.8184*	3.132	14.2910*	4.819	14.2272*	4.096
Scan Dummy	-0.4324	0.485	-.2272	0.306	-.0523	0.064
Herfindahl	-7.087	1.638	-.6183	0.154	.7027	0.150
Market Growth	29.2611*	3.672	38.5554*	5.237	36.6067*	4.294
% Households w/o Cars	.0411**	1.659	.0626*	3.163	.0406**	1.789
R^2		.30		.34		.26

Variables	Distribution Services					
	Wave 1		Wave 2		Wave 3	
	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic
Intercept	258.3106*	2.701	226.4293*	3.632	252.4435*	3.275
Price	-2.3331*	2.156	-2.0170*	2.792	-2.3536*	2.598
Quantity	.0089**	1.951	.0071**	1.786	.0087*	2.051
Labor Cost	-.0173	0.411	.0265	0.664	.0299	0.703
Occupancy Cost	-.2514*	3.829	-.1817*	2.693	-.1829*	2.441
Chain Dummy	3.4860	1.030	5.2771**	1.949	4.1905	1.302
Superstore	85.8841*	6.997	78.0613*	8.580	83.3259*	7.583
Traditional Mkt	82.9251*	6.215	74.3296*	7.693	79.3164*	6.850
Scan Dummy	6.9295*	2.285	6.7624*	2.450	6.1655*	2.089
Herfindahl	1.3246	0.063	11.6005	0.635	14.3421	0.724
Market Growth	34.0693	0.771	48.8410	1.183	55.6592	1.191
Zip Quality Index	.2075**	1.986	.1592*	1.705	.1981**	1.904
R^2		.36		.36		.34

* |t| > 2
** |t| > 1.645

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TABLE 2 (cont.): COMPARISON OF 2SLS RESULTS - WAVE 1,2,3

Variables	Demand					
	Wave 1		Wave 2		Wave 3	
	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic	Parameter Estimate	|t| Statistic
Intercept	2102.2436*	3.182	1719.7374*	2.971	1797.8849*	2.995
Price	-21.6926*	3.054	-16.3136*	2.695	-17.0272*	2.685
Services	1.1251	0.705	-1.1378	0.732	-1.1868	0.758
Shopping Center	-48.1532	1.196	-38.5527	0.944	-21.8342	0.527
Median Income	.0030	0.946	.0040	1.272	.0034	1.091
Population	.0031*	2.893	.0037*	3.415	.0035*	3.235
Selling Area	2.7717*	11.696	3.0161*	13.296	3.0475*	13.496
R^2		.46		.45		.45

* $|t| > 2$

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TABLE 3: NONLINEAR TWO STAGE LEAST SQUARES - DEMAND EQUATIONS

PARAMETER	WAVE 1		WAVE 2		WAVE 3	
	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR
δ_{10}	-2.1679*	.4858	-2.5921*	.4880	-2.3249*	.4686
δ_{11}	.0045*	.0006	.0041*	.0005	.0039*	.0005
δ_{20}	.4386*	.1806	.5137*	.1911	.4258*	.1878
δ_{21}	-.0029*	.0010	-.0037*	.0010	-.0034*	.0009
δ_{31}	-.0976**	.0526	-.0892**	.0514	-.0551	.0523
δ_{32}	1.0324*	.1997	1.1267*	.1898	1.1018*	.1801
δ_{33}	.0735**	.0436	.1084*	.0399	.1026*	.0402
[illegible]$_{34}$	.7980*	.0458	.7675*	.0443	.7842*	.0446
R^2	.53		.57		.56	
δ_1 MEAN	-2.1141		-2.5396		-2.2742	
MINIMUM	-2.1679		-2.5921		-2.3249	
MAXIMUM	-1.7629		-2.2231		-1.9739	
δ_2 MEAN	.2816		.3140		.2421	
MINIMUM	.1515		.1474		.0892	
MAXIMUM	.3516		.4101		.3306	

