

**Vertical Product Differentiation and Competition in the
Supermarket Industry**

by

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B.A. in Economics and Mathematics, University of California (1993)

Submitted to the Department of Economics
in partial fulfillment of the requirements for the degree of

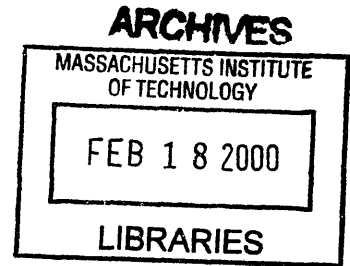
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Abstract

This thesis examines the mechanisms by which retail markets converge to a concentrated structure where competition is dominated by only a few large firms. Using a model of competition based on the vertical product differentiation (VPD) endogenous sunk cost framework proposed by Sutton (1991), several empirical implications are identified and evaluated using a detailed dataset of store level observations from the supermarket industry. Chapter 2 provides a formal test of the hypothesis that the high levels of concentration observed in the supermarket industry are the result of competitive investment in endogenous sunk costs. Using the bounds regression methodology developed in Sutton (1991), I document the existence of a large, positive lower bound to concentration that remains bounded above zero regardless of market size. This exercise is supplemented by a detailed case history of the industry that provides additional evidence that competition is focused on sunk outlays. In chapter 3, I expand the analysis by focusing on the local structure of competition. The principal contributions of the empirical work presented in this chapter involve identifying the high quality set of supermarket firms, demonstrating that they exist only in bounded numbers (do not increase proportionately with the size of the market), and identifying features of the observed market structure which are inconsistent with alternative explanations, namely by highlighting the distinctive nature of strategic complementarity. As such, I demonstrate that the VPD framework accords well with the combination of features observed in the supermarket industry, providing an accurate representation of the mechanisms sustaining its concentrated structure, which appear to be both competitive and stable. Three formal models of retail competition are presented in chapter 4, along with testable implications regarding the strategic interactions of rival firms.

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Contents

1	Introduction	8
2	Does Endogenous Sunk Cost Competition Explain Concentration in the Supermarket Industry?	12
2.1	Introduction	12
2.2	Sunk Costs and the Lower Bound to Concentration: Sutton's Synthesis	16
2.3	A historical overview of the supermarket industry	24
2.4	Data	33
2.5	The Lower Bound to Concentration	37
2.5.1	Scatter Plots	39
2.5.2	Regression Analysis	40
2.6	Summary and Conclusion	47
3	Vertical Product Differentiation and Concentration in the Supermarket Industry	49
3.1	Introduction	49
3.2	The evolution and structure of the supermarket industry	53
3.3	Endogenous Sunk Costs and Supermarket Competition	57
3.3.1	Vertical Product Differentiation and Strategic Complementarity	61
3.3.2	Alternative Explanations for Concentrated Market Structure	63
3.4	Data	67
3.5	Evidence of Oligopoly in Supermarkets	69

3.5.1	The Lower Bound to Concentration	70
3.5.2	Identifying an Oligarchy	71
3.5.3	Top Firms Provide a Distinct Product	76
3.5.4	The Structure of Local Competition	79
3.5.5	A Single Index of Competition	83
3.6	Quality Competition in the Supermarket Industry	87
3.7	Conclusions	91
4	Modeling Competition in Retail Industries: Cost Reduction and the Role of Quality	94
4.1	Introduction	94
4.2	The Baseline Model	97
4.2.1	The Exogenous Sunk Cost Case	98
4.2.2	The Endogenous Sunk Cost Case	100
4.2.3	The Behavior of Best Response Functions	108
4.3	Natural Oligopoly and Cost Reduction	110
4.4	A Model of Demand Enhancing Brandwidth	114
4.4.1	The Behavior of Best Response Functions	118
4.5	Conclusions	119
5	Appendix	122
6	Bibliography	130

List of Figures

2-1	The relationship between concentration and market size.	20
2-2	The effect of an increase in the intensity of price competition.	23
2-3	Market share of A&P (1932)	28
2-4	Concentration in the retail food industry, 1954.	33
2-5	Concentration in the retail food industry, 1963.	34
2-6	The lower bound to concentration (grocery industry)	40
2-7	The lower bound to concentration (supermarket industry)	41
2-8	The lower bound to concentration (supermarket industry - 1998)	41
2-9	Lower bound estimation - 1972	46
2-10	Lower bound estimation - 1998	46
3-1	The lower bound to concentration	72
3-2	Share of the second largest firm	72
3-3	Cumulative market share (Eugene)	74
3-4	Cumulative market share (Los Angeles)	74
3-5	Cumulative market share (West Coast MSAs)	75
3-6	Cumulative market share (State level)	76
3-7	Cumulative market share (regional)	77
3-8	The distribution of γ (all stores)	86
3-9	The distribution of γ (top store)	86
4-1	Concentration $\left(\frac{1}{N}\right)$ versus market size: fragmentation	99
4-2	Quality and the cost of quality versus market size	103

4-3	The relationship between γ and $F(z)$	103
4-4	Determining the equilibrium number of entrants	105
4-5	The solution of polynomial (1.12)	106
4-6	Profit in equilibrium	106
4-7	Concentration as a function of market size	107
4-8	Best response functions	111
4-9	The effect of a unilateral increase in quality	111
4-10	An example of strategic complementarity	120
5-1	Lorenz Curves – Western Markets (MSAs)	123
5-2	Lorenz Curves – Northwestern Markets (MSAs)	123
5-3	Lorenz Curves – Southwestern Markets (MSAs)	123
5-4	Lorenz Curves – Southern Markets (MSAs)	124
5-5	Lorenz Curves – Ohio Valley Markets (MSAs)	124
5-6	Lorenz Curves – Great Lakes Markets (MSAs)	124
5-7	Lorenz Curves – Northeastern Markets (MSAs)	125
5-8	Lorenz Curves – South Atlantic Markets (MSAs)	125
5-9	Map of Tampa, Florida	126
5-10	Map of Los Angeles, California	127
5-11	Map of Sacramento, California	128
5-12	Map of Eugene, Oregon	129

Chapter 1

Introduction

In the past two decades, several retail industries have become dominated by strong regional or even national chains. Whether the market is video rentals, auto supplies, books, or office supplies, these stores share several common features: a wide selection, aggressive pricing and advertising, quick turnover, and significant investment in advanced information and distribution systems (Bendetti and Zellner, 1992; Chakravarty, 1991; Chanil, 1991; Messinger and Narasimhan, 1995; Power and Dunkin, 1990; Saporito, 1991; Zinn and Power, 1990). Firms such as Home Depot, Staples and Crown Books have become household names by providing a staggering array of products at very competitive prices (Bagwell et al., 1997). While there are clearly strong forces encouraging the formation of larger and larger chains, what is unclear is whether these industries are tending toward local monopolies. An alternative hypothesis is that at least some of these retail industries are tending towards “natural” oligopolies, characterized by a small number of firms – but greater than one firm – competing head-to-head in quality in local markets. Because the nature of competition is so different across these two market structures (segmented monopolies versus head-to-head oligopoly), discerning the nature of competition in these markets is important both for antitrust policy as well our more general understanding of retail industries. By focusing on the supermarket industry, where rapidly growing regional chains offer an ever expanding selection of products (Messinger and Narasimhan, 1995), this paper evaluates the differences between these two hypotheses and suggests a methodology for how such an analysis might be applied to retail markets in general.

The principal contributions of the empirical work presented in this paper involve identifying the high quality set of supermarket firms, demonstrating that they exist only in bounded numbers (do not increase proportionately with the size of the market), and identifying features of the observed market structure which are inconsistent with alternative explanations, namely by highlighting the distinctive nature of strategic complementarity.

This thesis examines the mechanisms by which retail markets converge to a concentrated structure where competition is dominated by only a few large firms. Using a model of competition based on the vertical product differentiation (VPD) endogenous sunk cost framework proposed by Sutton (1991), several empirical implications are identified and evaluated using a detailed dataset of store level observations from the supermarket industry. Chapter 2 provides a formal test of the hypothesis that the high levels of concentration observed in the supermarket industry are the result of competitive investment in endogenous sunk costs. Using the bounds regression methodology developed in Sutton (1991), I document the existence of a large, positive lower bound to concentration that remains bounded above zero regardless of market size. This exercise is supplemented by a detailed case history of the industry that provides additional evidence that competition is focused on sunk outlays. In chapter 3, I expand the analysis by focusing on the local structure of competition. The principal contributions of the empirical work presented in this chapter involve identifying the high quality set of supermarket firms, demonstrating that they exist only in bounded numbers (do not increase proportionately with the size of the market), and identifying features of the observed market structure which are inconsistent with alternative explanations, namely by highlighting the distinctive nature of strategic complementarity. As such, I demonstrate that the VPD framework accords well with the combination of features observed in the supermarket industry, providing an accurate representation of the mechanisms sustaining its concentrated structure, which appear to be both competitive and stable. Three formal models of retail competition are presented in chapter 4, along with testable implications regarding the strategic interactions of rival firms.

The formal test of the VPD framework is presented in Chapter 2. First, using a detailed case history of the retail food industry, I document the innovations that led to the exit of a large number of unprofitable firms and increased concentration, highlighting the escalation in both store size and (to a lesser extent) advertising that differentiated the supermarket industry

from the smaller (in both store size and total revenue) grocery industry. Next, using the bounds-regression methodology on a large sample of distinct geographic markets, I document the existence of a large, positive lower bound to the four-firm concentration ratio (C_4) in the supermarket industry that asymptotes with increasing market size to a level above 30%. Using data from 1972 and 1998, I demonstrate that this bound has remained stable for at least 25 years. Since supermarkets invest extensively in store size and product selection and grocery stores compete mostly on the basis of location, the hypothesis that endogenous sunk cost investment is much more effective in the supermarket industry can be tested using a comparison of the two industries. Indeed, I find that C_4 in the grocery industry decreases to a level below 10%. While concentration in the grocery industry is not found to converge to zero, the asymptotic levels predicted constitute a very small degree of concentration, suggesting the role (if any) of endogenous sunk costs in the grocery industry is very limited. In contrast, the asymptotic values found in the supermarket industry converge to a level above 30%, substantially higher than the levels found in the grocery industry. These results indicate that endogenous sunk costs are an important source of concentration in the supermarket industry and may be related to competitive efforts to expand product selection through joint store-firm investments.

Chapter 3 expands this exercise by looking at behavior “above the bound.” I exploit the nature of supermarket competition, namely the existence of geographically distinct markets, to provide explicit tests of the predictions of the VPD model, to identify features of the observed market structure which are inconsistent with alternative models, and, in so doing, deepen our understanding of the nature of retail competition. This empirical characterization is achieved by exploiting a novel dataset of store level observations in 320 geographical markets, where a market is a Metropolitan Statistical Area. Examining these markets, I establish the existence of an oligopolistic structure that does not fragment as market size expands. By narrowing our focus to the store level, I demonstrate that this natural oligopoly extends all the way down to the most local levels. Unable to carve out distinct geographic markets, the natural “oligarchs” compete head to head for the same consumers. I then use this very local nature of competition to demonstrate that quality choice is a strategic complement among supermarkets in the same local markets. Using store size (as a proxy for product bandwidth) to measure quality, I provide evidence that the presence of rival high quality firms forces competing stores to increase their

own level of quality. I account for endogeneity using instruments constructed from the average size of rival's stores outside of the local market.

Chapter 4 contains three formal models of competition in retail markets. The purpose of this chapter is to formulate a model of retail competition with endogenous sunk investments where a few low-cost or high-quality firms – but not one firm – emerge in equilibrium. In addition, I demonstrate that, when investments in quality increase consumers willingness-to-pay, the strategic interaction between firms can distinguish oligopoly models from mechanisms leading to a single dominant firm. To understand this exercise more clearly, I first review the baseline endogenous sunk cost vertical product differentiation (VPD) model developed in Sutton (1991). I demonstrate that, in this model of quality differentiation, the level of quality chosen by rival firms behaves as a strategic substitute. Next, applying the central insight of Spence (1975, 1976) – that when services or quality are a perfect substitute for price reductions, so that consumers care only about price per unit of quality (efficiency units), quality increases are the equivalent of price reductions from the point of view of both buyer and seller – I demonstrate that Sutton's quality differentiation model is equivalent to a model of cost reducing investment. Reinterpreted as a model of cost reduction, Sutton's natural oligopoly result seems to apply not only to models of quality differentiation, but to any industrial application where "rivalry is both tough and focused on fixed outlays, not on per-unit price-cost margins" (Schmalensee, 1992). The central theoretical contribution of this paper is demonstrating that when the relationship between quality and price is non-linear (so that quality and price are no longer forced to be proportional) the strategic interaction between firms shifts from strategic substitutes to complements. The results on the strategic interaction between firms demonstrate that, by estimating firm's reaction functions, it is possible to distinguish models where quality increases expand consumer's willingness-to-pay from models of cost-reducing investment.

Chapter 2

Does Endogenous Sunk Cost Competition Explain Concentration in the Supermarket Industry?

2.1 Introduction

Economists have long been interested in the economic forces shaping the degree of concentration within industries, and how such concentration is influenced by the strategic interaction among firms. While the pioneering work of Bain (1951, 1962, 1956) emphasized the strategic determinants of concentration, Demsetz (1974) and Baumol, Panzar and Willig (1982) focused instead on efficiency differences between heterogeneous firms. The debate deepened with the emergence of a wealth of game theoretic models in the 1980s, emphasizing the strategic interaction between firms but placing few restrictions on the set of possible outcomes (Gilbert (1989) provides a detailed review). Building on research in the 1980s that highlighted the critical relationship between the nature of fixed costs and the conditions determining entry (Spence, 1982; Bresnahan and Reiss, 1987; Berry, 1992), Sutton (1991) provides a synthesis and extension of this work by focusing attention on a) whether fixed costs are exogenously determined or the product of strategic interaction and b) the relationship between equilibrium concentration and the size of the market. The principal contribution of this paper is to provide further empirical

insight into this relationship and the Sutton framework by applying the methodology proposed by Sutton to geographically localized retail markets. Specifically, I present empirical evidence that competition in the supermarket industry is focused on endogenously determined sunk costs and, as a result of this competition, concentration remains bounded above zero regardless of the size of the market.

To understand this exercise more clearly, this paper first reviews Sutton's principal insight and underlying methodology. Although the game theoretic entry models developed in the 1980s admit a tangled complexity of outcomes that depend critically on the structure of the particular game specification (Bresnahan, 1992), Sutton focuses on identifying properties which hold across a broad class of equilibria. Consequently, he emphasizes the single relationship between concentration and market size, relying only on the toughness of price competition and the distinction between exogenous and endogenous sunk costs as explanatory variables. Sutton uses these concepts to place bounds on the set of possible outcomes.

Using this *bounds approach* (Sutton, 1991), he argues that industries may be grouped into two types. In the first type, sunk costs are exogenously determined and the minimum level of concentration decreases to zero as market size increases. Therefore, given a large sample of such markets, one should observe at least a few large markets with relatively low levels of concentration. By contrast, in industries where sunk costs are determined endogenously, this relationship breaks down: as market size expands, the minimum level of concentration is strictly bounded away from zero. The incentive to escalate spending on fixed outlays scales up with the size of the market so that "increases in market size will be associated with a rise in fixed outlays by at least some firms and this effect will be sufficiently strong to exclude an indefinite decline in the level of concentration" (Sutton, 1991). Sutton argues that forces preventing fragmentation are most prevalent in industries where consumers' willingness to pay may be arbitrarily increased through sunk outlays such as advertising (Sutton, 1991) or R&D (Sutton, 1998).

This paper demonstrates how the endogenous sunk cost framework can be empirically tested using data from retail industries. In practice, testing the predictions of the endogenous sunk cost framework has proven to be challenge (Schmalensee, 1992; Bresnahan, 1992; Sutton, 1997). Prior studies, relying on data from manufacturing industries (Sutton, 1991; Robinson and Chi-

ang, 1996; Lyons and Matraves, 1995), focus on either a single industry across a few countries or several industries within a single country. Because many manufacturing industries serve national markets, single industry studies provide very few observations. While cross-industry studies yield a more reasonable number of observations, they require careful (and often flawed) estimation of cost components, particularly the exogenous component of fixed cost (i.e. minimum efficient scale). This study takes a different approach to the problem by focusing on retail industries, which are naturally segmented into distinct geographic markets. This allow us to focus on a single industry with a large number of observations and avoid the direct estimation of cost components, while holding a score of other unknown or difficult to measure variables constant. Therefore, retail markets combine the clean properties of the single industry study with the larger scale available in cross-industry analysis.

This paper focuses on competition in the retail food industry. Although “supermarket” and “grocery store” are often used as synonyms in newspapers and common speech, they are in fact distinct industries and are treated as such by the Federal Trade Commission (FTC). In particular, the FTC defines a supermarket as a “full-line retail grocery store with annual sales of at least \$2 million that carries a wide variety of food and grocery items” (Baer, 1999). Grocery stores are defined to be “retail stores other than supermarkets that sell food and grocery products” with annual sales of less than \$2 million.¹ Note that these are establishment (store, not firm) level definitions. The distinction between industries is significant because, as this paper documents, the nature of competition is very different across these industries.

In particular, this paper presents empirical evidence that endogenous sunk costs play a central role in determining the equilibrium structure of the supermarket industry, but do not significantly impact the grocery industry. Through a detailed case history of the retail food industry, I document the innovations (e.g. the invention of the supermarket format, the switch to self-service, and a decrease in transportation costs) that led to the exit of a large number of unprofitable firms and increased concentration. The analysis highlights the escalation in both store size and, to a lesser extent, advertising that differentiated the supermarket industry from

¹Examples include neighborhood “mom and pop” grocery stores, convenience stores, and specialty food stores. These stores do not offer the set of products and services that enable supermarket consumers to “one-stop shop” for food and grocery products. In addition, supermarkets primarily benchmark their food and grocery prices using the prices of nearby supermarkets and do not regularly price check products at other types of stores or change their prices in response to price changes by other types of stores (Baer, 1999).

the smaller (in both store size and total revenue) grocery industry.

This paper then applies the bounds-regression methodology to a large sample of distinct geographic markets. I document the existence of a large, positive lower bound to the four-firm concentration ratio (C_4) in the supermarket industry that asymptotes with increasing market size to a level above 30%. Using data from 1972 and 1998, I demonstrate that this bound has remained stable for at least 25 years. Since supermarkets invest extensively in store size and product selection and grocery stores compete mostly on the basis of location, the hypothesis that endogenous sunk cost investment is much more effective in the supermarket industry can be tested using a comparison of the two industries. Indeed, I find that C_4 in the grocery industry decreases to a level below 10%. While concentration in the grocery industry is not found to converge to zero, the asymptotic levels predicted constitute a very small degree of concentration, suggesting the role (if any) of endogenous sunk costs in the grocery industry is very limited. In contrast, the asymptotic values found in the supermarket industry converge to a level above 30%, substantially higher than the levels found in the grocery industry. These results suggest that endogenous sunk costs are an important source of concentration in the supermarket industry and may be related to competitive efforts to expand product selection through joint store-firm investments. For example, investments in information technology and advanced distribution systems link store level investments (e.g. store size) to firm level decisions. This may help to explain some of the motivation for operating a chain of stores. However, moving beyond suggestive evidence of the sources of endogenous sunk costs in the supermarket industry and identifying the strategic nature of competition requires a much more detailed dataset than is available here. Chapter 3 of this thesis employs a dataset consisting of store level observations to establish that large supermarkets constitute a local natural oligopoly based on competitive investment in store size.