* $|t| > 2$
** $|t| > 1.645$

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TABLE 4: THREE STAGE NONLINEAR LEAST SQUARES - WAVE 2

	PARAMETER	BASE 1		BASE 2	
		ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR
HELD CONSTANT	α_1	1		1	
	α_2	1		1	
SHIFT PARAMETERS IN COST FUNCTION	θ_1	.0673*	.0208	.0684*	.0207
	θ_2	.1136*	.0256	.1124*	.0255
	θ_3	-.0349*	.0107	-.0323*	.0103
COST FUNCTION PARAMETERS	π_1	.0562*	.0226	.0554*	.0225
	π_2	-.0202	.0142		
	α_{11}	35.3790*	8.3226	32.8469*	7.8081
	β_1	.9659*	.0146	.9650*	.0146
	α_{22}	1602.963*	774.9080	1437.476*	661.8198
	β_2	.4183*	.0921	.4234*	.0914
	α_{12}	.0523*	.0072	.0474*	.0057
WHOLESALE PRICE PARAMETERS	σ_0	36.6273*	8.5189	36.4873*	8.5731
	σ_1	-.6526	.4551	-.9038*	.4172
COMPETITION PARAMETERS	γ_1	.5455**	.3107	.5417**	.3095
	γ_2	-2.9403*	.5911	-2.9097*	.5867
SHADOW PRICE	r	134.1185*	26.0463	135.0461*	26.4750
P^*-C_Q-P	MEAN	19.5012		19.5185	
	MINIMUM	1.6936		1.6886	
	MAXIMUM	46.7815		46.8489	

* $|t| > 2$
** $|t| > 1.645$

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TABLE 5: THREE STAGE NONLINEAR LEAST SQUARES - CHANGING WAVES

	PARAMETER	BASE 2 [WAVE 2]		WAVE 1		WAVE 3	
		ESTIMATE	STD ERROR	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR
HELD CONSTANT	α_1	1		1		1	
	α_2	1		1		1	
SHIFT PARAMETERS IN COST FUNCTION	θ_1	.0664*	.0207	-.0009	.0237	.0850*	.0261
	θ_2	.1124*	.0255	.0580*	.0259	.1213*	.0319
	θ_3	-.0323*	.0103	-.0383*	.0140	-.0186**	.0098
COST FUNCTION PARAMETERS	π_1	.0554*	.0225	.0383	.0263	.0437**	.0239
	α_{11}	32.8469*	7.8081	27.9259*	9.0063	36.3317*	10.5765
	β_1	.9650*	.0146	.9721*	.0221	.9712*	.0143
	α_{22}	1437.476*	661.8198	1435.839**	778.1122	1451.050*	707.2278
	β_2	.4234*	.0914	.4491*	.1129	.4182*	.0975
	α_{12}	.0474*	.0057	.0563*	.0078	.0436*	.0056
WHOLESALE PRICE PARAMETERS	σ_0	36.4873*	8.5731	41.0902*	10.2121	31.3491*	11.3404
	σ_1	-.9038*	.4172	-1.5467*	.5068	-1.1112*	.4601
COMPETITION PARAMETERS	γ_1	.5417**	.3095	1.1468*	.3132	.3597	.3099
	γ_2	-2.9097*	.5867	-1.9653*	.5690	-2.8162*	.5863
SHADOW PRICE	r	135.0461*	26.4750	135.0277*	32.7345	128.0452*	27.2323
P^*-C_Q-P	MEAN	19.5185		22.6896		21.8627	
	MINIMUM	1.6886		-12.5002		1.2260	
	MAXIMUM	46.8489		46.2131		56.7278	
	OBS<0	0		3		0	