This paper is organized as follows. I begin with a brief overview of a model of endogenous sunk cost competition and the testable implications provided. I then present an historical view of the supermarket industry. The data are discussed in section 4 and the empirical findings follow in section 5. I conclude with a discussion of the results and topics for future research.

2.2 Sunk Costs and the Lower Bound to Concentration: Sutton's Synthesis

The goal of this section is to provide an overview of Sutton's (1991) bounds approach and endogenous sunk cost (ESC) framework, placing it in the context of prior attempts to understand market structure and indicating how it can be used to identify the forces governing competition in the supermarket industry. The bounds approach and the ESC framework extend a long line of research focusing on the economic forces determining the realized levels of market concentration. The pioneering case study analysis of Stigler (1949, 1968) gave way to the cross-industry, theory testing vision of Bain (1951, 1956, 1962), who used a broad run of industries to evaluate the structure-conduct-performance (SCP) paradigm, emphasizing strategic explanations for high degrees of observed concentration. Demsetz (1974) argued that concentration was the result of superior capabilities, not strategic behavior; this efficiency explanation was formalized in the contestability models developed by Baumol, Panzar and Willig (1982). Beginning in the 1980s, a wealth of game theoretic models criticized the strong assumptions of the efficiency argument. The new focus on precise, game theoretic models produced a large body of "particularizing" theory (Fisher, 1989) where a "tangled web of delicate informational and commitment opportunities seemed critical to understanding how individual firm strategies would play out in equilibrium" (Bresnahan, 1992). This highly specific theory led to detailed statistical studies of specific industries (Bresnahan (1989) provides an excellent review), which created a wealth of *stylized facts* (Schmalensee, 1989) and the cynical criticism that "anything can happen." Sutton (1991) extends the work of Bresnahan and Reiss (1987) and Berry (1992), which shifts the focus to identifying propositions that hold across a broad set of equilibria. Because the "right" model is rarely obvious and many models involve multiple equilibria, making general claims that hold across a broad run of industries requires identifying "strong" mechanisms that hold across entire classes of models.² Understanding the primary determinants of market struc-

²For example, specific models may allow for extensive variation in the type (or toughness) of competition, the nature of entry (e.g. sequential or simultaneous), the equilibrium selection mechanism, the role of information, and the nature of players' beliefs. The point of focusing on strong mechanisms is to identify properties that hold in all of these cases.

ture is interesting both in its own right and for how it might inform competition policy.³ To begin unpacking the determinants of market structure, it is necessary to first understand the relationship between equilibrium price and the number of entrants.

The notion that equilibrium concentration should fall with market size is in no sense novel. Indeed, in a simple economic model with both fixed and marginal costs, firms will only enter as long as they can profitably cover fixed costs (up to an integer constraint). Therefore, larger markets, with more consumers over which to spread fixed costs, will support a greater number of firms. Bresnahan and Reiss (1987, 1990) apply this logic to conclude that if both price and total industry profit fall with entry (the price-competition effect), the number of entrants should increase less than proportionately with the size of the market.⁴ If price competition did not intensify with entry (and profits were the same), the number of entrants would be proportional to market size. Therefore, the direct result of price competition is higher equilibrium concentration. The authors quantify the price-competition effect by estimating what they call the *threshold market sizes* at which entry by an additional firm becomes profitable. Looking at a sample of geographically isolated (rural) markets, they find that entry indeed increases less than proportionately with market size, but that the price-competition effect is exhausted with 3-5 entrants, after which market size and the number of entrants increase proportionately.

Drawing on the central insight of the Demsetz critique (Demsetz, 1974), Berry (1992) explores an alternative explanation for the “less than proportionate” increase: that more efficient firms enter first. Using a dataset of airline firms operating in city pairs and a clever simulation estimator, Berry conducts an exercise similar to Bresnahan and Reiss while also controlling for firm heterogeneity. Although he finds that heterogeneity is significant, his results are consistent with a strong price-competition effect. Together, these papers provide strong empirical evidence for the stylized fact (Schmalensee, 1989) that price falls with increased entry and that tougher price competition is consistent with higher equilibrium concentration. This finding forms one of the basic assumptions of the Sutton framework.

While both Bresnahan and Reiss and Berry focus on the relationship between market size

³For example, attempts to increase competition by limiting seller concentration are only warranted if concentrated equilibria are the product of weak competition.

⁴Since profits are lower when a second (third, fourth, etc.) firm enters the market, the size of the market required to profitably sustain two firms is greater than twice the size of the market required to sustain a monopoly.

and fixed costs, Sutton (1991) substantially broadens both the scope and generality of this empirical work by organizing his analysis around the distinction between exogenous and endogenous sunk costs, and their impact on the single empirical relationship between market size and equilibrium concentration.⁵ Sutton specifies a model where firms, operating within the context of a multi-stage game, choose levels of fixed and sunk costs,⁶ and then, having made these investments, compete in a final stage price game. Specifically, competition takes place in two stages. In the first stage, firms choose whether to enter and incur a fixed and sunk cost F . In the second stage (price competition), firms earn profit $S\pi$, where S denotes market size and π is a function of the products entered (and fixed costs incurred) by all the firms in stage 1. Sutton (1997) establishes the following theorem:

Theorem 1 *Non-fragmentation (Sutton, 1997)*

Suppose: for some constants $\delta > 0$ and $K > 1$, a firm that spends K times as much as any rival on fixed outlays will earn a final stage payoff no less than δS ;

Then: there is a lower bound to concentration (as measured by the maximal share of the largest firm), which is independent of the size of the market.

Proof. see Sutton (1997) ■

Stated more loosely, “as market size increases, the incentives to escalate spending on fixed outlays rises. Increases in market size will be associated with a rise in fixed outlays by at least some firms and this effect will be sufficiently strong to exclude an indefinite decline in the level of concentration” (Sutton, 1997). This *escalation mechanism* (Sutton, 1991) follows from the fact that the relative increase that a firm can achieve through an increase in fixed outlays is correspondingly greater as each firm’s market share is relatively smaller. The lower bound to concentration depends on the degree to which escalations in fixed outlays increase profits in the final stage (measured by the ratio $\gamma = \frac{\delta}{1+K}$). In industries where δ (and thus γ) equals zero, the

⁵Sutton makes several contributions to this literature. First, he formalizes the intuition that concentration may fall indefinitely as market size increases. He illustrates this fragmentation result using a model of competition that relies only on the assumption that profit per firm decreases with entry. Second, he identifies conditions under which the fragmentation result fails so that equilibrium *concentration* remains bounded above zero regardless of how large the market becomes. Using an alternative specification, Shaked and Sutton (1983) identify conditions under which no further *entry* will occur beyond a certain market size, resulting in a “natural oligopoly” consisting of a finite number of firms.

⁶These sunk costs might take the form of a new plant, a new product, R&D expenditures, advertising or a host of other quality enhancing sunk investments.

lower bound to concentration will tend to zero as market size expands, but industries for which γ lies above some minimal positive value have concentration levels which are bounded below. In these non-zero γ industries, firms are able to “enhance consumers’ willingness-to-pay for a given product...by way of a proportional increase in fixed costs” (Sutton, 1991). These industries, where concentration remains strictly positive regardless of the size of the market, are classified as endogenous sunk cost industries. Conversely, industries where $\gamma = 0$ (sunk outlays do not increase willingness-to-pay) are classified as exogenous sunk cost industries. More generally, Schmalensee (1992) demonstrates for an industry to exhibit endogenous sunk cost behavior, “what does seem to be necessary is that market share be sufficiently sensitive to variations in *fixed* costs, so that rivalry is both tough and focused on fixed outlays, not on per-unit price-cost margins.” Therefore, any sunk outlay which increases consumers willingness to pay in the final stage is an endogenous sunk cost. Sutton and subsequent authors have focused on advertising and R&D as the main examples.⁷

A somewhat more subtle insight developed by Sutton concerns his emphasis on identifying the lower bound to concentration, rather than predicting the precise level of concentration corresponding to a given market size. As stated, the non-fragmentation theorem simply puts bounds on the outcomes which can be sustained as equilibria. This lack of precision is a product of the theory’s breadth. What occurs above the bound varies dramatically depending on the specifics of the model chosen. In particular, Sutton emphasizes that, while specific models may yield unique predictions, those predictions depend critically on the parameters of the models chosen, resulting in a variety of “point” predictions associated with different specifications. Allowing variation in the form of competition, type of equilibrium, sequence of entry, and role of information will lead to several distinct outcomes. The central insight of Sutton’s approach is that, for a broad class of models, it is possible to place bounds on the set of these “point” predictions.

To fix ideas, it is necessary to focus on a few specific examples. Consider a simple model where products are homogenous and the type (toughness) of competition is the same across

⁷The endogenous sunk cost mechanism is nicely illustrated using the example of computer microchip production. To produce faster microprocessors or memory chips with larger capacity it is necessary to invest in large, state of the art fabrication plants, without increasing marginal costs. Since chips are valued almost exclusively on speed or capacity, a manufacturer can increase consumers’ willingness to pay by increasing its sunk outlays. Therefore, it should not be surprising that chip sales are concentrated among only a few large firms.

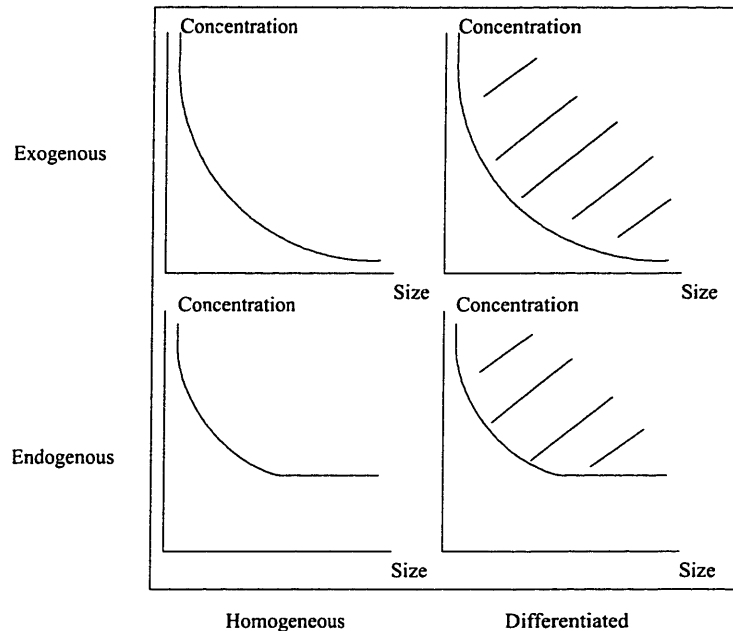


Figure 2-1: The relationship between concentration and market size.

markets. Shaked and Sutton (1987) demonstrate that, in this case, each market size yields a unique equilibrium. Therefore, there is a unique mapping from market size to concentration. However, the relationship between market size and concentration depends critically on the type of sunk costs required to compete in the industry. This dependence is illustrated in the left panels of Figure 2-1. Equilibrium concentration in industries with exogenous sunk costs tends to zero as market size increases. In contrast, equilibrium concentration in endogenous sunk cost industries ($\gamma > 0$) tends to a strictly positive value (compare the figure in the upper left corner to the figure in the lower left corner). In both of these cases, the figure illustrates the actual *level* of concentration, not a lower bound. Therefore, empirical studies of homogeneous industries should (in theory) uncover a tight, functional relationship between concentration and size. However, few industries have so simple a structure. At least some degree of product differentiation exists in most every industry, as do differences in price competition and the sequence of entry. When the analysis is extended to include horizontally (for example spatially) differentiated products for example, the tightness of these predictions are weakened.

When markets are spatially differentiated, as in the case of most retail markets, we are

unable to determine if the equilibrium chosen will consist of several firms each operating a single plant or a few firms operating several plants, even if the plants owned by each type of firm operate at minimum efficient scale (Shaked and Sutton, 1990). This indeterminacy is a direct result of multiple equilibria and the issue impacts any differentiated products market. Whether one firm produces many products or several firms produce a few products is simply a particular choice among multiple equilibria.⁸ More precise predictions cannot be made without putting more structure on the problem. The key insight of the bounds approach lies in identifying properties which hold across a class of models, irrespective of the specific choice among non-unique equilibria. This intuition applies not only to the product differentiation example considered here, but also to variation in the form of entry, type of competition, and the role of information (Sutton, 1991).

The non-fragmentation theorem in fact provides a strong prediction: in industries characterized by endogenous sunk costs, there is a lower bound to concentration. This prediction holds across a broad class of models. To illustrate this prediction, let $C(S)$ be a function mapping each market size to the least concentrated equilibria consistent with a market of size S . In exogenous sunk cost industries, the *lower bound function* $C(S)$ decreases indefinitely as market size S expands, whereas in endogenous sunk cost industries, $C(S)$ remains strictly positive as market size increases. While we cannot predict what will occur above the bound, we may rule out outcomes which lie below it. Both of these cases are represented in the right panels of Figure 2-1, which illustrate how the bounds approach rules out equilibria below the lower bound, while placing no restrictions on behavior above it. The entire set of points above the bounds in the right panels of Figure 2-1 are feasible outcomes – only points below the bounds are ruled out. This contrasts sharply with the exogenous sunk cost case (represented in the left panels of Figure 2-1), in which the precise level of concentration is determined for each market size.⁹

Variation in the toughness of price competition across markets further justifies focusing

⁸Of course, if there are cost advantages to offering several products (stores), then more concentrated equilibria will be favored. However, since even these cost advantages presumably have a limit, horizontal product differentiation (HPD) alone will not prevent an industry from fragmenting beyond some market size (Shaked and Sutton, 1990).

⁹We can summarize the main contributions of Sutton's research on market structure as a) identifying a second "strong" mechanism (that in the presence of endogenous sunk costs, the tendency for markets to become indefinitely fragmented breaks down) and b) demonstrating that within a general framework, we can only place bounds on the set of possible outcomes.

on the lower bound to a set of feasible equilibria. Restated within the context of the bounds approach, Bresnahan and Reiss (1987) demonstrates that, when entry intensifies price competition, the lower bound to concentration is higher than if entry had no effect on price (or profit). Sutton (1991) extends this intuition to include the effect of any exogenous influence (e.g. transportation costs, regulation) that intensifies price competition or alters the structure of the underlying game. Sutton's approach is motivated by the existence of unobservable factors such as information asymmetries, equilibrium selection mechanisms, and agent belief structures. He exploits the fact that, just as with entry by additional firms, changes in these factors simply shift the functional relationship between price and profit. In the context of price competition, increasing the toughness of competition reduces the ex post gains from entry and leads to more concentrated equilibria by shifting the lower bound to concentration $C(S)$ up, but has no impact on its asymptotic level (Figure 2-2). Specifically, Cournot competition will lead to higher equilibrium concentration for all market sizes than joint profit maximization. On the other hand, an increase in horizontal product differentiation, which reduces the intensity of price competition, shifts the lower bound down. However, the central prediction of Theorem 1 continues to hold. Concentration in an endogenous sunk cost industry with softer price competition will still be bounded above zero, the bound $C(S)$ will simply be lower (closer to the horizontal axis) than in an industry with tougher price competition. Similarly, if an exogenous sunk cost industry experiences a sudden increase in the intensity of price competition, the lower bound will shift up, resulting in higher equilibrium concentration at all market sizes, but $C(S)$ will still converge to zero as market size expands. Clearly, if the toughness of price competition varies across markets, we will only be able to identify a lower bound to the set of possible outcomes. Finally, increases in the (exogenous) fixed cost of entry have the same effect as an increase in the intensity of competition. Because the cost that a firm must recover to break even is higher, fewer firms will "fit" into a given market size, increasing the overall level of concentration.

While prior applications of the bounds methodology have focused almost exclusively on cross-national differences in manufacturing industries, the methodology can be applied to any set of markets which a) operate according to similar underlying economic forces, but b) vary by size and the number of entrants. In particular, retail industries, such as the grocery and

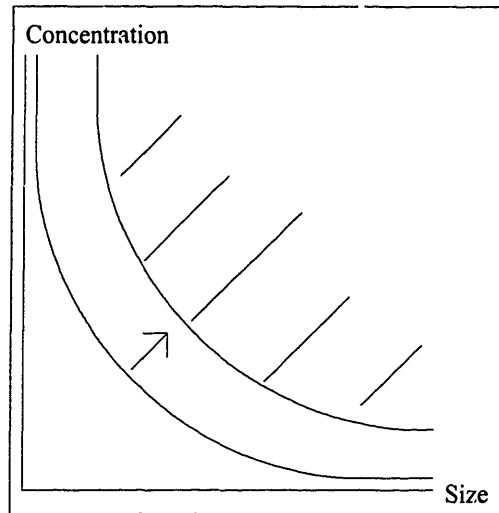


Figure 2-2: The effect of an increase in the intensity of price competition.

supermarket industries, provide an attractive application. By focusing on these industries, this study identifies the economic drivers of concentration in these industries (exogenous versus endogenous sunk costs) and provides insight into the generality of Sutton's approach.

Specifically, due to their competitive investment in both advertising and store size, I argue that supermarkets are an example of an endogenous sunk cost industry, while grocery stores, which do not significantly invest in either, are not. Therefore, a testable implication of the model is that the effect of endogenous sunk cost competition will be much more substantial in the supermarket industry. In particular, if the impact of sunk investment on profit is indeed larger in the supermarket industry, the non-fragmentation result should be more pronounced in this industry.

Both the supermarket and grocery industries are spatially and horizontally differentiated,¹⁰ compete in ways that undoubtedly vary by market, and are unlikely to face the same entry conditions across markets.¹¹ Consequently, when we plot concentration versus market size, we

¹⁰A supermarket chain is simply an example of a firm with several plants operating at minimum efficient scale (MES), while an independent is a single plant firm which may or may not be operating at MES. Supermarkets and grocery stores also sell differentiated products: store layouts and the products offered are tailored to different consumer groups. The degree of both types of differentiation is likely to vary both by region and over time depending on transportation costs, population density, income, and other factors.

¹¹For example, newer markets are more likely to have seen simultaneous entry by large, established super-

should expect to find a cloud of points. Sutton developed the bounds approach precisely to handle this issue. The testable restrictions will be on the bounds constraining these scatters of points: concentration will only be bounded above zero in the presence of endogenous sunk costs. Specifically, the lowest level of concentration for the supermarket industry should be significantly higher than the lowest level of concentration for the grocery industry. Moreover, using a detailed case history, we should be able to identify both the escalation mechanism (increasing investment in sunk outlays by a small subset of firms) and the impact of the price-competition effect (exit by under-performing firms) in the historical development of the industry. I turn to this exercise in the following section.

2.3 A historical overview of the supermarket industry

Because the sunk cost framework relies on a game-theoretic approach to explain market structure, case history evidence can play a significant role in evaluating its claims. In particular, the framework provides implications about how firms will react to changes in market conditions. When conditions change over time, case histories allow us to observe how firms react.¹² According to Sutton (1997), “the empirical content lies in the claim that certain outcomes will not be observed, and the model of necessity provides us with a qualitative description of the kind of deviation which will be profitable in such a configuration.” If the importance of endogenous sunk costs increases, the escalation process should be accompanied by rising advertising (or other sunk cost) to sales ratios, falling profit to sales ratios, and exit by unprofitable firms resulting in a more concentrated equilibrium structure.

Examining both the supermarket and grocery industries, I find that only the development of the supermarket industry in the 1950s follows this pattern; exit by small firms together with massive increases in both store size and the array of products offered resulted in large increases in local concentration. This contrasts with the (earlier) development of the grocery industry, brought on by the chain store revolution. Although concentration did increase sharply with the introduction of the chain store, there is no evidence that competition was focused on sunk costs.

market chains, while some older markets have been served by the same dominant chain for decades.

¹²For example, Greif (1993) and Genesove and Mullin (1998) use case history evidence to evaluate the predictions of game theoretic models

While the falling costs of storage and transportation may have increased economies of scale and the toughness of price competition, the focus of competition remained price-cost margins, not sunk outlays. Accordingly, while many markets became concentrated, it is likely that *some* markets remained quite unconcentrated during the grocery era. The focus of competition shifted with the introduction of the supermarket format, which greatly changed the nature of the product offered to consumers. Firms began competing in store size and product offerings and local concentration increased dramatically.

From 1880 to the present, the retail food industry evolved from the general store, which operated on a premise of low turnover and high margins, to a mixture of modern supermarkets, operating on a premise of wide variety, high turnover and low margins, and grocery stores, offering convenience (often in the form of proximity) at the expense of both price and variety. There were two periods of major change: 1910-1930 (the rise of the chain stores) and 1930-1960 (the introduction of the supermarket).

The first major change in the industrial structure of the retail food industry was the chain store revolution (Adelman, 1959; Progressive Grocer, 1995). The chain stores, led by A&P, gained a cost advantage over independent stores by integrating backward into wholesaling and manufacturing. Due at least in part to decreases in transportation costs, chains were able to create a large network of stores that could take advantage of quantity discounts on the products they didn't make themselves and economies of scale on self-produced items (Tedlow, 1990). The chain stores also benefited from the scale economies associated with information processing (Tedlow, 1990). The large number of stores and intricate distribution network allowed the chains to centralize accounting and better forecast demand, resulting in more efficient inventory management and site selection. These cost savings were passed through to consumers in the form of lower prices. Various price studies performed in the late 1920s and early 1930s found that chain store prices were 4.5-14% lower than their independent counterparts (Tedlow, 1990). Concentration also rose sharply. Between 1919 and 1932, the share of the top 5 firms in the U.S. increased from 4.2% to 28.8%, and the share of all chain stores (firms operating four or more stores) increased to over 35% (Lebhar, 1952).

Although substantial changes occurred over this period in all segments of the economy, the structural changes in the food industry seem to have been driven by two factors. First, the

fixed (exogenous) cost of entry seems to have increased substantially so that the minimum efficient scale was no longer a single store, but a chain of stores (Lebhar, 1952). Second, the fall in transportation costs intensified competition among stores, as evidenced by falling prices (Tedlow, 1990). While the Sutton model would suggest that each of these changes will lead to an upward shift in the lower bound to concentration, neither will affect the asymptotic behavior of the lower bound (see Figure 2-2).

To see why operating a chain of grocery stores did not involve endogenous sunk outlays, it is important to understand exactly how scale impacted the food industry. In order to take advantage of scale economies, it was not *necessary* that stores be jointly owned (though it was clearly feasible). By joining a cooperative or simply purchasing from a large wholesaler, small stores could take advantage of quantity discounts as well. In fact, although the distribution system they employed was quite new, the physical stores operated by the chains were not much different from their independent counterparts: delivery and credit were common in many locations and consumers were still served by a clerk who would retrieve items and suggest others (Tedlow, 1990). The chains also did not significantly advertise or build larger stores. Their main advantage was a distribution system introduced first by the chains and later adopted by independents. Furthermore, building a distribution center and operating trucks is certainly a fixed cost, but probably not a sunk one. The escalating level of sunk outlays consistent with a shift to endogenous sunk cost competition was absent from the development of the grocery industry. From the perspective of the sunk cost framework, the chain store revolution may have simply intensified price competition among stores, rather than leading to endogenous sunk cost competition. It also greatly increased the number of equilibria which could occur in any given market as firms could now own any number of stores. If this is in fact the case, we should observe rising concentration, consistent with an upward *shift* of the lower bound (and increasing heterogeneity above the bound), but the lower bound should still decrease to zero as market size expands.

While detailed micro data on the structure of the retail food industry are not available prior to 1929, it is still possible to form a picture of the overall market structure using aggregate data and a few specific examples. For example, the dramatic increase in market share of the top 5 firms (their share of sales increased from 4.2% in 1919 to 28.8% in 1932 (Lebhar, 1952)

indicates that concentration grew substantially prior to 1929. By 1929, the market share of all chain stores (firms operating 4 or more stores) reached 38.5% (Lebhar, 1952). This share remained stable (at around 38%) until well after the introduction of the supermarket format in the 1930s (Lebhar, 1952). Clearly, the chain store revolution dramatically increased the overall level of concentration. However, it seems clear that the increase in concentration was consistent with either the price-competition effect, an increase in exogenous sunk costs, or the increasing multiplicity of feasible equilibria (or a combination of the three), but not with the introduction of endogenous sunk costs. To establish this point directly, we need to observe the asymptotic behavior of the lower bound to concentration.

Unfortunately, detailed market share data is only available for a single firm, A&P. However, the ad hoc decision to focus on only a single firm to document equilibrium market structure of the entire industry is mitigated somewhat by the fact that A&P played such a dominant role in the grocery industry during this period (Adelman, 1959). In particular, A&P's share of national sales was 16.4% in 1931, while the next 4 largest chains only accounted for an additional 12.1% (Lebhar, 1952). The combined market share of all other chains (more than four stores) accounted for only an additional 10%. Furthermore, historical evidence indicates that no other chain had a national presence anywhere approaching that of A&P (Adelman, 1959). Therefore, A&P was likely market leader in almost every market in which it competed and thus, despite the fact that data on local concentration is not available for this time period, we can establish a reasonable picture of the structure of local markets by using A&P's share of local markets as a proxy for the share of the largest firm. Nonetheless, these results should be viewed with a degree of skepticism as this exercise would be completely misleading if A&P were not such a dominant firm. Adelman (1959) presents A&P's share of overall sales in 43 cities for 1932. Figure 2-3 shows the relationship between concentration and market size for these markets. For this set of markets, A&P's share of total sales actually appears constant in market size, suggesting that concentration was not so much related to scale as to the choice among multiple equilibria stemming from the ability to operate any number of stores. The existence of several relatively unconcentrated small markets is inconsistent with the presence of substantial (exogenous or endogenous) sunk costs.

While the rise of the grocery store seems relatively disconnected from statistically conse-

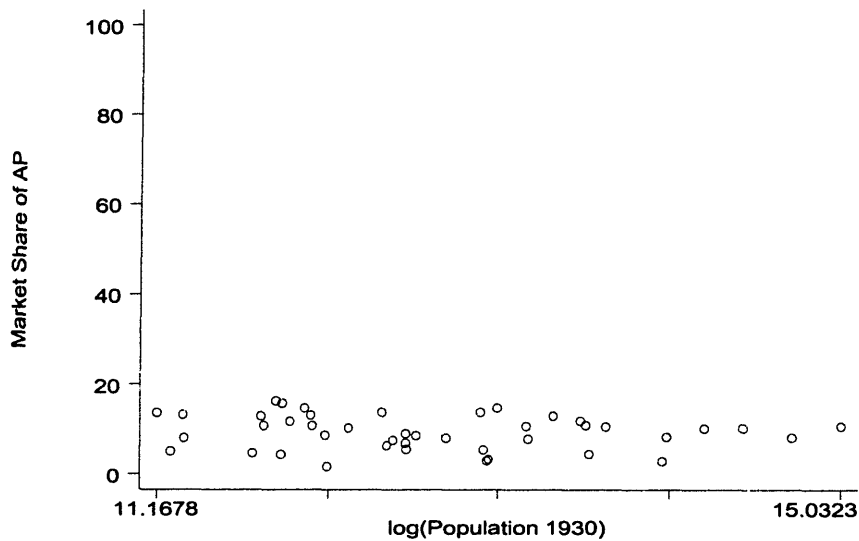


Figure 2-3: Market share of A&P (1932)

quential endogenous sunk cost investment (e.g. operating a chain of grocery stores did not require any significant *sunk* outlays and there is no evidence of rising levels of sunk outlays among these firms), the formation and growth of the supermarket industries revolves directly around such investments. Consider first the “inventor” of the supermarket format, Michael Cullen, of the now defunct King Kullen supermarket chain. In 1930, Cullen brought a proposal to his employers at Kroger (the second largest *grocery* chain) detailing his plan for a new breed of huge, cash only, non-delivery, self-service stores. These new super stores would be located on the outskirts of town to take advantage of low rents. Furthermore, these stores would sell a wide variety of nationally advertised, branded goods and would advertise heavily. His proposal called for $\frac{1}{2}\%$ of sales (20% of net profit) to be spent on advertising. Cullen’s plan was to operate on low margins and low expenses, making up the difference on volume. Unlike the price reducing scale economies inherent in the chain store formula, Cullen changed the nature of the store itself, introducing a new, vertically differentiated product. His most important changes were increased store size (5 times larger), suburban location, the shift to self-service, and advertising.¹³ The introduction of the supermarket format coincided with growth in na-

¹³Cullen’s proposal was ultimately rejected by his supervisors at Kroger, prompting him to form his own chain

tionally advertised brands which the chains, who were heavily invested in their own brands, often refused to carry. The popularity of national brands reduced the cost advantage of vertical integration into manufacturing.

Again, transportation costs played a central role, along with decreased storage costs. The spread of the automobile and paved highways facilitated the supermarkets' strategy of locating on the outskirts of town. Advances in refrigeration allowed shoppers to make fewer trips by stocking up while the retailers themselves faced lower storage costs.¹⁴ The invention of the shopping cart helped facilitate bulk purchases. Clearly, these changes in transportation and storage represented a large decrease in the degree of locational differentiation, as consumers now had several alternative outlets to frequent. However, the introduction of the supermarket represented a dramatic change in the cost structure of the retail food industry. Firms were now building stores that could not easily be converted and resold for other uses. The desire to accommodate a larger variety of products increased the degree to which investment was sunk. Furthermore, as stocking a large array of products intensified the need to invest in information technology, a connection was established between store and firm level investment. The introduction of the supermarket essentially created a new industry, built largely on investments consistent with endogenous sunk costs. Over time the supermarket and grocery segments became increasingly distinct, with supermarkets becoming the primary food providers while grocery stores evolved into convenience stores and corner stores that captured a much smaller portion of the overall food market.

The rise of the supermarket industry carries the fingerprint of the endogenous sunk cost escalation mechanism: falling margins, escalating sunk outlays, and the appearance of a lower bound to concentration which remains strictly positive as market size increases. With the introduction of the supermarket format, margins began to fall in the retail food industry (Table 1).¹⁵ The falling margins were accompanied by the exit of a large number of stores (Tables 2 & 3), as single store firms exited the market and multi-store firms either exited or closed

of supermarkets, King Kullen. The supermarket format was later adopted by Kroger when it became obvious that the supermarket would become the dominant format.

¹⁴In fact, the supermarket format had been introduced without success much earlier (1910-20) in a few cities, but it was not until shoppers were able to make larger, less frequent trips that the format thrived (Tedlow, 1990).

¹⁵Since the introduction of the supermarket coincided with the Great Depression, we should not overemphasize the importance of falling profits.

old grocery stores to open new supermarkets. Both the number of supermarket stores and the market share of supermarket firms grew considerably throughout the 1950s and 1960s (Table 3). The growth of the supermarket industry was accompanied by a rapid growth in both the average store size and the average number of products carried per store (Table 4). Advertising, which increased sharply with the introduction of the supermarket, remained thereafter at the same levels.¹⁶ Although the grocery industry also experienced a substantial exit of firms, it was not accompanied by either escalating store size or increasing advertising levels. By 1972, the average C_4 (across 263 MSAs) in the grocery industry was 25.4% with a minimum value of 8.6%, compared to 69.5% and 34.5% respectively in the supermarket industry.

However, beyond these averages, the principal insight into market structure lies in the overall distribution of equilibrium outcomes. Specifically, how did the introduction of the supermarket format impact the lower bound to concentration? Unfortunately, separate data on the two industries is not available prior to 1972. Figures 2-4 and 2-5 present plots of C_4 versus market size (measured by the log of population) for the combined industry for 1954 and 1963. Concentration is clearly bounded above zero in both years, suggesting that the convergence mechanism had broken down in at least one of these industries by 1954. The degree to which endogenous sunk costs impacted each industry is addressed in section 2.5, in which separate lower bounds to concentration are estimated for each industry for 1972.

To summarize, although the chain store revolution dramatically increased concentration in the grocery industry, there is little evidence linking the rise of the chain stores to any substantial investment in sunk outlays. The chain stores offered essentially the same product as their independent counterparts, albeit at lower prices. However, the independent stores were able to narrow the price margin by forming cooperative buying associations. There is no evidence of investment in quality enhancing sunk costs by either set of firms, and the increasing levels of concentration appear to be the product of tougher price competition and a greater multiplicity of equilibria. On the other hand, the creation of the supermarket format introduced a new, higher quality product requiring substantial investment in both advertising and store size. The shift of competitive focus onto sunk outlays is reflected in the rising number of products offered, the dramatic increase in store sizes, the exit of large numbers of smaller firms, and the appearance

¹⁶The advertising/sales ratio is still about 1.5% (Adweek, 1998).

of a positive lower bound to concentration. We turn to the formal test of the significance of this lower bound in section 2.5.

Table 1
Top 4 Profits

Year	Gross Margin
1931	21.5
1932	22.1
1933	22.8
1934	21.7
1935	20.2
1936	19.9
1937	19.2
1938	19.6
1939	19.3
1940	18.1
1941	17.3
1942	15.9
1943	15.8
1944	16.1

Source: Lebhar, 1952.

Table 2
Grocery Store Firm Types

Year	Grocery Stores	Single-Store Firms	Multi-Store Firms
1939	387,000	334,000	53,000
1948	378,000	347,000	31,000
1954	279,000	254,000	25,000
1958	260,000	235,000	25,000
1963	245,000	215,000	30,000

Source: Lebhar, 1952.

The unit of observation in all three columns is the store.

Table 3
Supermarket Share

Year	Total Foodstores	Supermarkets	Supermarket Share of Sales
1939	386,900	NA	18.3%
1958	259,756	15,282	46.9%
1967	218,130	23,808	62.6%
1977	175,820	33,120	76.3%
1982	162,000	28,950	71.7%
1987	150,000	30,400	73.0%
1991	140,000	30,670	74.9%
1997	126,000	30,300	76.7%

Source: Grinnel et al., 1979.

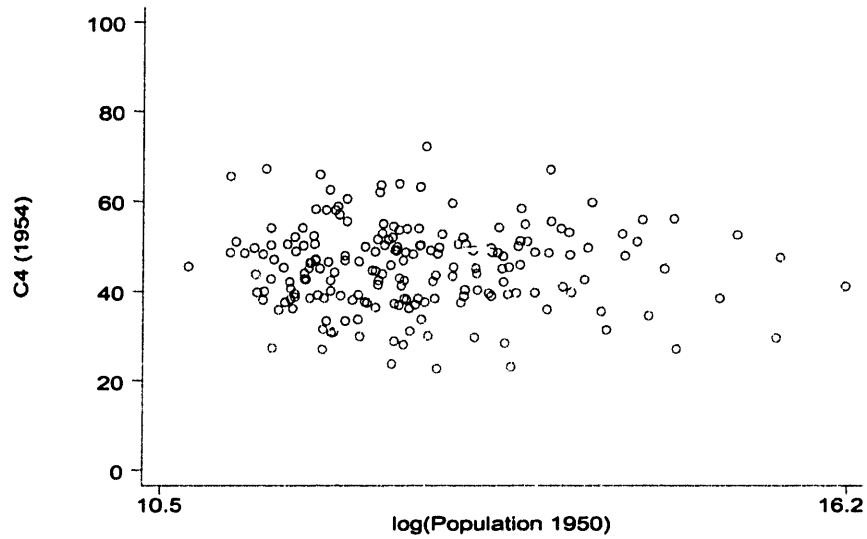


Figure 2-4: Concentration in the retail food industry, 1954.

Table 4

Product Proliferation and Increasing Store Size

Year	Items per Store	Store Size
1964	6,900	NA
1970	7,800	NA
1975	8,974	12,290
1980	14,145	12,759
1985	17,459	18,066
1990	30,000	20,797
1998	NA	28,155

Source: Messinger and Chakravarthi (1995) and Progressive Grocer.

2.4 Data

I now turn to the central empirical exercises of this paper: documenting the impact of endogenous sunk costs on the structure of the supermarket industry by establishing the existence of a

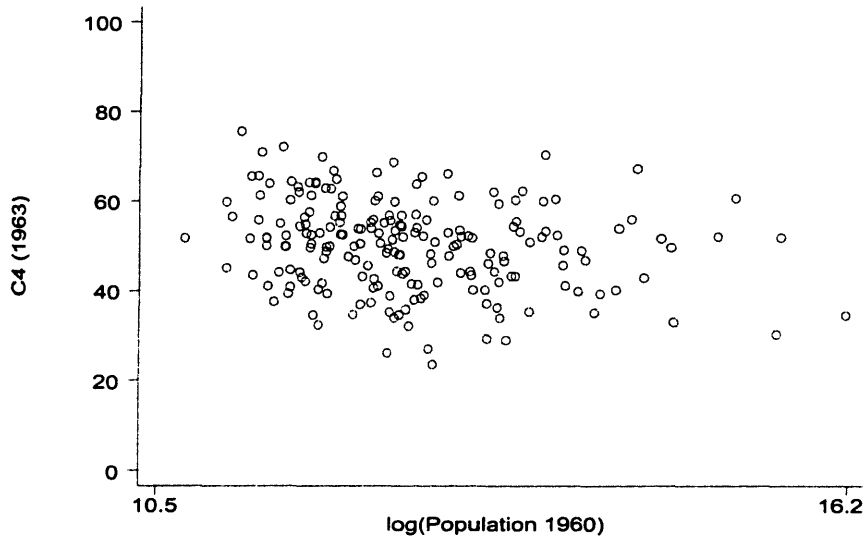


Figure 2-5: Concentration in the retail food industry, 1963.

positive lower bound to concentration. This is accomplished by using datasets from the Federal Trade Commission (FTC) and Trade Dimensions to estimate the asymptotic behavior of the lower bound. The key pieces of data required are, for a cross section of markets, a measure of concentration and a measure of market size. For market size, each market is defined to be a Metropolitan Statistical Area (MSA). This definition has been widely used in previous studies of the supermarket industry (Chevalier, (1995, 1996); Cotterill and Haller, 1991; Cotterill, (1986, 1999)), in trade journals, and by the FTC in assessing merger activity (Baer, 1999). Its choice is justified by the fact that supermarket chains operate divisions and distribute at the MSA level, distribute advertising circulars at the MSA level, and consider their competitors to be firms operating in the same MSA (Chevalier, 1995). Nevertheless, a variety of alternative market definitions (IRI market, Nielsen market, State, County), measures of size (population density, sales volume), and measures of concentration (C_1 , herfindahl) were tested.¹⁷ In order to assess the stability of the lower bound to concentration over time, I collected data for two time periods, 1972 and 1998. A single source was not available. The data for 1972 come from

¹⁷The comparisons were performed using the 1998 dataset only, because the FTC dataset does not permit different aggregation of the data (apart from the MSA). The results for 1998 were broadly similar using a variety of market definitions and measures of concentration.

the Federal Trade Commission (FTC) and cover both the supermarket and grocery industries. The MSA is the only market definition provided in this dataset. The data for 1998 were obtained from the marketing firm Trade Dimensions. This dataset covers only the supermarket industry, but can be grouped according to any market definition.