* $|t| > 2$
** $|t| > 1.645$

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TABLE 6: 1% INCREASE IN CONCENTRATION						
	Sample	Direction of Price and Services Index Change		Direction of Welfare Change		Complete Sample
		Same Direction	Opposite[a] Directions	Reduction in Welfare	Improvement in Welfare	
Observations	340	319	21	210	130	498
Means of Predicted Change						
Change in Price Index	-.0102	-.0106[1]	-.0038	-.0137[1]	-.0044	
Change in Services Index	-.0489	-.0537[1]	.0233	-.0885[1]	.0151	
Net Welfare Change	-.7138	-1.1953[1]	6.6013	-6.3883[1]	8.4529	
Sample Means						
Price Index	99.8166	99.9341[1]	98.0319	101.2413[1]	97.5151	99.6510
Service Index	97.1954[3]	96.6188[2]	105.9548	93.9183[1]	102.4892	100.6009
Quantity	688.5808	675.7976[1]	882.7633	327.4470[1]	1271.9507	697.8079
Concentration	.0921	.0924	.0869	.0938	.0892	.0913
Potential Entry	.0077	.0066	.0239	.0101	.0038	.0061
Median Income	19154.12	19243.24	17800.38	19477.92	18631.05	18932.19
Households w/o Cars	12.1279	12.1053	12.4714	11.7386	12.7569	12.8088
Zip Quality	54.7294	54.9279	51.7143	55.3857	53.6692	53.9719
Proportion of Sample						
Warehouse Stores	5.00%	5.33%[1]	0.00%	2.86%[1]	8.46%	4.82%
Traditional Supermarkets	80.29%	81.82%[1]	57.14%	92.86%[1]	60.00%	79.52%
Superstores	14.71%	12.85%[1]	42.86%	4.29%[1]	31.54%	15.66%
Stores w/ Scanners	19.71%	19.12%	28.57%	5.24%[1]	43.08%	23.90%

[1] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 5% or lower level of significance.

[2] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 10% level of significance.

[3] A two sided test of difference in means rejects the null hypothesis of equality between the subsample and the complete sample at a 10% level of significance.

[a] Price index declined; Distribution Service index rose.

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TABLE 7: 1% INCREASE IN PRICE ELASTICITY OF DEMAND

	Sample	Direction of Price and Services Index Change		Direction of Welfare Change	
		Same Direction	Opposite[a] Directions	Reduction in Welfare	Improvement in Welfare
Observations	340	176	164	40	300
Means of Predicted Change					
Change in Price Index	-.2377	-.3130[1]	-.1570	-.8573[1]	-.1551
Change in Services Index	-.0368	-.9965[1]	.9932	-7.4566[1]	.9526
Net Welfare Change	223.9678	275.7960[1]	168.3474	-302.7170[1]	294.1925
Sample Means					
Price Index	99.8165	97.9893[1]	101.7776	98.8438	99.9463
Service Index	97.1954	103.3637[1]	90.5758	102.3523	96.5078
Quantity	688.5808	1090.20[1]	257.5697	793.0425[1]	674.6525
Concentration	.0921	.0863[2]	.0983	.0960	.0916
Potential Entry	.0077	.0069	.0085	.0126	.0070
Median Income	19154.12	19199.59	19105.32	17629.50[1]	19357.40
Households w/o Cars	12.1279	11.4670	12.8372	13.5550	11.9377
Zip Quality	54.7294	54.9091	54.5368	51.7250	55.1300
Proportion of Sample					
Warehouse Stores	5.00%	6.25%	3.66%	2.50%	5.33%
Traditional Supermarkets	80.29%	66.48%[1]	95.12%	70.00%	81.67%
Superstores	14.71%	27.27%[1]	1.22%	27.50%[2]	13.00%
Stores w/ Scanners	19.71%	32.95%[1]	5.49%	30.00%	18.33%

[1] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 5% or lower level of significance.

[2] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 10% level of significance.

[a] Price index declined; Distribution Service index rose.