The data on the supermarket and grocery store industry in 1972 were obtained from the FTC report “Grocery Retailing Concentration in Metropolitan Areas, Economic Census Years 1954-72” (summary statistics are in Table 5). The data presented in the FTC report are drawn from special tabulations of the Census of Manufacturers, which contains the market share and store and firm counts for all grocery and supermarket firms in 263 metropolitan statistical areas (MSAs). Thus, for each MSA we observe the number of grocery stores (establishments) and grocery firms, and the number of supermarket stores (establishments) and firms, as well as the share of sales accounted for by the four largest grocery firms and the four largest supermarket firms (C_4). C_4 for the grocery industry includes only grocery firms in the calculation of total sales and C_4 for the supermarket industry includes only supermarket firms. Stores are classified at the *establishment* level as supermarkets or grocery stores depending on whether their annual sales volume is greater or less than \$1 million. This cutoff was the accepted standard within the grocery industry in 1972 (Manchester, 1992). Market shares are calculated at the firm level. Although a single firm could operate *stores* of both types (grocery and supermarket), it is not a frequent occurrence, especially among large chains. The larger supermarket chains tend to operate stores which are well above the cutoff, whereas the largest grocery firms are convenience store chains, whose stores are below the cutoff. Population is drawn from the 1960 and 1970 census.

Table 5
1972 Variables

Variable	Definition	Mean	S.D.
C_4 Grocery	C_4 for grocery firms by MSA	25.6	10.9
C_4 Supermarkets	C_4 for supermarket firms by MSA	69.5	13.9
Population	Population in thousands	562.4	1039.4
Grocery Stores	Number of grocery stores	355.1	599.4
Supermarket Stores	Number of supermarket stores	74.6	127.4
Grocery Firms	Number of Grocery firms	342.6	606.4
Supermarket Firms	Number of supermarket firms	24.6	32.4

Source: Federal Trade Commission.

The data on supermarket concentration in 1998 was obtained directly from Trade Dimensions, which collects information from supermarkets operating in 317 MSAs in the United States (summary statistics are in Table 6). They do not collect information on grocery stores. Trade Dimensions define a supermarket as “any full-line, self-service food store with an annual sales volume of \$2 million or more.” The \$2 million dollar cutoff corresponds to the standard currently used by trade journals, industry associations, and the FTC (it was increased from \$1 million in 1980 (Manchester, 1992)). Given the rate of inflation over the last 25 years, the definitions are roughly comparable. Although Trade Dimensions collects information on all the supermarkets operating in the U.S., to facilitate the comparison across years, the analysis here is restricted to only those operating in a designated MSA. As with the FTC data, the market will be defined to be an MSA and concentration will be measured by C_4 . The boundaries of several MSAs have changed since 1972. However, the current analysis does not track the development of markets over time, only the relationship between market size and structure. For this reason, I have not attempted to create a subsample of markets which maintained the same boundaries, choosing instead to present the full set of markets.

Table 6
1998 Variables

Variable	Definition	Mean	S.D.
C_4 Supermarkets	C_4 for supermarket firms by MSA	78.8	11.4
Population	Population in thousands	659.2	1090
Supermarket Stores	Number of supermarket stores	68.8	101.7
Supermarket Firms	Number of supermarket firms	9.4	4.9

Source: Trade Dimensions.

From Table 5, it is clear that the supermarket industry is far more concentrated than the grocery industry. Indeed, the average number of grocery firms is close to the average number of stores, suggesting the existence of a large number of single store firms. This is clearly not the case in the supermarket industry, which is also served by far fewer stores. Finally, a comparison across years reveals that although the level of concentration and average number of stores have remained relatively stable, the number of firms decreased substantially, possibly reflecting the merger activity of the 1980s (Chevalier, 1995) and the exit of under-performing firms.

2.5 The Lower Bound to Concentration

Sutton's framework provides strong predictions concerning the relationship between market size and equilibrium concentration levels. In industries where the levels of sunk cost are exogenously determined, the minimum level of concentration (the lower bound $C(S)$) will continue to decrease indefinitely as market size expands. In industries where these costs are endogenously determined, the minimum level of concentration will remain strictly positive as market size expands ($C(S)$ converges to a positive value as $S \rightarrow \infty$). In the context of Theorem 1, fragmentation or its absence depends on the degree to which escalation in sunk costs increases profits in the final stage (measured by the parameter γ). However, because there is no obvious way to estimate the effectiveness of sunk investments in increasing willingness-to-pay (γ), we cannot directly predict the asymptotic value of the lower bound $C(S)$. Sutton (1991) and subsequent authors address this issue by assuming that for some group of (advertising or R&D intensive) industries, γ lies above some minimal positive level. Sutton (1991) divides industries

on the basis of the advertising to sales ratio. Since sunk outlays are *assumed* to increase consumers willingness-to-pay in advertising intensive industries, under the maintained hypothesis concentration in a pooled sample of those industries will remain strictly positive regardless of the size of the market. This prediction may then be tested both by visual inspection of the observed relationship between concentration and market size (using scatter plots) and by empirically estimating the lower bound function $C(S)$. Our analysis follows Sutton's approach. If competition in the supermarket industry is focused on quality enhancing sunk costs ($\gamma > 0$), then a pooled sample of distinct geographic markets will have a lower bound to concentration which remains strictly positive regardless of the size of the market. The grocery industry, which we assume to have γ close or equal to zero, should have a lower bound which converges to zero.

Empirically testing the predictions of the endogenous sunk cost framework requires choosing a candidate industry or set of industries. Previous studies, relying on data from manufacturing industries (Sutton, 1991; Robinson and Chiang, 1996; Lyons and Mataves, 1995), focus on either a single industry across a few countries or several industries within a single country. Because many manufacturing industries serve national markets, single industry studies provide very few observations. While cross-industry studies yield a more reasonable number of observations, they require careful (and often flawed) estimation of cost components, particularly the exogenous component of fixed cost.¹⁸ This study takes a different approach to the problem by focusing on retail markets, which are naturally segmented into distinct geographic markets. This allows us to focus on a single industry with a large number of observations and avoid directly estimating cost components, while holding a score of other unknown or difficult to measure variables constant. As such, retail markets combine the clean properties of the single industry study with the larger scale available in cross-industry analysis.

The analysis proceeds in 2 stages. First, scatter plots depicting the realized levels of concentration allow us to visually inspect the differences between the supermarket and grocery industries. Concentration is indeed much higher in the supermarket industry, and there is no evidence of a negative correlation between market size and concentration. This is not the case

¹⁸In Sutton's empirical work, market size is measured by population divided by the fixed cost of entry, which is approximated by an engineering estimate of minimum efficient scale (MES). This exercise involves significant effort and potential for error. While this adjustment is necessary in cross-industry analyses (since the level of set-up costs affects the shape of the lower bound), MES is arguably constant within a particular industry so that single industry studies are less sensitive to this adjustment.

in the grocery industry. The stability of the structure of the supermarket industry over time is established by comparing the market structure in 1972 to the structure in 1998.

Both sets of results support the presence of a large, positive lower bound to concentration in the supermarket industry, suggesting that competition is indeed focused on endogenous sunk costs. The lower bound is over four times larger in the supermarket industry than in the grocery industry, suggesting that endogenous costs play a much smaller (if any) role in that industry.

2.5.1 Scatter Plots

Figures 2-6 and 2-7 show the relationship between the four-firm concentration ratio (C_4) and market size for the grocery and supermarket industries respectively in 1972. In both cases, we observe a range of concentration levels. This is not surprising, given that both industries provide differentiated products. The toughness of price competition and degree of horizontal differentiation are also likely to vary by region.

In the grocery industry (Figure 2-6), there is a strong negative correlation between size and concentration. The minimum levels of concentration observed in the largest markets is quite small (under 10%). In contrast, in the supermarket industry in 1972 (Figure 2-7), the lowest observed level of C_4 is 34.6% and there are several large markets where C_4 lies in the 50-70% range. A negative correlation between size and concentration is much less apparent. In fact, while large, highly concentrated markets are relatively common in the supermarket industry, such outcomes are virtually non-existent in the grocery industry. Moreover, ignoring the two most outlying points (Los Angeles and New York City), the lower bound to concentration appears non-monotonic, first decreasing and then increasing.¹⁹ This effect is even more pronounced in Figure 2-8, which shows the same relationship for supermarkets in 1998. Here, New York City is the only outlier as concentration in Los Angeles increased sharply over this period. This provides further evidence that the lower bound may in fact be non-monotonic.

¹⁹This non-monotonic behavior is consistent with the endogenous sunk cost model, where there may exist a threshold level at which endogenous sunk cost competition begins. However, it cannot be explained by static economies of scale, where a greater number of firms should “fit” into larger markets if size or advertising levels are not strategic variables. In the supermarket industry, by 1998, New York City is the only outlier in the scatter plot (Figure 2-8). Because New York City places strict restrictions on the size of stores, this suggests that the lower bound to concentration may in fact be strongly non-monotonic, providing further evidence in favor of the endogenous sunk cost model of competition.



Figure 2-6: The lower bound to concentration (\bar{c} grocery industry)

In addition, in the supermarket industry, the lower bound appears to have changed very little over 25 years, suggesting that the forces leading to high levels of local concentration are neither recent nor transitory.

This set of results provides strong visual evidence that the non-fragmentation result applies only to the supermarket industry. While concentration reaches quite low levels in the grocery industry, the same cannot be said for the supermarket industry. In addition, the strong negative correlation between market size and concentration apparent in the grocery industry is absent from the plots for the supermarket industry, where the relationship may in fact be non-monotonic. In the following section, I formalize this analysis by estimating lower bound functions for each industry.

2.5.2 Regression Analysis

Bounds regression analysis was introduced to economics in Sutton (1991), but it has been utilized extensively in the statistics literature, particularly in the use of extreme value theory for predicting climatology, pollution levels, and other “record breaking events” (Jenkinson, 1958; Gumbel, 1958; Smith, (1988, 1994)). Bounds analysis allows for the estimation of a

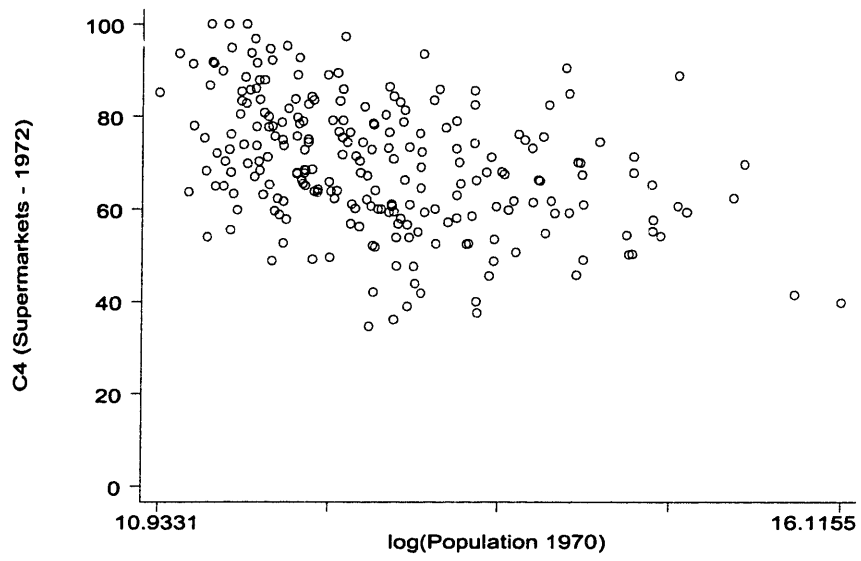


Figure 2-7: The lower bound to concentration (supermarket industry)

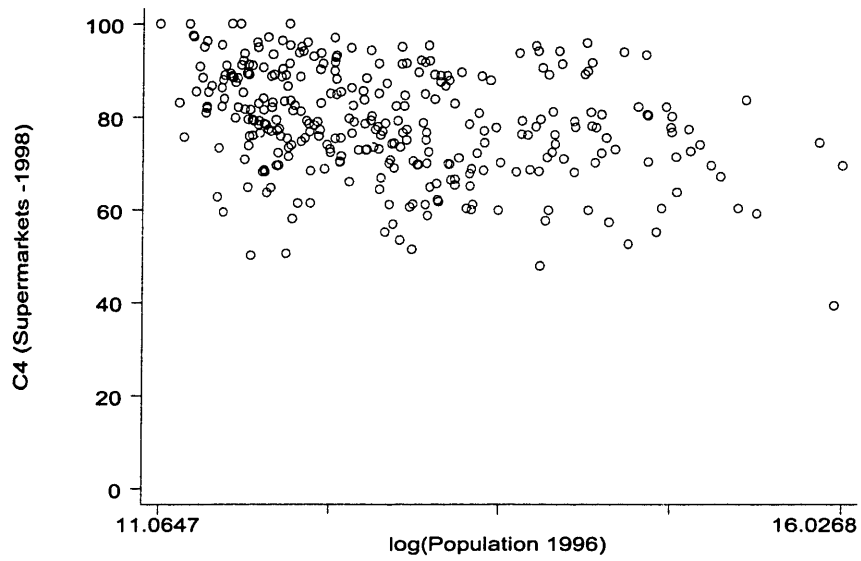


Figure 2-8: The lower bound to concentration (supermarket industry - 1998)

“lower envelope” function for two variables based on an assumption about the distribution from which the observed data are drawn. As such, the methodology allows for a formal test of the hypothesis that the lower bound remains strictly positive as market size expands ($C(S) > 0$ as $S \rightarrow \infty$).

The formal process of estimating the lower bound to concentration $C(S)$ begins with the null hypothesis that the level of sunk costs is exogenously fixed. Under the null hypothesis, the presence of higher levels of fixed costs (e.g. greater advertising and store sizes in the supermarket industry) will shift the lower bound as a function of market size, but the bound will still approach zero as market size increases. Because the lower bound to concentration tends to zero for all industries under the null, it is reasonable to estimate lower bounds for a pooled set of markets from a single industry.

As suggested above, estimation depends on an assumption about the distribution function generating the observed levels of concentration. Sutton and subsequent authors follow the standard statistical literature (Smith, 1994) in selecting the Weibull distribution. The fact that the Weibull distribution comes from the extreme value family makes it an attractive choice. Because the n firm concentration ratio C_n is the sum of the largest n values in a sample of market shares (drawn from some underlying distribution), C_n is itself an extreme value. Thus, I proceed by modeling the distribution of residuals between the observed values and the lower bound as a Weibull distribution. Specifically, letting x_i be an observed level of concentration and $b(z_i)$ a parametric (bound) function of market size z_i , the residuals $x_i = y_i - b(z_i)$, are distributed according to the distribution function:

$$F(x) = 1 - e^{\left(-\frac{x}{s}\right)^\alpha}, \alpha > 0, s > 0$$

Smith (1994) demonstrates the inconsistency of maximum likelihood estimation (MLE) when $\alpha < 2$ and suggests an alternative two-step estimation procedure which is consistent and reasonably efficient over the entire range of α .²⁰ This is the technique utilized in Sutton (1991). In the first step, a functional form is chosen for $b(z)$ and parameters are estimated which minimize the sum of the residuals $y_i - b(z_i)$, subject to the constraint that all residuals

²⁰Smith demonstrates that the likelihood function has no local maximum for $\alpha < 1$, while for $1 < \alpha \leq 2$, a local maximum exists, but does not have the usual asymptotic properties of MLE.

be non-negative. The residuals from this linear programming problem are then fitted to a Weibull distribution using MLE. The estimated Weibull distribution may then be used to bootstrap standard errors for the parameters of the bound function by generating an empirical distribution for each parameter.

The estimation procedure requires that the distribution of residuals be homoskedastic (identical across market sizes). Therefore, the following logit transformation of C_4 to \tilde{C}_4 is specified:²¹

$$\tilde{C}_4 = \ln\left(\frac{C_4}{100-C_4}\right)$$

To illustrate that the results are robust to the choice of functional form, I have chosen to estimate both a linear and quadratic model as follows:

$$\begin{aligned}\tilde{C}_i &= a + \frac{b}{\ln(S_i)} + \varepsilon_i \quad (\varepsilon_i > 0) \quad (\text{Linear model}) \text{ and} \\ \tilde{C}_i &= a + \frac{b}{\ln(S_i)} + \frac{c}{(\ln(S_i))^2} + \varepsilon_i \quad (\varepsilon_i > 0) \quad (\text{Quadratic model})\end{aligned}$$

In each specification, the asymptotic level of (the transformed measure of) concentration is captured by the intercept parameter a , while the parameters b and c determine the *shape* of the lower bound. The estimated bounds are presented in Table 7 while the fitted Weibull parameters are contained in Table 8. The asymptotic values of the estimated bounds for the grocery industry, as $S \rightarrow \infty$, are 8.5% and 7.9% for the linear and quadratic models respectively (columns 2 and 3 of Table 7). The estimated values of C_4 at the sample maximum market size are 8.5% and 8.1%. The corresponding asymptotic values in the supermarket industry are 34.0% and 29.7%, with values of C_4 at the sample maximum market size of 34.2% and 31.3% (columns 4 and 5). The lower bound to concentration in the supermarket industry is about four times higher than the bound in the grocery industry, suggesting that endogenous sunk costs play a much stronger role in the supermarket industry. Since the asymptotic value of C_4 is calculated by solving $a = \ln\left(\frac{C_4}{100-C_4}\right)$ for C_4 , yielding $C_4^\infty = \frac{e^a}{e^a+1}$, we can test the null hypothesis that concentration in both industries converges to the same value by comparing the difference in the estimated asymptotic values with the standard error estimated for a , leading to a clear rejection. The estimated lower bounds are presented in Figure 2-9.

²¹In three markets, C_4 equals 100. In these cases, the value of 100 is replaced by 99 to avoid division by zero.

Finally, columns 5 and 6 of Table 7 present the lower bounds estimated for the supermarket industry using data from 1998. The results are surprisingly similar to the earlier period. The asymptotic values of C_4 are 37.5% and 35.2%, while the values of C_4 at the sample maximum market size are 39.3% and 37.3%.²² The null hypothesis that the asymptotic values in both years are the same can be tested using the same procedure as before. Although the difference in estimates is statistically significant, the fact that the lower bound has increased by less than 3% in 25 years suggests that the naturally oligopolistic structure of the supermarket industry is very stable. This is somewhat surprising given the sharp decrease in the number of firms that occurred between 1972 and 1998 (see section 2.4), the large number of new entrants that joined the industry in recent years (e.g. Walmart), and the wave of merger activity that occurred in the 1980s (Chevalier, 1995) and late-1990s. The estimated lower bounds are presented in Figure 2-10.

The bounds regression results are intended to both supplement and formalize the intuition provided by the scatter plots in section 2.5.1. However, they should be interpreted with caution. The estimation procedure does not allow for either error in measurement or observations which are out of equilibrium.²³ As a result, the estimation technique is very sensitive to outliers. Although other estimation techniques are more robust to outliers (Koenker, Ng, and Portnoy, 1994), I chose to implement Smith's method because it is the method used by both Sutton and subsequent authors, thus eliminating any inconsistency that would arise from using different estimation methods. Using this methodology, I find strong evidence of a positive and significant lower bound to concentration in the supermarket industry, consistent with the presence and importance of endogenous sunk cost competition in this industry.

²²The exercise was repeated excluding New York City, yielding a non-monotonic lower bound to concentration which conformed closely to the lower envelope of the scatter of points. The quadratic term was positive and significant. I have elected not to present these results on the grounds that outliers are in fact a significant part of the bounds framework and should only be ignored when it is clear that their behavior is being determined by an outside process. While the argument seems appropriate for the 1998 sample (where New York City is the only outlier), the decision seems much less clear cut in 1972.

²³The Smith procedure forces the bound function to go through points in the lower envelope.

Table 7
Lower Bound Functions

Industry	Grocery Stores		Supermarkets		Supermarkets	
	1972		1972		1998	
Year	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
a	-2.38 (.07)	-2.46 (.12)	-0.66 (.08)	-0.86 (.12)	-0.51 (.16)	-0.61 (.18)
b	0.04 (.05)	0.21 (.13)	0.04 (.05)	0.37 (.13)	0.41 (.13)	0.47 (.17)
c		-0.003 (.002)		-0.005 (.002)		0.007 (.02)
C_4^{Max}	8.5	7.9	34.0	29.7	37.5	35.2
C_4^{∞}	8.5	8.1	34.2	31.2	39.3	37.3

Standard errors in parentheses.

Table 8
Weibull Distribution Parameters

Industry	Grocery Stores		Supermarkets		Supermarkets	
	1972		1972		1998	
Year	Linear	Quadratic	Linear	Quadratic	Linear	Quadratic
α	2.19 (.12)	2.20 (.12)	1.98 (.10)	2.01 (.10)	2.26 (.10)	2.15 (.09)
s	1.35 (.04)	1.30 (.04)	1.79 (.06)	1.71 (.06)	1.90 (.05)	1.90 (.05)
Log-L	-182.7	-171.4	-275.4	-258.8	-355.2	-378.7

Standard errors in parentheses.

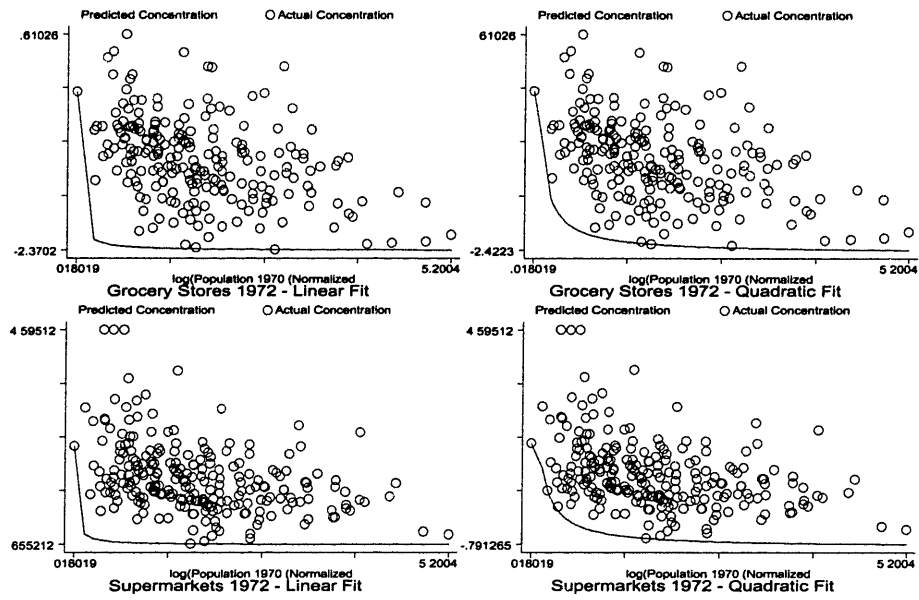


Figure 2-9: Lower bound estimation - 1972

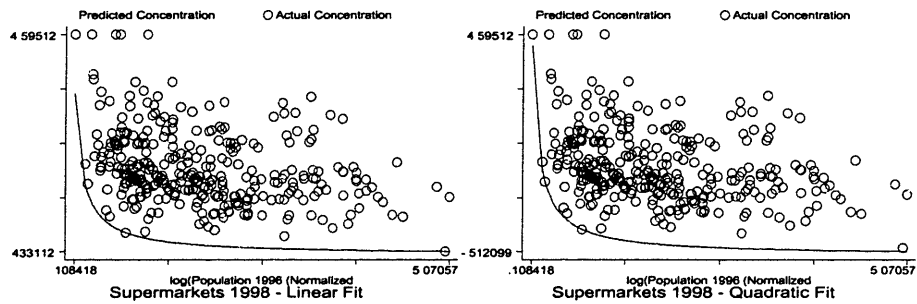


Figure 2-10: Lower bound estimation - 1998

2.6 Summary and Conclusion

This paper presents empirical evidence that endogenous sunk costs play a central role in determining the equilibrium structure of the supermarket industry. Using the bounds-regression methodology on a large sample of distinct geographic markets, I document the existence of a large, positive lower bound to the four-firm concentration ratio (C_4) that asymptotes with increasing market size to a level above 30%. Using data from 1972 and 1998, I demonstrate that this bound has remained stable for 25 years. Through a detailed case history of the retail food industry, I document the innovations that led to the exit of a large number of unprofitable firms and increased concentration, highlighting the escalation in both store size and (to a lesser extent) advertising that differentiated the supermarket industry from the smaller grocery industry.

This paper provides a novel test of the Sutton endogenous sunk cost framework using data from geographically distinct retail markets. While previous tests have relied either on data from different industries within a single country or a single industry across countries, this study takes a different approach. Focusing on retail markets in the same industry within the same country eliminates the need to control for technological or cultural differences, without having to rely on a small sample of observations. The results provide strong support for the hypothesis that endogenous sunk cost investments cause industries to remain concentrated, regardless of the size of the market. In addition, the case study evidence reveals that a steady increase in sunk investments accompanied the rising levels of concentration that followed the introduction of the supermarket format, providing additional support for the mechanism of competition proposed by the endogenous sunk cost framework.

This paper also provides insight into the competitive structure of the supermarket industry, which has been the focus of several recent studies (Chevalier, 1995; Cotterill and Haller, 1992; Cotterill, 1999). Through a comparison with the grocery industry, I demonstrate that supermarket competition is focused on quality enhancing sunk costs resulting in much higher levels of concentration than those found in the grocery industry. Again, the statistical evidence of sharply differing lower bounds is supplemented with a case history detailing the development of each industry. While there is no evidence of endogenous investment in the grocery industry, it played a significant role in the formation of the supermarket industry, where advertising, store

size and product bandwidth increased alongside concentration.

This exercise suggests several avenues of further research. First, demonstrating that store size and product bandwidth are the strategic variables which shape endogenous cost investment requires looking beyond the lower bound to the interactions between individual firms. This exercise is taken up in Chapter 3 of this thesis. Second, the emphasis on product bandwidth is not unique to the supermarket industry, but is an important component of competition in several retail industries such as consumer electronic stores, book stores, video rentals, and consumer dry goods (Walmart). These firms often invest heavily in advertising as well as information technology and advanced distribution systems. Understanding how these endogenous sunk investments interact is the subject of future research.

Chapter 3

Vertical Product Differentiation and Concentration in the Supermarket Industry

3.1 Introduction

In the past two decades, several retail industries have become dominated by strong regional or even national chains. Whether the market is video rentals, auto supplies, books, or office supplies, these stores share several common features: a wide selection, aggressive pricing and advertising, quick turnover, and significant investment in advanced information and distribution systems (Bendetti and Zellner, 1992; Chakravarty, 1991; Chanil, 1991; Messinger and Narasimhan, 1995; Power and Dunkin, 1990; Saporito, 1991; Zinn and Power, 1990). Firms such as Home Depot, Staples and Crown Books have become household names by providing a staggering array of products at very competitive prices (Bagwell et al., 1997). While there are clearly strong forces encouraging the formation of larger and larger chains, what is unclear is whether these industries are tending toward local monopolies. An alternative hypothesis is that at least some of these retail industries are tending towards “natural” oligopolies, characterized by a small number of firms – but greater than one firm – competing head-to-head in quality in local markets. Because the nature of competition is so different across these two

market structures¹ (segmented monopolies versus head-to-head oligopoly), discerning the nature of competition in these markets is important both for antitrust policy as well our more general understanding of retail industries. By focusing on the supermarket industry, where rapidly growing regional chains offer an ever expanding selection of products (Messinger and Narasimhan, 1995) and local markets are often very concentrated (Chevalier²; 1995), this paper evaluates the differences between these two hypotheses and suggests a methodology for how such an analysis might be applied to retail markets in general. The principal contributions of the empirical work presented in this paper involve identifying the high quality set of supermarket firms, demonstrating that they exist only in bounded numbers (do not increase proportionately with the size of the market), and identifying features of the observed market structure which are inconsistent with alternative explanations, namely by highlighting the distinctive nature of strategic complementarity. Utilizing a set of complimentary empirical exercises, I demonstrate that competition in the supermarket industry is focused on quality enhancing sunk costs, resulting in a concentrated but competitive market structure that is remarkably stable across different markets.

This paper tests for the existence of a stable oligopolistic market structure and identifies the mechanisms sustaining it. The focus on providing a wide bandwidth of products, together with high levels of concentration, makes vertical product differentiation (VPD) with endogenous sunk cost investment an attractive candidate for modeling supermarket competition. In a standard VPD model, such as Sutton (1991), firms compete for the same consumers by offering higher quality products. When firms increase quality primarily through fixed cost investment, rivalry between firms forces markets to converge to a *natural oligopoly*, where markets of varying sizes are served by similar numbers of high quality firms (Shaked and Sutton, (1983, 1990);

¹For example, suppose concentration is the result of a cost-reducing investment game (e.g. Bagwell et al., 1997) where vigorous price competition results in the emergence of a low-cost, low-price leader. The market leader only has an incentive to lower price as long as his competitors remain in the market. If cost differences become large enough, the rival firms may exit, and, if the cost of re-entry is high enough, the surviving firm may be able to charge the monopoly price indefinitely (Athey and Schmutzler, 1999). A similar argument can be applied to the level of quality selected by the surviving monopolist. In the endogenous sunk cost framework, high quality and low prices (below monopoly) are sustained by the presence of rival firms (and the threat of entry).

²Chevalier (1995) exploits the concentrated structure of the supermarket industry and the dominant role of powerful multi-market chains to evaluate the impact of capital market imperfections on product market competition.

Gabszewicz and Thisse, 1980). Two important features of this model are that markets need not tend towards monopoly and, while the model accommodates the presence of a large “fringe” of low-quality firms, it focuses attention on the nature of competition between high-quality providers. In particular, as market size expands, rival oligarchs choose successively higher levels of quality. Because firms must cover ever expanding sunk outlays, only a finite number of high quality firms can “fit” into a market. As a result, the minimum efficient scale is endogenously determined, expanding with the size of the market. Consequently, markets of very different sizes may have very similar concentration distributions.

This model seems to accord well with the features of the supermarket industry documented here. For example, in the supermarket industry, the top 4 firms consistently capture 65-75% of the market. This is true for markets as small as Eugene, Oregon and as large as Los Angeles, California. While larger markets do tend to have more firms, the increase is confined almost exclusively to the expansion of a fringe of small firms who provide smaller, lower quality stores. By assumption, quality (as measured by the variety of products carried or *bandwidth*) is increased by incurring larger fixed costs without increasing marginal costs. Consequently, firms who invest in higher quality are able to provide a better product (a greater bandwidth) for the same price. As market size expands, rival firms who choose to remain in the market must match their competitor’s quality increase (or risk losing their entire market share).

Beyond simply demonstrating the existence of a natural oligarchy, the analysis also attempts to characterize the nature of the strategic interaction among oligarchs, an exercise which provides additional support for the VPD interpretation of competition. Specifically, whereas most models of strategic investment imply strategic substitution between rival firms (Bagwell and Staiger, 1994; Athey and Schmutzler, 1999), investment in the VPD model yields strategic complementarity when quality enhancements expand the size of the market (by inducing consumers to devote a larger fraction of their income to the quality good or by inducing new consumers who previously consumed an outside good to join the market (Ronnen, 1991; Lehman-Grube, 1992; Chapter 4 of this thesis)). While consistent with the VPD framework, evidence in favor of strategic complementarity in equilibrium investment is inconsistent with several competing models of competition, including most standard models of capacity competition, horizontal product differentiation, cost-reducing investment and product proliferation. In

particular, strategic complementarity draws a sharp distinction with models of horizontal competition, in which firms maximally differentiate in order to exploit local monopoly power and with models of cost reducing investment, where the optimal response to an opponent's investment increase is typically to reduce own investment. Much of the empirical work in this paper focuses on demonstrating regularities in the observed structure of the supermarket industry which distinguish between the implications of these competing models.

This paper exploits the nature of supermarket competition, namely the existence of geographically distinct markets, to provide explicit tests of the predictions of the VPD model, to identify evidence which suggests that alternative models do not seem to be as salient, and, in so doing, deepen our understanding of the nature of retail competition. This empirical characterization is achieved by exploiting a novel dataset of store level observations in 320 geographical markets, where a market is a Metropolitan Statistical Area (MSA). Examining these markets, I establish the existence of an oligopolistic structure that does not fragment as market size expands. By narrowing the focus to the store level, I demonstrate that this natural oligopoly extends all the way down to the most local levels. Unable to carve out distinct geographic markets, the natural "oligarchs" compete head to head for the same consumers. I then use this very local nature of competition to test one of the main predictions of the VPD framework: a positive interaction between quality choice, market size and the equilibrium number of entrants. In addition, for a fixed market size, I demonstrate that quality choices are strategic complements among supermarkets in the same local markets. Using store size (as a proxy for bandwidth) to measure quality, I provide evidence that the presence of rival high quality firms forces competing stores to increase their own level of quality. Since quality choices by rival firms are endogenous variables, I account for endogeneity using instruments constructed from the average size of rival's stores outside of the local market. The quality level of rival firms outside the market in focus are likely to be highly correlated with the rival's choice of quality in this market (because quality choice requires investments above the market level (e.g. advertising, distribution, reputation) but are uncorrelated with specific market conditions (e.g. size or unobserved consumer attributes) or a competitors behavior in this market.³ As emphasized above, the finding of strategic complementarity eliminates several competing hypotheses.

³A similar approach is used in the context of new good valuation in Hausman (1994).

Taken together, this paper makes several contributions to our emerging empirical understanding of sunk cost industries. First, this paper demonstrates how the VPD framework can be applied to an industry where the two most common sources of endogenous sunk costs (advertising and R&D) play only a minor role. Here, the endogeneity of investment derives from the requirement that firms build larger stores to carry a wider array of products. Second, explicit, cross-sectional tests of the implications of the VPD model are presented, highlighting features of observed market structure which are inconsistent with competing hypotheses. Finally, I present strong evidence of an oligopolistic structure which extends from the regional to the local market and demonstrate that the main dimension of store quality acts as a strategic complement. While competing theories may succeed in explaining a subset of the features observed in this industry, the VPD framework accords well with the entire structure, where a small set of high quality firms compete head to head, responding to rivals' quality increases with increases of their own.

The paper is organized as follows. Section 2 provides a context for the study through an overview of the history and competitive structure of the supermarket industry. Section 3 provides a theoretical framework aimed at adapting the VPD model to the supermarket industry. In particular, I identify a dimension of store quality that satisfies the assumptions of the VPD model. The dataset is described in Section 4. In section 5, I present a first set of empirical results aimed at determining whether competition in the supermarket industry indeed constitutes a stable natural oligopoly. A second set of empirical results documenting the strategic interaction between rival firms are presented in section 6. A final section offers some concluding remarks and suggestions for further research.

3.2 The evolution and structure of the supermarket industry

In this section, I present a brief historical overview of the supermarket industry, with an emphasis on the innovations that contributed to its current structure. A more detailed description of the industry's evolution is presented in Chapter 2 of this thesis.

From 1880 to the present, the retail food industry evolved from the general store, which operated on a premise of low turnover and high margins, to a mixture of modern supermarkets,

operating on a premise of wide variety, high turnover and low margins and grocery stores offering convenience (often in the form of proximity) at the expense of both price and variety (Tedlow, 1990; Lebhar, 1952; Adelman, 1958; Messinger and Narasimhan, 1995). There were two periods of major change: 1910-1930 (the rise of the chain stores) and 1930-1960 (the introduction of the supermarket) (Tedlow, 1990; Progressive Grocer, 1995).

The first major change in the industrial structure of the retail food industry was the chain store revolution. The chain stores, led by the Atlantic and Pacific Tea Company (A&P), gained a cost advantage over independent stores by integrating backward into wholesaling and manufacturing (Adelman, 1958). Due at least in part to decreases in transportation costs, chains were able to create a large network of stores which could take advantage of quantity discounts on the products they didn't make themselves and economies of scale on self-produced items. The large number of stores and intricate distribution network allowed the chains to centralize accounting and better forecast demand, resulting in more efficient inventory management and site selection. These cost savings were passed through to consumers in the form of lower prices. Various price studies performed in the late 1920s and early 1930s found that chain store prices were 4.5-14% lower than their independent counterparts (Tedlow, 1990). Concentration also rose sharply. Between 1919 and 1932, the share of the top 5 firms in the U.S. increased from 4.2% to 28.8% (Lebhar, 1952), and the share of all chain stores increased to over 35%. However, as demonstrated in Chapter 2 of this thesis, the innovations introduced by the chain stores did not involve endogenous sunk outlays. The introduction of scale economies and tougher price competition increased concentration at all levels, but the focus of competition never shifted from price-cost margins to endogenous sunk outlays. Grocery stores continued to operate stores which were physically similar to their independent counterparts (Tedlow, 1990). By the late 1920s, the price differences between chains and independents shrank as independent grocers formed cooperative buying groups (Lebhar, 1952).

The second era of change coincided with the introduction of the supermarket format, which heralded in a new era of endogenous sunk cost investment. These new stores, which were located on the outskirts of town to take advantage of low rents, sold nationally advertised goods and advertised heavily (Tedlow, 1990). In addition, a supermarket was 5 times larger than a grocery store, carried far more products, and required customers to serve themselves.

While the chain formula may have introduced economies of scale to the food industry, the creation of the supermarket format changed the nature of the store itself, introducing a new, vertically differentiated product. Over time the supermarket and grocery segments became increasingly distinct, with supermarkets becoming the primary food providers. Grocery stores evolved into convenience stores and corner stores, capturing a much smaller portion of the overall food market (Progressive Grocer, 1995).

The rise of the supermarket industry carried the fingerprint of the endogenous sunk cost escalation mechanism⁴ (Sutton, 1991): falling margins, escalating sunk outlays, and the appearance of a lower bound to concentration bounded well above zero.⁵ While the overall number of food stores decreased from 386,900 to 126,000 from 1939 to 1997, the number of supermarkets increased from less than 1,000 to 30,300. Across 154 Metropolitan Statistical Areas (MSAs), the average four firm concentration ratio (C_4) increased from 45.4% in 1954 to 74.8% in 1998 (U.S. Department of Agriculture, 1992). The increase in concentration coincided with the rise of multi-market chains, who today account for 79% of supermarket sales. Growth was strongest among regional and sectional chains. Local chains (operating in only a single MSA), which grew considerably during the 1970s and 1980s, have been bought out by larger firms in the 1990s, as larger chains continue to dominate the market (Manchester, 1992).