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TABLE 8: 1% INCREASE IN THE SLOPE OF THE MARGINAL COST OF OUTPUT (α_{11})					
	Sample	Direction of Price and Services Index Change		Direction of Welfare Change	
		Same Direction	Opposite[b] Directions	Reduction in Welfare	Improvement in Welfare
Observations	337	130	207	330	7
Means of Predicted Change					
Change in Price Index	.4568	.5517[1]	.3971	.4414[1]	1.1791
Change in Services Index	.0973	1.5021[1]	-.7849	-.0887[1]	8.8669
Net Welfare Change	-316.6087	-468.5280[1]	-221.2005	-329.7511[1]	302.9614
Sample Means					
Price Index	99.8010	97.5506[1]	101.2143	99.7834	100.6299
Service Index	97.2156	103.0370[1]	93.5596	96.9043[1]	111.8883
Quantity	690.0898	1274.7335[1]	322.9223	689.2976	727.4344
Concentration	.0923	.0874	.0954	.0921	.1011
Potential Entry	.0075	.0048	.0092	.0071	.0249
Median Income	19169.04	18770.51	19419.32	19246.29[1]	15526.86
Households w/o Cars	12.1727	12.5438	11.9396	12.1333	14.0286
Zip Quality	54.7567	53.8615	55.3188	54.9182	47.1429
Proportion of Sample					
Warehouse Stores	5.04%	8.46%[1]	2.90%	5.15%[1]	0.00%
Traditional Supermarkets	80.11%	59.23%[1]	93.24%	80.30%	71.43%
Superstores	14.84%	32.31%[1]	3.86%	14.55%	28.57%
Stores w/ Scanners	19.88%	43.85%[1]	4.83%	19.70%	28.57%

[1] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 5% or lower level of significance.

[b] Price index rose; Distribution Service index declined.

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TABLE 9: 1% INCREASE IN THE SLOPE OF THE MARGINAL COST OF DISTRIBUTION SERVICES (a_{22})			
		Direction of Welfare Change	
	Sample	Reduction in Welfare	Improvement in Welfare
Observations	340	100	240
Means of Predicted Change			
Change in Price Index	.1429	-.3419[1]	.3450
Change in Services Index	1.6664	-4.1357[1]	4.0839
Net Welfare Change	212.7153	-247.2134[1]	404.3522
Sample Means			
Price Index	99.8166	98.0560[1]	100.5418
Service Index	97.1954	103.8654[1]	94.4163
Quantity	688.5808	1029.3520[1]	546.5928
Concentration	.0921	.0921	.0921
Potential Entry	.0077	.0109	.0064
Median Income	19154.12	18957.16	19236.18
Households w/o Cars	12.1279	11.3470	12.4533
Zip Quality	54.7294	54.6400	54.7667
Proportion of Sample			
Warehouse Stores	5.00%	9.00%[2]	3.33%
Traditional Supermarkets	80.29%	60.00%[1]	88.75%
Superstores	14.71%	31.00%[1]	7.92%
Stores w/ Scanners	19.71%	48.00%[1]	7.92%

[1] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 5% or lower level of significance.

[2] A two sided test of difference in means rejects the null hypothesis of equality between the subsamples at a 10% level of significance.

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APPENDIX TABLE 1: COMPARISON OF MEANS - WAVE 1,2,3

Variables	Wave 1 Mean Value	Wave 2 Mean Value	Wave 3 Mean Value
Price Index	99.2446	99.6510	99.8739
Service Index	100.9912	100.6009	100.0462
Quantity	702.0193	697.8079	693.7460
Labor Cost	99.7483	98.8783	98.8550
Occupancy Cost	100.7275	102.5596	102.8539
Chain Dummy	.6334	.6325	.6255
Warehouse Store	.0477	.0482	.0486
Traditional Market	.7918	.7951	.7935
Superstore	.1605	.1566	.1579
Scan Dummy	.2451	.2390	.2368
Herfindahl	.0922	.0913	.0913
Market Growth	.0036	.0061	.0055
% Households w/o Cars	11.9607	12.8088	12.9905
Zip Quality Index	54.1475	53.9719	54.0263
Shopping Center Dummy	.6247	.6104	.6053
Median Income	19388.43	18932.19	18960.82
Population	31665.83	30974.15	31410.59
Selling Area (hundreds)	185.30	182.9673	182.0316

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APPENDIX TABLE 2 EQUATIONS FOR NONLINEAR ESTIMATION

$$[p^* - C_Q - p]\frac{\partial Q}{\partial p^*} - Q(\mu - 1) = \epsilon_1 \qquad (4)$$

$$-C_D + [p^* - C_Q - p]\frac{\partial Q}{\partial D} - \mu r = \epsilon_2 \qquad (5)$$

where

$$C_Q = e^{\theta_1 S_1 + \theta_2 S_2 + \theta_3 S_3}[\alpha_1 + \alpha_{11}\beta_1 \frac{Q^{\beta_1}}{Q} + \alpha_{12} D][V_1^{\pi_1} V_2^{\pi_2}] \qquad (14)$$

$$C_D = e^{\theta_1 S_1 + \theta_2 S_2 + \theta_3 S_3}[\alpha_2 + \alpha_{22}\beta_2 \frac{D^{\beta_2}}{D} + \alpha_{12} Q][V_1^{\pi_1} V_2^{\pi_2}] \qquad (15)$$

$$p = \sigma_0 + \sigma_1 S_4$$

$$\mu = \frac{e^{\gamma_1 M_1 + \gamma_2 M_2}}{1 + e^{\gamma_1 M_1 + \gamma_2 M_2}} \qquad (12)$$

r is treated as a parameter to be estimated and

$$\frac{\delta Q}{\delta p^*} = (\delta_{10} + \delta_{11} X_1)\frac{Q}{p^*}, \quad \frac{\delta Q}{\delta D} = (\delta_{20} + \delta_{21} X_2)\frac{Q}{D}$$

where $\delta_{10}, \delta_{11}, \delta_{10}, \delta_{11}$ are from estimation of (7).

$$Q = p^{*\delta_1} D^{\delta_2} X^{\delta_3} + \epsilon_3 \qquad (7)$$

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APPENDIX TABLE 3: THREE STAGE NONLINEAR LEAST SQUARES - WAVE 2

Rev 3

PARAMETER	BASE 2		CHANGING VALUE OF σ_1				CHANGING VALUE OF σ_2			
	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR	ESTIMATE	STD ERR
HELD CONSTANT	[VALUE]		[VALUE]		[VALUE]		[VALUE]		[VALUE]	
σ_1	1		5		1.5		1		1	
σ_2	1		1		1		.5		1.5	
θ_1	.0664*	.0207	.0663*	.0207	.0665*	.0207	.0664*	.0208	.0663*	.020
θ_2	.1124*	.0255	.1128*	.0256	.1126*	.0256	.1129*	.0256	.1124*	.0255
θ_3	-.0323*	.0103	-.0325*	.0103	-.0324*	.0103	-.0325*	.0104	-.0324*	.0103
π_1	.0554*	.0225	.0553*	.0225	.0553*	.0225	.0554*	.0225	.0552*	.0225
α_{11}	32.8469*	7.8081	33.1551*	7.7600	32.3260*	7.8002	32.8364*	7.7509	32.8622*	7.8071
β_1	.9650*	.0146	.9656*	.0142	.9643*	.0150	.9649*	.0147	.9650*	.0146
α_{22}	1437.476*	661.8198	1440.784*	665.1095	1446.655*	669.6083	1426.034*	653.6957	1455.736*	676.3066
β_2	.4234*	.0914	.4231*	.0916	.4222*	.0918	.4252*	.0909	.4210*	.0922
α_{12}	.0474*	.0057	.0474*	.0057	.0474*	.0057	.0473*	.0057	.0474*	.0057
σ_0	36.4873*	8.5731	36.7053*	8.5142	36.5434*	8.5743	36.7197*	8.5259	36.5060*	8.5586
σ_1	-.9038*	.4172	-.9028*	.4172	-.9031*	.4172	-.9034*	.4173	-.9028*	.4171
γ_1	.5417**	.3095	.5408**	.3095	.5410**	.3095	.5422**	.3097	.5403*	.3093
γ_2	-2.9097*	.5867	-2.9039*	.5865	-2.9067*	.5866	-2.9101*	.5865	-2.9022*	.5867
r	135.0461*	26.4750	135.1356*	26.5181	134.7499*	26.4791	134.2540*	26.4741	135.8381*	26.5218
P'-C_0-P										
MEAN	19.5165		19.5191		19.5198		19.5421		19.5241	
MINIMUM	1.6886		1.6819		1.6898		1.6985		1.6863	
MAXIMUM	46.8489		46.8425		46.8503		46.8595		46.8471	