From 1950 to 1980, supermarkets grew mostly at the expense of the grocery segment, steadily eroding the grocery stores' share of retail food sales. However, the share of food sales accounted for by supermarkets leveled off at around 75% in the 1970s (Messinger and Narasimhan, 1995). Most of the competition now occurs within the supermarket format as opposed to across foodservice formats, with *chain supermarkets* (firms operating 11 or more stores) gaining an ever increasing share of the market (Manchester, 1992). Store formats have also changed as superstores⁶ and stores offering both food and drug products have begun to

⁴The *quality escalation mechanism* emphasized in Sutton (1991) refers to the process by which outcomes that are "too fragmented" are broken as markets tend toward equilibrium. In particular, "as market size increases, the incentives to escalate spending on fixed outlays rises. Increases in market size will be associated with a rise in fixed outlays by at least some firms and this effect will be sufficiently strong to exclude an indefinite decline in the level of concentration" (Sutton, 1997). This follows from the fact that the relative increase that a firm can achieve through an increase in fixed outlays is correspondingly greater as each firm's market share is relatively smaller.

⁵See Chapter 2 of this thesis for a formal empirical analysis.

⁶Superstores are larger versions of the conventional supermarket that provide at least 30,000 square feet of selling area and offer more than 14,000 items. These formats often include a service deli and seafood department.

replace the conventional supermarket format. Furthermore, the firms providing these extended formats make complementary investments in information technology (satellite communication systems, electronic inventory control systems) which reduces the cost of stocking a large number of products (Messinger and Narasimhan, 1995). Advertising, which helped drive the diffusion of the supermarket format, now plays a much reduced role.⁷ On the other hand, the number of products offered per store has increased from 14,145 in 1980 to 21,949 in 1994, while average store size has increased at a rate of about 1,000 square feet per year (Progressive Grocer; Messinger and Narasimhan, 1995).

The structure of the supermarket industry has been the focus of several recent studies. Chevalier (1995), focusing on the impact of capital market imperfections, demonstrates that leverage makes supermarket firms weak, encouraging tough price competition and entry by rival firms. Cotterill and Haller (1991) look at entry by large chains. They find that supermarket firms are more likely to enter markets which are closer to their base of operations and experienced recent growth. Entry is negatively correlated with concentration and the number of incumbent firms, except in the case of the market leader (Albertson's), which chose to enter more concentrated markets.⁸ Finally, Simpson and Hosken (1998) study the effects of mergers on price competition. In only 1 of 3 supermarket mergers analyzed do the authors find any evidence that the merger increased rival firms' performance, suggesting that supermarket mergers are undertaken for efficiency reasons rather than collusive motives. Therefore, there is at least suggestive evidence that, despite high levels of market concentration, competition among the top firms in the supermarket industry is fierce.

The rise of the supermarket industry included the fierce competition and escalation in sunk outlays predicted by the VPD model of endogenous sunk costs, which is introduced in the following section. This focus on competing investment in quality enhancing sunk costs shows no signs of abating with time, suggesting that tough competition among a few oligarchs is an important feature of the structure of supermarket competition. In the following section, I

The superstore is a distinct concept from the (non-food item intensive) hypermarket and the low-margin, reduced variety warehouse format.

⁷The Advertising/Sales ratio is currently about 2%. Since 89% of advertising dollars are spent on newspapers and circulars, it is unlikely that large chains benefit significantly from scale economies in advertising (Adweek, 1998).

⁸Perhaps Albertson's was the "one smart agent" envisioned in Shaked and Sutton (1997).

outline a formal model of competition that will be empirically tested using store level data.

3.3 Endogenous Sunk Costs and Supermarket Competition

The observed structure of the supermarket industry requires a model of competition that combines the market power and concentration of oligopoly with the competitive focus of monopolistic competition (Dixit and Stiglitz, 1977; Spence, 1976). In particular, while the supermarket industry is dominated by a few powerful firms in each market, there is at least suggestive evidence that competition is fierce among the few and focused, to at least some extent, on quality enhancing sunk costs. In this section, I present a theoretical framework which will both guide the empirical investigation and give an interpretation to our findings. Our initial approach follows Sutton's bounds methodology in attempting to identify robust, testable implications which impose only minimal constraints on the specific choice of model or form of competition. Therefore, instead of presenting a single model of supermarket competition, I present an overview of the class of VPD models developed in Sutton (1991) and demonstrate how these models can be used to inform our understanding of the structure of the supermarket industry.

The bounds approach creates a tension between breadth of application and the tightness of predictions. At its most general, the theory simply places bounds on the outcomes which can be sustained as equilibria, while imposing a finer structure yields models with closed form solutions for unique equilibria. The purpose of this section is to create a framework for assessing the appropriateness of VPD as a model of competition in the supermarket industry by identifying a set of features which are consistent with the broad class of VPD models but are inconsistent with alternative explanations. I begin with a basic model of vertical differentiation with a homogeneous product and a representative consumer.

In the simplest model of VPD (e.g. Chapter 3 of Sutton (1991)) firms produce products that differ only in their level of quality. Consumers are identical, with preferences defined by a function where willingness to pay is non-decreasing in quality. Thus, if two goods of differing quality are offered at the same price, all consumers will choose the product of higher quality.⁹

⁹This contrasts with the case of horizontal differentiation, where each product captures a positive market share. The horizontal parameter describes tastes which are consumer specific, while the vertical parameter does not. Specifically, consumers may differ in tastes, but they agree on quality. The vertical model of preferences is

Competition takes place in three stages: entry, quality choice and product market competition. In the first stage, firms choose whether or not to enter the market and pay a fixed cost of entry. In the second stage, the firms who have chosen to enter select a level of quality for the product they will produce. Increasing the level of quality requires a second fixed cost outlay, with little or no increase in marginal costs. The fixed costs of quality enhancement are an increasing function of the quality level and are sunk in the period prior to product market competition. The fixed cost function is also assumed to be sufficiently convex to rule out some multiple equilibria that would arise in this stage.¹⁰ Product market competition in the third and final stage is assumed to be Cournot.

Since stage 3 is Cournot, consumers choose products that maximize the quality/price ratio. In equilibrium, the prices of goods supplied by all firms with positive market shares must be proportionate to quality. Looking now at the second stage, the additional convexity assumption on the fixed cost function allows calculation of the symmetric equilibrium in quality choice. The symmetric equilibrium follows from a combination of three assumptions: 1) consumers are identical, 2) the fixed cost function is continuous (no threshold effects), and 3) competition is Cournot. Entry in the first stage will drive profits to zero if we ignore integer constraints on the number of firms. In the discrete case, firms will enter until the next potential entrant would earn negative profits, so that large profits (and margins) are sustainable in equilibrium. Finally, since fixed costs and quality scale up with market size (because quality competition becomes more intense), we expect roughly the same number of firms to enter, regardless of market size.¹¹ This non-fragmentation property is the central result of the endogenous sunk cost literature. Since only a finite number of firms will be able to cover the increased fixed costs necessary to provide a high quality product, a finite number of firms will enter regardless of the size of the market.¹² The equilibrium that obtains in this baseline case is referred to as a *natural oligopoly*

frequently characterized in the marketing literature as having an “infinite ideal point”.

¹⁰The exact condition is derived in Sutton (1991), p. 53.

¹¹This argument depends on the assumption that marginal costs increase only slightly with higher levels of quality, allowing firms to shift the focus of competition onto fixed outlays. If quality were provided through increases in marginal costs, the fragmented Hotelling result would obtain in the vertical case as well, with firms stratifying along the quality dimension and serving distinct consumer groups, segmented by income bands (Tirole, 1988).

¹²This example may be extended to allow for Bertrand competition in the third stage (Shaked and Sutton, 1983; Ronnen, 1991) or sequential entry (Sutton, 1991; Lehmann-Grube, 1997). The natural oligopoly result will continue to hold with similar assumptions. However, the equilibrium will no longer be symmetric: firms

(Shaked and Sutton (1983)).

In the context of the supermarket industry, a natural candidate for a purely vertical measure of quality is *bandwidth*, or the number of products carried by the store. A wide choice set appeals to all consumers and allows supermarkets to draw from a broader customer base. Furthermore, to efficiently expand bandwidth firms must make a joint investment in fixed costs at the store and the firm level. On the one hand, firms invest in industry specific information technology and distribution systems to efficiently stock a wider array of products (Messinger and Narasimhan, 1995). However, firms must also build larger stores to carry their products.¹³ Because of their unique, single-floor, space-intensive design, supermarkets are not easily converted into other uses.¹⁴ Therefore, increasing bandwidth requires outlays which are both fixed and sunk. Furthermore, since the cost of land increases in consumer density, store level sunk costs may actually increase with the size of the market.¹⁵

Clearly there are several other dimensions of quality along which supermarkets compete, such as offering deli bars, fresh produce, and shorter check-out lines. In practice, the stores offering the widest selection tend to invest in other quality enhancements as well.¹⁶ Furthermore, cost reducing investments create complementarities across several forms of quality. Nonetheless, our empirical analysis focuses on bandwidth as the single measure of store quality.

In the homogeneous vertically differentiated product case, there is a unique equilibrium number of entrants corresponding to each market size (Gabszewicz and Thisse, 1980; Shaked and Sutton, 1983). Furthermore, the equilibrium number of entrants is finite, regardless of the size of the market. The limiting number of entrants depends on the convexity of the cost function (Sutton, 1996). Depending on the parameters of the model, the number of firms may either approach this *finite* limit from above or below as market size increases. In the case where

offer a staggered set of qualities, but only a finite number of qualities (products) are introduced, yielding a finite number of entrants. If competition were Bertrand but consumers were identical, only one firm would enter in equilibrium.

¹³Surveys consistently indicate that consumers place a high value on wide aisles and easily accessible products (Progressive Grocer). It is not sufficient to simply cram a wider selection into smaller, existing stores.

¹⁴The owners of a supermarket chain that recently chose to close down and sell off their assets claimed that the most recently built stores were the most difficult to unload (personal communication with author).

¹⁵If sunk costs increase with the size of the market, maintaining a fixed level of quality is more expensive in larger markets. In this case, the larger number of consumers over which to spread sunk costs is offset by the rising level of sunk costs, providing an alternative mechanism through which sunk costs may be endogenized.

¹⁶The exception of course being ultra high quality specialty stores such as Gelson's Markets or Whole Foods Markets.

fixed costs are a function of quality alone (not the size of the market), the level of quality increases monotonically with the size of the market. (See the baseline model of Chapter 4 of this thesis for a specific analytical example.)

When the model is extended to include horizontal differentiation, the results are more complicated (Shaked and Sutton, (1987, 1990)). To understand how the addition of a horizontal dimension impacts the outcome, it is informative to begin by considering the purely horizontal case, in which firms enter simultaneously and produce a single, distinct product that does not have a vertical attribute. Marginal costs are assumed to be constant. In this case, the number of firms increases proportionately with the size of the market, causing concentration to decrease indefinitely (Sutton, 1991). Intuitively, the number of firms which fit into a market depends only on the relationship between fixed cost and market size. As market size increases, fixed costs fall relative to the size of the market, increasing the equilibrium number of firms that may profitably enter.

This simple result is complicated when firms enter sequentially or own multiple stores (Shaked and Sutton, 1990; Sutton, 1991). There may no longer be a unique equilibrium. Therefore, the relationship between market size and the equilibrium number of firms is no longer a unique mapping. However, it is still feasible to demonstrate that, in the horizontal case, the maximal number of equilibrium entrants corresponding to a given market size increases without bound as market size expands (Shaked and Sutton, 1990; Sutton, 1991). Therefore, given a large sample of markets, we should observe some outcomes in which the market fragments.

When the horizontal and vertical cases are combined (as in Sutton (1991) pp. 65-66), a dual structure may emerge in which firms belong to one of two tiers. In the simplest, symmetric example, the top tier of firms compete in sunk outlays and provide high quality. Only a finite number of these firms will enter, regardless of the size of the market. The second tier of firms provides the minimum quality level, investing only in the (exogenous) sunk cost of entry.¹⁷ The number of these firms increases indefinitely with the size of the market. Clearly, the total number of firms in the industry will increase without bound as well.

Because of the indeterminacy associated with multiple equilibria and the aggregate nature

¹⁷The two-tiered industry structure is also analyzed in Lancaster (1996), although the focus there is not on endogenous versus exogenous sunk costs.

of most data on industry structure, tests of the endogenous sunk cost framework have tended to focus on the non-fragmentation property of these models. The non-fragmentation property states that when sunk costs are endogenously determined, the maximal market share of the largest firm is bounded above zero, independent of the size of the market. This property can be tested by estimating the lower bound to observed levels of (some measure of) concentration (Sutton, 1991; Robinson and Chiang, 1996; Chapter 2 of this thesis). However, given sufficiently disaggregated data and some additional assumptions, it is possible to evaluate some of the theory's more restrictive predictions. In particular, if it is feasible to identify the firms making investments in high quality, there is a direct test of whether these firms exist only in bounded numbers. Furthermore, by looking at the geographic locations of firms, we can observe whether firms indeed compete head to head for the same consumers as the theory implies. The challenge of the empirical work presented in this paper is to identify the high quality set of supermarket firms, demonstrate that they exist only in bounded numbers (do not increase proportionately with the size of the market), and to identify features of the observed market structure which are inconsistent with alternative explanations, namely by highlighting the distinctive nature of strategic complementarity. To facilitate the latter exercise, we will first need to deepen our understanding of the strategic nature of quality competition.

3.3.1 Vertical Product Differentiation and Strategic Complementarity

How firms react to investments by rival firms provides direct insight into the mechanisms that shape competition. In particular, if a firm responds to a rival's quality increase with an increase of its own, it is unlikely that the investment was cost reducing in nature, since the optimal response in that case is typically to reduce own investment (Athey and Schmutzler, 1999). This is also the case when the investment takes the form of a capacity increase (Dixit, (1979, 1980); Spence, (1977, 1979)). As such, a finding of complementarity in investment greatly narrows the scope of candidate models. In chapter 4 of this thesis, I demonstrate that the VPD framework is consistent with either strategic substitution or complementarity in the level of quality. Which result obtains depends critically on the manner in which quality enters the indirect utility function. In the baseline model of Sutton (1991), quality enters through the ratio of quality to price, meaning that consumers care only about quality per dollar or

efficiency units. This (log) linear relationship between quality and price is common to several models of quality differentiation. Chapter 4 demonstrates that, in this baseline model, quality choices are always (local) strategic substitutes. This result follows from the fact that increases in quality do not induce consumers to spend a higher fraction of their income on the quality good. Therefore, if a single firm raises its quality (and price), it will need to capture a larger share of the market to cover the increased fixed costs of providing a higher quality. Since the level of demand is fixed, the optimal reaction of his competitor is to reduce quality (and price).

This intuition is much more general and applies across a wide class of models of cost reducing investment (Bagwell and Staiger, 1994; Athey and Schmutzler, 1999). In chapter 4, I demonstrate that, since consumers care only about efficiency units, the baseline model can be reformulated as a model of cost reducing investment where quality does not enter the utility function at all. Thus, reinterpreted as a model of cost reducing investment, it is not surprising that Sutton's baseline model yields strategic substitution. Furthermore, his emphasis on *quality* competition seems misplaced. Instead, the natural oligopoly result follows more directly from the fact that "rivalry is both tough and focused on fixed outlays" (Schmalensee, 1992), irrespective of the particular output of those outlays. Moreover, Sutton's (1991) focus on the quality escalation mechanism is misleading. While it is true that in movements from disequilibrium to equilibrium¹⁸, firms will increase quality together, it is clearly not the case that, within equilibrium, firms will respond in kind to increases in quality by rival firms.

However, when the relationship between quality and price is *non-linear*, increases in quality can induce consumers to spend a higher fraction of their income on the quality good, shifting the strategic interaction between firms to strategic complementarity. In chapter 4, I present an alternative specification of the baseline model where quality choices are strategic complements around the equilibrium. The set-up is identical to Sutton (1991), only quality and price no longer enter as a ratio. Instead, a non-linear specification allows consumers to value the overall level of quality opposed to simply efficiency units.¹⁹ As a result, in equilibrium, increases in quality induce consumers to devote a larger fraction of income to the quality good (by substituting out

¹⁸For example, if market size expanded or the underlying technological structure of an industry changed, markets would, at least temporarily, be out of equilibrium.

¹⁹In the context of supermarket competition, consumers might be willing to pay more *for all goods* when they are offered a broader selection.

of an outside good).²⁰ Consequently, firms are no longer splitting a “fixed pie”, consumption and the level of quality are endogenously determined. The effect on strategic interaction is a shift to strategic complementarity: firms react in kind to increases in quality by their rivals.

The complementarity result is not confined to the example presented in Chapter 4 of this thesis. Analogous findings are presented in Ronnen (1991) and Lehmann-Grube (1997). In Ronnen’s example, which is based on Shaked and Sutton (1983), consumers’ incomes are allowed to vary and competition is Bertrand. In the resulting equilibrium, firms offer a staggered set of qualities. In the two firm case, when the high quality firm raises quality, the low quality firm follows suit and vice versa. The result follows from the fact that the market is not fully covered in equilibrium so that changes in quality induce consumers who previously consumed the outside good to join the market. Again, quality enhancements effectively increase the available “pie”. Lehmann-Grube presents similar results to Ronnen in a model with sequential entry.

This set of results indicate that strategic complementarity is consistent with several models of VPD, suggesting a potentially powerful tool to distinguish VPD from alternative mechanisms of competition. In the following section, I highlight several competing explanations for the observed structure of the supermarket industry. In many cases, strategic substitution is an empirical implication. Where it is not, I will indicate additional implications which can be evaluated using the data at hand.

3.3.2 Alternative Explanations for Concentrated Market Structure

Our discussion of the VPD framework was motivated by the high levels of concentration in the supermarket industry across geographic markets of varying size. Of course, there exist a variety of alternative explanations for the observed data (such as sequential entry, horizontal product differentiation, or complementarities in cost reducing investment) and, without further analysis, we cannot distinguish among these alternatives. Therefore, the remainder of this section briefly reviews some principal alternative explanations and identifies potential empirical implications to distinguish between VPD and each of these alternative theories.

In particular, I will demonstrate how standard models of product proliferation or capacity competition can be rejected by the data. Finally, I will consider two alternative forms of

²⁰The fraction of income devoted to the quality good is constant in the baseline Sutton (1991) model.

endogenous sunk cost investment, quality enhancement and cost reduction, and demonstrate how the strategic choices of firms can be used to distinguish between models of endogenous cost.

Our first task is simply to re-emphasize the central theme of the section 3.3: exogenous sunk costs alone cannot lead to non-fragmentation. Specifically, even if large chains are able to take advantage of economies of scale in the form of quantity discounts and more efficient distribution, so long as these economies are *exogenously determined*, fragmentation will continue to occur at some level (Shaked and Sutton, 1987; Sutton, 1991). Assuming that the economies are regional or even national in scale, we should observe several local and even regional monopolies. Small markets should consistently be served by a single firm. Observing the same number of firms serving markets of vastly differing sizes is simply not consistent with a static model of scale. Only when sunk costs are endogenously determined will we observe a positive lower bound to concentration. Therefore, evidence of non-fragmentation alone is sufficient to discredit the exogenous scale hypothesis.²¹ However, the nature of competition can be altered to produce higher equilibrium levels of concentration while preserving the exogenous nature of sunk investments.

A natural class of alternative models to consider are horizontal product differentiation (HPD) models of sequential entry. While Shaked and Sutton (1987) demonstrate that HPD with *simultaneous* entry will not yield non-fragmentation,²² models where firms enter sequentially are consistent with persistently high levels of concentration. Shaked and Sutton (1990) demonstrates that the fragmentation result continues to hold when entry is sequential. However, the non-fragmentation result is not the only empirical implication which can distinguish the HPD mechanism from VPD. Consider a standard product proliferation model with sequential entry,

²¹The static scale economies story is more consistent with the chain store era of grocery store competition, when large chain stores were vertically integrated into production (manufacturing). The market share of A&P, one of the first truly national grocery chains, rose and fell on the merits of its private label brands. A&P established a large market share in the 1920s by offering much lower prices on their own brands. However, the introduction of the supermarket format and the concomitant rise of national brands has all but wiped A&P out of existence (they no longer depend on own brand sales). Some supermarket chains continue to offer private label products in addition to national brands. Their popularity grew in the 1970s but has since waned. Since private labels are much more common in Europe, a cross national comparison of markets would be enlightening.

²²In the standard circle model (Salop, 1979), for example, although there is no formal measure of market size, the number of entrants increases monotonically with the ratio of transportation costs to fixed costs. Since transportation costs are increasing in distance, it is clear that the number of entrants increases proportionately with the "size" of the market.

such as Schmalensee (1978), where a small group of firms, acting as a cartel, try to pack the product space by filling all available niches and thereby, soften price competition among their products. In equilibrium, competition is localized, with single firms (or the cartel) producing all the products along a continuous segment of the product space. Bonano (1987) extends this analysis to include strategic location choice by a monopolist. Further persistence of local monopoly results are established by Prescott and Visscher (1977), Eaton and Lipsey (1979) and Reynolds (1987). In each of these models, competition is *localized* (Schmalensee, 1985) meaning that firms enjoy a monopoly over continuous regions of the product space. As such, a finding of head to head competition, where firms compete directly for the same consumers, is inconsistent with most standard models of HPD with concentrated equilibria.²³ Moreover, Tirole (1989) demonstrates that in HPD models of competition on the line where firms are able to choose their unit costs by investing in sunk outlays, the fixed investments behave as strategic substitutes.

Another class of models consistent with highly concentrated equilibria are models of entry deterring capacity investment. In fact, the measure of quality proposed in this paper - bandwidth - could easily be interpreted as a capacity choice, especially when bandwidth is measured by store size. In a standard Stackelberg (1934) model of capacity choice (Spence (1977, 1979); Dixit (1979, 1980)), large firms invest in excess capacity to deter entry, resulting in highly concentrated equilibria. However, in all of these models, capacity choices behave as strategic substitutes. While Bulow et al. (1985a) construct a model where capacity choices are complements, the complementarity result relies on extreme convexity of the demand function. Moreover, the complementarity result applies only to the Stackelberg leader; for the Stackelberg follower, capacity choice remains a strategic substitute. As such, a finding of strategic complementarity is again sufficient to rule out most Stackelberg games of capacity competition.²⁴ By estimating the reaction curves²⁵ of rival firms, we should be able to distinguish capacity competition from the endogenous sunk cost VPD framework.

²³An exception is Eaton and Lipsey (1982), where firms cluster around certain “poles”, such as shopping districts and shopping malls.

²⁴Obviously, when capacity choice is simultaneous, competition is Cournot and reaction functions are downward sloping (Bulow et al, 1985b).

²⁵Note that in this exercise the reaction curves are between *capacity* choices in the Cournot capacity model and *quality* choices in the endogenous sunk cost model. Of course, both concepts are measured by the same bandwidth (store size) parameter.

A growing literature, extending the capacity choice/entry deterrence framework, is aimed at explaining the high degree of concentration in retail markets using models of cost reducing investment (Bagwell and Ramey, 1994; Bagwell et al., 1997). In these models, vigorous price competition leads to the emergence of a dominant low-cost, low-price leader.²⁶ Although these investments in cost reduction are not endogenous, they are clearly strategic and consistent with a very high degree of concentration (monopoly, in fact, in the limit). Cost reducing investments can be endogenous investments as well. In chapter 4 of this thesis, I demonstrate that the Sutton (1991) baseline model can be reformulated as a model of cost reduction, indicating that cost reducing investments are consistent with both monopoly (Bagwell et al., 1997) and natural oligopoly (Sutton, 1991) outcomes. However, in both models, investment in cost reduction is a strategic substitute among rival firms. In fact, the substitution result holds across most standard models of cost reducing investment. Bagwell and Staiger (1994) demonstrate that investments in cost-reducing or quality enhancing R&D are strategic substitutes under fairly general conditions (satisfied by both Bagwell and Ramey, 1994 and Bagwell et al., 1997). I demonstrate that strategic substitution obtains in the baseline Sutton (1991) model in chapter 4 of this thesis. Athey and Schmutzler (1999) extend Bagwell and Staiger's results to include several additional classes of models, including Bertrand or Cournot competition with differentiated goods, constant marginal costs and linear demand (e.g. Dixit, 1979), HPD on the line (d'Aspremont et al., 1979) or the circle (Salop, 1979) with quadratic transportation costs, and the VPD model of Shaked and Sutton (1983). Indeed, it seems that only when investments are quality enhancing, as in the bandwidth model of chapter 4, are investments complements. Specifically, it is only when quality enhancing investments induce consumers to substitute out of an outside good and devote a larger share of income to the quality good, that VPD models lead to complementarity in quality.²⁷ Therefore, although strategic complementarity in investment may not rule out every conceivable model of cost reduction, it is inconsistent at least with

²⁶The emergence of a monopolist who, if re-entry is costly, can charge the monopoly price once his rivals have exited, suggests that welfare may be lower in this case than in the case where oligopolists must continue to compete for customers.

²⁷There are, in fact, three distinct versions of this result: Ronnen (1991), Lehmann-Grube (1997) and chapter 4 of this thesis. The first two examples utilize Bertrand competition and characterize asymmetric equilibria in quality. Consumers are restricted to consuming at most one unit of the quality good. In the examples presented in chapter 4 of this thesis, competition is Cournot, consumers are allowed to consume any quantity of the quality good, and symmetric equilibria in quality are characterized.

the standard models, allowing broad classes of models to be eliminated from consideration.²⁸ Moreover, estimating reaction functions provides an empirical method of not only distinguishing models where investments result in monopoly, but distinguishing between competing models of endogenous investment as well.

The collection of alternative models and empirical implications discussed here (the main results are summarized in Table 1) illustrate how the empirical methods utilized in this paper cannot rely on a single result to prove that VPD is the most appropriate model of competition in the supermarket industry. Rather, I will present a combination of results which, taken together, correspond closely to the predictions of the VPD framework, but contradict central implications of the alternative hypotheses discussed here. After providing an overview of the data in the following section, I will proceed to the central empirical exercises of this paper.

Table 1

Principal Empirical Predictions of Alternative Models

Source of concentration	Principal Predictions	References
Scale economies/capacity (exog. sunk costs)	Monopoly in small markets, fragmentation, strategic substitution	Dixit (1979, 1980) Spence(1977, 1979)
HPD with preemptive entry (exog. sunk costs)	Localized competition, strategic substitution	Schmalensee (1978) Bonano (1985)
Cost-reducing investment (exog. sunk cost)	Monopoly, strategic substitution	Bagwell et al. (1997)
VPD with cost-reducing investment (endog. s. c.)	Natural oligopoly, strategic substitution	Sutton (1991)
VPD with income effect (endog. sunk cost)	Natural oligopoly, strategic complementarity	Ronnen (1991), Chapter 4

3.4 Data

Documenting the competitive structure of an industry requires very detailed data that can be disaggregated down to the store level. In particular, for each supermarket in every market,

²⁸Those familiar with the literature on patent races know that strategic complementarity is fairly common in models of R&D and innovation. However, the complementarity result does seem to depend on the “winner take all” aspect specific to patent races (Reinganum, 1989).

we need to observe the ultimate owner or parent company, a measure of sales volume, several measures of quality (e.g. size, features), and its exact location. The data come from Trade Dimension's Retail Tenant Database. Trade Dimensions collects store level data on nearly every supermarket in operation in the U.S. for use in their *Marketing Guidebook* and *Market Scope* publications, as well as selected issues of *Progressive Grocer* magazine. The data is also sold to marketing firms and food manufacturers for use in the marketing of supermarket products. The definition of a supermarket used by Trade Dimensions is the industry standard: a foodstore with greater than \$2 million in yearly revenues. Note that this is an establishment level definition. In 1998, there were 30,557 supermarkets in the U.S., 21,225 operating in counties within a designated MSA. Individual stores are identified by street address, zip code and county code. Each store is assigned a unique identifying code that remains with the *location*, even if ownership changes. Thus, newly built stores can be distinguished from remodels or buyouts. For each store in the database, its place in the organizational hierarchy is clearly documented, indicating the operating name, ultimate parent company, the number of stores in the chain and the principal supplier. The degree of vertical integration is therefore completely observable. Stores are already grouped according to several market definitions (zip code through MSA) and additional groupings are straightforward.

At the store level, Trade Dimensions collects information on average weekly volume, store size, number of checkouts, number of full and part time employees, whether scanners are in operation, and the presence or absence of various service counters (e.g. deli, seafood) as well as other measures of quality (atm, check cashing). This information is gathered through quarterly surveys sent to store managers and checked against similar surveys given to the principal food broker associated with that store. Demographic variables were collected from census projections for 1997 at the MSA, county and zip code levels. When different aggregations were needed (e.g. 4 digit zip code demographics), population weighted averages were used. Summary statistics are contained in Table 2.

From Table 2, it is clear that the average supermarket operates far above the \$2 million cutoff. In fact, the largest supermarkets have revenues over \$1 million per week. The average supermarket has a selling area of 30,700 square feet. The newest stores offer between 60,000 and 80,000 square feet of selling area (*Progressive Grocer*). The relatively small average size reflects

the fact that many stores have been in place for 10 to 20 years. Only 54% of supermarkets supply themselves (vertically integrate into distribution), while the remaining stores contract with an independent supplier. 28% of supermarkets are owned by firms that operate in only one MSA. Most of these firms are independent (in fact, single store) firms. Finally, while scanning registers have diffused into the vast majority of supermarkets, other features such as ATM machines and service bakeries are less common.

Table 2

Variables

Variable	Definition	Mean	S.D.
Volume	Weekly Sales Volume	251432.2	166042.4
Size	Square Feet of Selling Area	30.7	17.0
Checkouts	Number of checkouts	9.5	5.5
VI	Vertical Integration Indicator	0.54	0.50
Stores	Total stores in parent comp.	418.4	479.2
Single Market	Single market firm indicator	0.28	0.45
Multi Market	Multi market firm indicator	0.72	0.45
Chain	National chain indicator	0.25	0.44
Scanner	Scanner indicator	0.88	0.33
Deli	Service deli indicator	0.83	0.38
Bakery	Service bakery indicator	0.74	0.44
ATM	ATM machine indicator	0.55	0.50
N	Number of observations	21255	

3.5 Evidence of Oligopoly in Supermarkets

The empirical analysis proceeds in four stages, the overall goal of which is to provide a body of evidence in favor of the quality enhancing VPD explanation of concentration in the supermarket industry, while providing several pieces of evidence to reject some of the key alternative hypotheses discussed in section 3.3. First, the existence of a positive lower bound to concentration is established – in most markets, 3-5 firms capture a 60-80% market share. This key finding is robust to the level of aggregation or the region analyzed; in large markets, the number of fringe

firms expands, but the number and realized share of the oligarchs remains stable. Second, a “quality wedge” between oligarchs and fringe firms is identified; oligarchs offer approximately double the “bandwidth” of the fringe firms and are much more likely to provide additional quality enhancements such as bakeries, service counters and in-store ATM machines. The focus then shifts to demonstrating that oligarchs *compete* head-to-head, at least geographically. In particular, I am able to demonstrate that at numerous levels of aggregation, there is little geographic segmentation. Finally, in section 3.6, I refine the analysis to focus on the nature of strategic interaction, demonstrating that the quality choices of rival firms are strategic complements. This finding allows us to rule out several competing hypotheses, including several models of cost reducing investment. The challenge of the empirical work presented here is to document the existence of a set of high quality firms which a) exist only in bounded numbers and b) compete head to head for the same consumers. In addition, I will identify features of the market structure which are inconsistent with competing theories. The first set of results illustrates how concentration remains strictly positive, regardless of the size of the market.

3.5.1 The Lower Bound to Concentration

Our first set of results highlight the central non-fragmentation result presented in Chapter 2: equilibrium concentration remains strictly positive as market size increases. Figure 3-1 illustrates the relationship between concentration and market size using the share of the largest firm (C_1) to measure concentration.²⁹ Here, a market is taken to be an MSA, the definition used both by supermarket firms and in previous studies of the industry.³⁰ I measure the size of a market using the log of its population. There are 320 distinct markets in the sample. New York City was dropped from the sample because zoning laws place severe restrictions on the size of supermarkets in Manhattan.³¹ The non-fragmentation result is immediate upon inspection.

²⁹See chapter 2 of this thesis for a formal empirical analysis using an alternative measure of concentration (C_4).

³⁰This definition has been widely used in previous studies of the supermarket industry (Chevalier (1995, 1996); Cotterill and Haller, 1992), in trade journals, and by the Federal Trade Commission in assessing merger activity. Its choice is justified on theoretical grounds by the fact that supermarket chains operate divisions and distribution centers at the MSA level, distribute advertising circulars at the MSA level, and consider their competitors to be firms operating in the same MSA (Baer, 1999; Chevalier, 1995).

³¹New York City was included in the analysis in Chapter 2 of this thesis. This is because a) it was not the only outlier in the earlier period (1972) and b) outliers play a central role in bounds analysis. Moreover, the non-fragmentation result continues to hold when New York City is included. However, because New York City

There is a clear lower bound to concentration which remains strictly positive as market size expands. Indeed, the lower bound reaches a minimum quite quickly and then actually increases with market size. This convex, bounded relationship suggests that while scale economies may play an important role, they are not the main determinant of market structure. With pure scale economies, concentration would tend to zero as the market expands. Only when sunk costs (and minimum efficient scale) are determined endogenously, can we expect to see markets remain concentrated indefinitely. The fact that the lower bound first falls and then increases can be explained with a model of endogenous sunk costs where investment only impacts willingness-to-pay beyond a certain threshold level (of investment).³² However, this non-convex behavior cannot be explained by simple (static) scale economies, where a larger number of firms fit into larger markets.

The share of the second largest firm (Figure 3-2) is also bounded below, indicating that even the smallest markets do not converge to monopoly. Although the share of the market served by the second through fourth firms decreases substantially, it does not decrease to zero (the fourth firm serves on average 9% of a market). Moreover, in several instances the fourth largest firm in a market is the market leader somewhere else. These findings of non-fragmentation can be viewed as the first piece of evidence that supermarket competition must, at some level, be focused on sunk outlays. However, demonstrating that VPD is in fact the mechanism of competition requires identifying a natural oligopoly of high quality firms competing side by side. This can only be accomplished by looking above the bound.

3.5.2 Identifying an Oligarchy

In this section, I demonstrate that, in markets of differing sizes, roughly the same number of firms capture 70-80% of the market. This result is robust to the level of aggregation or definition of market. In the following sections, I demonstrate that a) these firms provide a distinct, higher quality product than the remaining fringe of firms and b) they compete head to head for the same consumers. However, in order to justify proceeding to these more detailed

is the only outlier in 1998 and a reasonable case can be made that the forces determining its observed level of concentration are outside the endogenous sunk cost framework (i.e. government regulation), I chose to exclude New York City from the current analysis.

³²For example, advertising might only be effective beyond some minimal level or there might be minimum purchase requirements for television commercials (Sutton, 1991).

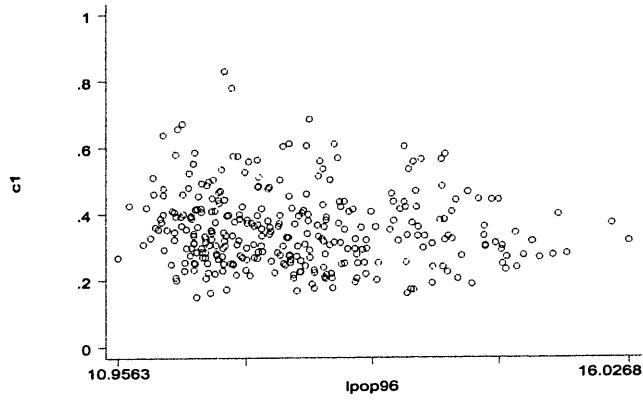


Figure 3-1: The lower bound to concentration

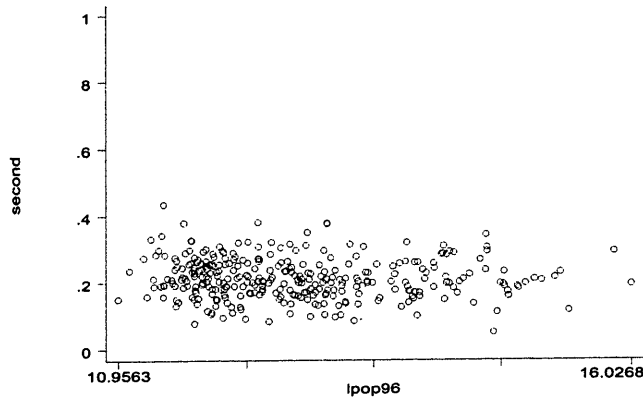


Figure 3-2: Share of the second largest firm

results, it is first necessary to establish the existence of an oligarchy. Our second set of empirical results addresses this question by focusing on individual firms, establishing that roughly the same number of high quality firms enter a market, irrespective of its size. Figures 3-3 and 3-4 present Lorenz curves for two west coast markets (MSAs), Eugene Oregon and Los Angeles California. In this exercise, the horizontal axis measures the rank of the firm (from largest to smallest) in terms of sales while the vertical axis measures cumulative sales as a share of the total. Although the markets vary greatly in size, the larger market differs from the smaller one almost exclusively in the length of the tail of small firms.³³ Figure 3-5 presents Lorenz curves for MSAs in several west coast markets. The uniformity in outcomes across markets is striking. For a wide class of markets, 65-70% of the market is controlled by 4 or 5 firms, with the remainder of the market being served by a fringe of firms that expands with population. Figures 5-1 to 5-8 in the appendix extend this analysis to include every MSA in the sample. There are a few outliers (e.g. Minneapolis in the northwest, Oklahoma City in the southwest, Kansas City in the Ohio Valley, and New York in the Northeast), but the uniformity of outcomes remains. Again, these configurations are not consistent with an exogenous scale economy story, as there does not appear to be any tendency towards a single dominant firm. Among the 320 MSAs, only 36 have a single firm capturing over 50 percent of the market. Of these 36 markets, 12 have a single firm capturing between 60 and 70 percent and 2 have a single firm capturing between 70 and 85 percent. If concentration were being driven purely by exogenous economies of scale, we would expect to *consistently* observe one firm, especially in the smaller markets. The fact that we observe so few single-firm dominated markets even in the smallest markets, suggests that natural oligopoly is a stable outcome and that some additional force is driving industry structure.