* |t| > 2
** |t| > 1.645

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APPENDIX TABLE 4a: NONLINEAR TWO STAGE LEAST SQUARES - [DEMAND EQUATIONS] - 430 OBS

PARAMETER	WAVE 1		WAVE 2		WAVE 3	
	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR	ESTIMATE	STANDARD ERROR
δ_{10}	-2.4404*	.5164	-2.6347*	.4973	-2.3440*	.4925
δ_{11}	.0046*	.0006	.0049*	.0006	.0046*	.0006
δ_{20}	.5106*	.1918	.5504*	.1883	.4547*	.1888
δ_{21}	-.0033*	.0010	-.0037*	.0010	-.0032*	.0010
δ_{31}	-.1095**	.0560	-.1000**	.0534	.0899**	.0537
δ_{32}	1.1382*	.2096	1.2148*	.2002	1.1040*	.1949
δ_{33}	.0794**	.0462	.0786**	.0454	.0783**	.0457
δ_{34}	.7837*	.0471	.7938*	.0466	.8078*	.0463
R^2	.53		.57		.55	
δ_1 MEAN	-2.3854		-2.5719		-2.2842	
MINIMUM	-2.4404		-2.6347		-2.3440	
MAXIMUM	-2.0264		-2.1937		-1.9300	
δ_2 MEAN	.3321		.3507		.2818	
MINIMUM	.1841		.1841		.1379	
MAXIMUM	.4118		.4468		.3651	

* $|t| > 2$
** $|t| > 1.645$

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APPENDIX TABLE 4b: THREE STAGE NONLINEAR LEAST SQUARES - CHANGING WAVES - 430 OBS

PARAMETER	WAVE 2		WAVE 1		WAVE 3	
	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR	ESTIMATE	STD ERROR
HELD CONSTANT	[VALUE]		[VALUE]		[VALUE]	
α_1	1		1		1	
α_2	1		1		1	
θ_1	.0488*	.0219	.0015	.0255	.0666*	.0252
θ_2	.0920*	.0269	.0658*	.0275	.1109*	.0303
θ_3	-.0295*	.0111	-.0378*	.0139	-.0275*	.0113
π_1	.0549*	.0234	.0519**	.0272	.0554*	.0248
α_{11}	38.2078*	10.0407	25.5593*	8.5353	32.2476*	9.6929
β_1	.9557*	.0182	.9799*	.0211	.9776*	.0146
α_{22}	1121.882*	500.2988	1163.837**	613.1804	1071.407*	478.8496
β_2	.4724*	.0940	.4660*	.1056	.4675*	.0924
α_{12}	.0504*	.0063	.0533*	.0076	.0457*	.0060
σ_0	34.5679*	11.2097	42.6209*	10.1525	32.4409*	10.9240
σ_1	-.8696**	.4419	-1.7995*	.5482	-1.2704*	.4908
γ_1	.8203*	.3345	1.4200*	.3827	.7375*	.3303
γ_2	-2.9518*	.6517	-2.6046*	.7152	-3.0065*	.6365
Γ	138.2445*	30.0024	129.2463*	28.7878	132.3092*	27.9281
P^*-C_Q-P						
MEAN	18.4142		17.5103		17.2789	
MINIMUM	-.2623		-17.9850		-1.6612	
MAXIMUM	44.8340		42.2145		51.7331	
OBS<0	1		4		3	

* $|t| > 2$
** $|t| > 1.645$

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