The level of concentration clearly depends on market definition. While the MSA is widely considered to be the level at which large supermarket chains compete (both advertising and distribution take place at the MSA level), it is possible that these results could depend critically on the level of aggregation. I find that they do not. Table 3 presents average market concentration (C_4) for several market definitions, broken down by region. While concentration

³³This analysis includes only firms which operate more than one store. The inclusion of single store firms merely increases the length of the tail of firms in large markets, but scale problems make the graphs difficult to compare.

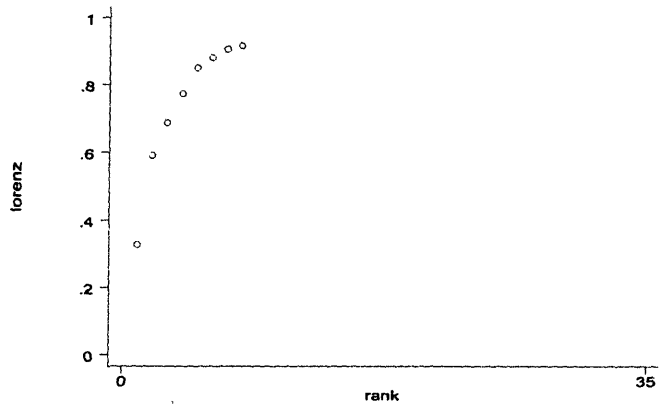


Figure 3-3: Cumulative market share (Eugene)

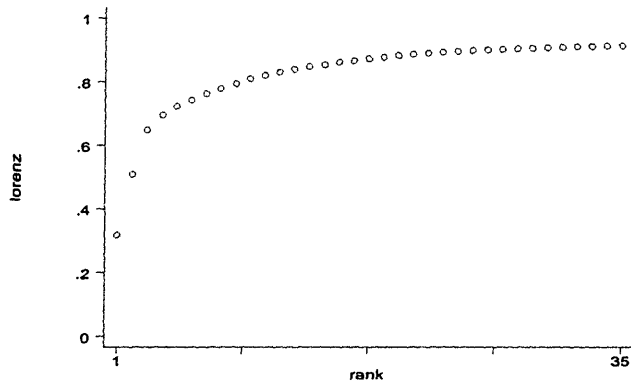


Figure 3-4: Cumulative market share (Los Angeles)

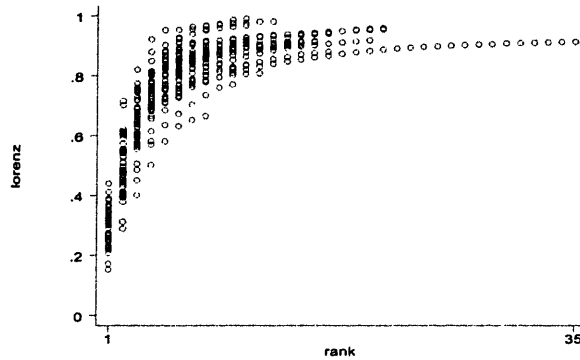


Figure 3-5: Cumulative market share (West Coast MSAs)

decreases significantly at the regional level, the state and MSA levels are quite similar. These results also indicate that while regional variation exists, it is not consistent across markets. For example, although the older markets appear less concentrated at the state and regional level, the effect is much less pronounced at the MSA level. Figures 3-6 and 3-7 demonstrate that the oligopolistic structure extends up to the state and regional levels respectively (the sample remains west coast markets for ease of comparison). At each level of aggregation, the top 4 firms in the market capture most of the total sales.

Taken together, these results suggest that supermarket competition indeed takes the form of natural oligopoly. In fact, although the oligopolistic structure extends up several levels of aggregation, MSAs are still served by 4-5 high quality firms. While economies of scale clearly play an important role and endogenous sunk costs may efficiently be sunk above the MSA level, firms still face direct competition in every market. In the following sections, I demonstrate how this result extends all the way down to the individual store.

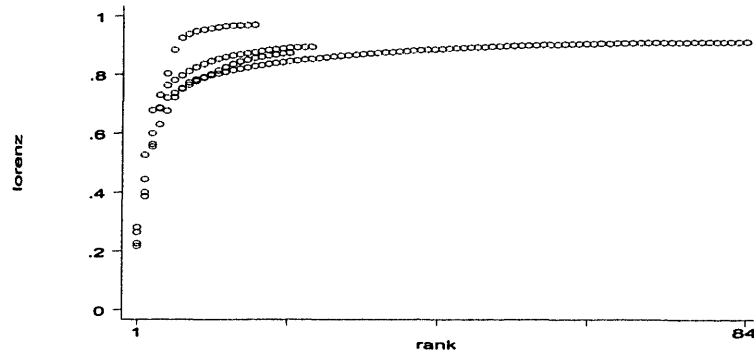


Figure 3-6: Cumulative market share (State level)

Table 3
Concentration by Market

Area	MSA	State	Region	National
West	.73	.68	.61	.24
Northwest	.88	.78	.46	.24
Southwest	.79	.71	.55	.24
South	.82	.63	.45	.24
Ohio Valley	.75	.58	.46	.24
Great Lakes	.74	.51	.33	.24
Northeast	.76	.68	.30	.24
South Atlantic	.81	.69	.56	.24

3.5.3 Top Firms Provide a Distinct Product

The preceding exercises established not only that concentration remains positive at all market sizes, but that the top 4 firms capture 70-80% of a market's sales, regardless of the size of the market. In this subsection, I extend this analysis by demonstrating that the product provided by top 4 firms is significantly different from that of the fringe. In particular, the quality level of the top firms (as measured by store size and the number of store features) is almost twice as high as the level chosen by firms in the fringe. Establishing that the oligarchs provide a distinct

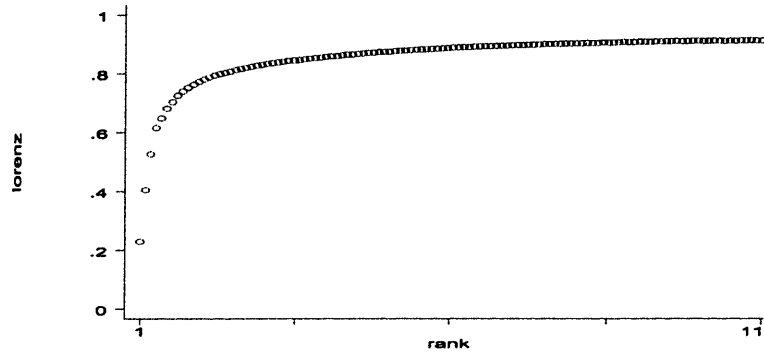


Figure 3-7: Cumulative market share (regional)

product justifies focusing on competition among firms in this set alone. In the following section, I demonstrate that this set of oligarchs compete side by side in local markets and do not carve out local (geographic) monopolies. This finding of competition at the local level reflects the rivalry emphasized in the VPD framework and casts doubt on the validity of alternative non-competitive explanations (e.g. product proliferation) which predict substantial balkanization of competition.

Although the optimal measure of quality suggested by the VPD model would combine a measure of bandwidth with store size,³⁴ Trade Dimensions does not collect information on the number of products offered by each store. Therefore, I will use store size alone to proxy for quality. As a robustness check, I present two alternative measures of quality constructed from store characteristics: the number of features present in a store (0-2 among an in-store bakery and deli) and a similar measure for scanners and atm machines (technology).

Table 4 investigates the relationship between store quality and firm type. For the entire sample of 320 MSAs, firms are divided into the top 4 firms in each MSA and the remaining fringe of firms (firms which operate in more than one MSA are treated as separate observations). The average store level characteristics are calculated for each class of firm across all MSAs. The top 4 firms offer significantly higher levels of quality along all three dimensions. In addition,

³⁴Providing a large bandwidth requires stocking a wide array of products and building a larger stores. Wide aisles and easily accessible products consistently rate highly in consumer surveys (Progressive Grocer). Therefore, even the number of stock keeping units (SKUs) offered in each store would not fully capture this measure of quality.

top 4 firms are more than twice as likely to be vertically integrated and operate over three times as many stores.³⁵ The last two columns of Table 4 address the hypothesis that sunk cost outlays may be optimally sunk above the firm level. Stores are divided according to whether their parent company operates stores in one or more than one market. The results are broadly similar to the results from the top4/fringe division: multi-market firms choose higher levels of quality and are considerably more likely to be vertically integrated.

Table 4
Store Characteristics by Firm Type

Characteristic	Firm Type			
	Top 4	Fringe	Multi-market	Single-market
Size	40.4 (16.0)	24.1 (15.2)	33.5 (17.0)	20.0 (15.0)
Technology	1.58 (.42)	1.21 (.62)	1.40 (.58)	1.21 (.49)
Features	1.75 (.42)	1.31 (.74)	1.54 (.68)	1.34 (.56)
% VI	0.68 (.46)	0.31 (.46)	0.57 (.49)	0.01 (.10)
Stores	487.6 (469.9)	131.7 (261.4)	344.4 (422.7)	2.84 (3.34)
Observations	1257	1735	2439	553

Table 5 uses regression analysis to test the significance of the quality “wedge” for the top 4 firms. Using the sample of firm-MSA level observations, each measure of average store quality is regressed on a dummy variable indicating whether the firm is in the top 4 in this MSA and a full set of MSA fixed effects. Quality is measured in levels, with average store size measured in 1000s. All three measures of quality are significantly higher among the top 4 firms. These results suggest that membership in the “oligarchy” entails providing a significantly different product than the fringe firms. If scale economies and quantity discounts alone were determining market structure, we would not expect the *store* characteristics of lead firms to differ from the followers.

³⁵The number of stores operated is the total number of stores operated by a firm across all MSAs.

We would simply expect the market leaders to have lower prices.³⁶

As such, this set of findings justifies shifting our focus to competition among the oligarchs, treating the fringe as a separate industry,³⁷ which does not significantly impact competition among the oligarchs. To summarize, the preceding empirical results identified a high quality set of supermarkets that exists only in bounded numbers, regardless of the size of the market. The goal of the next set of results is to demonstrate that these firms in fact compete side by side for the same consumers, consistent with the rivalry emphasized in the VPD framework.

Table 5
Store Characteristic Regressions

	Dependent Variable		
	Size	Technology	Features
Top 4 Dummy	17.4 (.61)	.39 (.02)	.44 (.02)
Constant	23.6 (.38)	1.32 (.01)	1.32 (.02)
MSA Fixed Effect		Included	
R^2	.32	.23	.23
Observations	2992		

Standard errors in parentheses.

3.5.4 The Structure of Local Competition

The empirical exercises in the previous subsections establish that markets of varying sizes are served by roughly the same number of high quality firms. However, several forms of *local* competition are consistent with this structure. For example, in equilibrium, firms might serve distinct geographic regions (as in product proliferation models). Consumers would therefore face

³⁶This was precisely the case when A&P dominated the grocery industry (Tedlow, 1990).

³⁷This raises the question of what market is actually being served by the fringe firms. Cotterill (1986) finds that prices are 2.6% higher among independent supermarkets in the Vermont area, suggesting that independent firms may charge a premium for location or convenience. In addition, he finds a non-linear relationship between price and store size, suggesting that the largest stores are able to charge a premium for quality (size). These findings support the claim that independent supermarkets and premium chains serve distinct markets.

local monopolies in each submarket. On the other hand, each market might be served by several firms, so that each firm would face competition at each store location. These two cases have very different consumer welfare implications,³⁸ clearly illustrating the importance of market definition in any analysis of retail competition. This issue can only be resolved by narrowing our analysis to small geographic submarkets and focusing on local competition. Schmalensee (1985) provides an explicit statistical test for localization of competition in differentiated products markets. However, because the differentiation considered here is simply spatial, I am able to rely on simpler methodology. I present several complementary pieces of evidence which demonstrate that firms are unable to carve out local monopolies at almost any level of aggregation. The fact that local monopoly is consistently so rare suggests that rivalry between firms is a central feature of the mechanism underlying the competitive structure of the supermarket industry.

Extending the results presented above, I focus on competition in local markets between supermarkets that are among the top 4 firms in an MSA. The top 4 concept is defined at the MSA level: the top 4 firms are identified for each MSA and then the number of distinct top 4 firms operating in each zip code within that MSA is calculated. Table 6 presents the average number of top 4 *firms* per zip code versus the average number of *stores* of any type per zip code. The sample is restricted to only those zip codes which are served by at least one top 4 store (5995 of 8174 total zip codes). Since zip codes vary considerably by region, results are broken down by region. For most regions, the average number of top 4 firms is well over 1, suggesting that monopoly is relatively rare. However, conditioning on the presence of at least one top 4 firm introduces selection that may confound this analysis. It also fails to control for the *size* of the market, an omission which could bias these findings.

Table 7 addresses this concern by conditioning instead on the number of supermarket stores of any type (including fringe stores). The number of stores is likely to provide an accurate measure of the size of the market that fully reflects differences not captured by population alone (e.g. the presence of shopping centers or other consumer attracting “poles”). Indeed, the number of top 4 stores increases quite quickly with the total number of stores, indicating

³⁸As noted earlier, once a local monopoly is established, the surviving monopolist may be able to charge the monopoly price so long as re-entry is costly, even if his monopoly position resulted from vigorous competition to become the low cost leader. Local monopoly can only serve to soften price competition and reduce the incentive to invest in future quality enhancements or cost reducing investments.

that monopoly, when it does occur, is mostly confined to smaller markets. Table 8 extends this analysis by identifying the frequency of monopoly outcomes. Here, I present the frequency of one, two, three and four top 4 firm market configurations for two alternative market definitions. Although almost half the zip code markets are served by only a single top 4 firm, this simply reflects the small size of some zip codes: monopolies only account for a quarter of four digit zip code markets.³⁹ Table 9 further illustrates this point by conditioning on the number of top 4 stores. For zip code markets which contain two or more top 4 stores (3355 of 5595 markets), the frequencies of possible market configurations are presented. Multi-store monopoly is an extremely rare occurrence. When zip codes can fit more than one top 4 store, most often there is more than one top 4 firm.

In the appendix, I supplement this analysis by presenting maps of the actual locations of all the supermarkets in four markets (MSAs): Tampa (FL), Sacramento (CA), Los Angeles (CA), and Eugene (OR). Firm locations are matched to a zip code and plotted using symbols that correspond to their overall share in the market (MSA). In each case, top 4 firms appear to cluster in groups of 2 to 4. There is no evidence that, in equilibrium, firms serve distinct regions of the market: in no case is there a distinct geographic region which is controlled by a single top 4 firm, even though the share of the top firm approaches 30% in some markets. This result is particularly striking in Tampa, where natural boundaries might facilitate market power. Moreover, the interwoven structure of firm competition exists for both the smaller and larger markets. This finding is difficult to reconcile with most models of product proliferation.

³⁹It is important to keep in mind that a “monopoly” means only that the market is served by a single top 4 firm. Few of these markets are actually served by only one firm of any type.

Table 6

Top 4 Firms Per Zip Code

Region	Stores	Top 4 Firms	Observations	Population
West	3.6	1.9	1039	30297
Northwest	2.4	1.6	199	20296
Southwest	2.9	1.8	307	23255
South	3.0	1.8	738	23046
Ohio Valley	3.3	1.8	294	22463
Great Lakes	3.0	1.6	914	26628
Northeast	2.4	1.4	1333	21318
South Atlantic	3.3	1.9	1171	22632
Total Zip Codes			5995	

Table 7

Top 4 Firms in Multi-Store Zip Codes

	Number of Stores						
	1	2	3	4	5	6	7+
Top 4 firms	.45	1.11	1.69	2.04	2.28	2.58	2.83
Population	11122	18711	25079	30957	54821	38835	48112
Observation	2934	1916	1278	853	546	294	353
Total zip codes				8174			

Table 8

The Frequency of Monopoly Outcomes

Market Type	Configuration				Total Markets
	Monopoly	Duopoly	Triopoly	Quadropoly	
Zip Code Markets	2943	1966	868	218	5595
4 Digit Markets	633	718	654	486	2481

Table 9
 Monopoly: Conditional on
 the Number of Top 4 Stores

Configuration	Number of Top 4 stores			
	2	3	4	5+
Monopoly	265	29	8	1
Duopoly	1354	437	129	46
Triopoly	-	428	276	164
Quadropoly	-	-	68	150
Total Markets	3355			

The preceding exercises attempt to demonstrate that top firms do not serve geographically distinct markets. Instead, firms compete directly with their rivals at every store location. However, I was forced to argue this point using a variety of methods, none of which captured the structure of competition in a single index. The final exercise of this empirical section proposes a single index of concentration to characterize the industrial structure of the full set of geographic markets. In particular, I construct an index of agglomeration which captures excess concentration relative to that which would occur randomly with suitably weighted potential locations (weighted, for example, by population). By comparing the calculated index for the industry as a whole (all stores) to the index calculated for only the top firm in each market, it is possible to test directly whether the lead firm chooses locations which are more localized than the industry as a whole (i.e. locating within only a few distinct submarkets). Localization is rejected if the index of concentration is the same or smaller for the top firm than for the industry as a whole. Using this methodology, I am able to demonstrate that the top firm does not select locations which are more clustered than the industry as a whole (or population), thereby rejecting the hypothesis of localized competition.

3.5.5 A Single Index of Competition

The basic finding demonstrated here is that the top firm in a market chooses store locations in manner which is no more geographically concentrated than the industry as a whole. To formalize this logic, I employ the “dartboard” method developed by Glenn Ellison and Edward Glaeser

(1997). The authors propose a measure of spatial agglomeration that “controls’ for differences in industry and data characteristics without knowing what combination of natural advantages or spillovers is responsible for the agglomeration of each industry.” In other words, their index measures excess concentration, accounting for differences in the number of stores owned by a firm and the size of the geographic region. The index was designed to capture the effect of spillovers or advantages causing (manufacturing) firms to locate plants in the same geographic regions. In practice, the index may be used to measure excess concentration among all plants in an industry or among only those plants owned by a specific firm. “Excess concentration” measures concentration beyond that which would be expected if firms chose plant locations by throwing darts at a suitably weighted “board” of potential locations. In the context of manufacturing, the weights are typically taken to be the share of overall manufacturing in a local submarket. In the supermarket industry, a more appropriate measure is the overall share of the consumer population residing in the local submarket. Using this index of excess concentration, we can then test the hypothesis that the top firm in a market chooses locations which are more agglomerated than the industry as a whole. This will not tell us whether the lead firm can enter first and occupy the best locations. However, it will identify firms that are attempting to serve distinct regions. Specifically, consider the following measure of concentration:

$$\gamma = \frac{\sum_i (s_i - x_i)^2 - \sum_i (1 - x_i^2) \cdot \frac{1}{N}}{\sum_i (1 - x_i^2) \cdot (1 - \frac{1}{N})}$$

where s_i is the share of stores in submarket i , x_i is the share of population in submarket i , and N is the total number of stores in the overall market area (MSA). While the overall market area for which each γ is defined is taken to be an MSA, I will utilize several potential definitions of the local submarket (e.g. zip code, 4 digit zip code, county). By evaluating this measure for both the top firm and the industry as a whole, we are able to make a direct comparison of the level of agglomeration among these two groups of firms. If firms succeed in dividing the market into local monopolies, the top firm should be more clustered than the industry as a whole, resulting in a larger value of γ . Since it is not clear how large a local submarket a potential monopolist might control, it is important to present a variety of local submarket definitions.

Table 10 presents parameter estimates of γ calculated for each set of firms using two alternative submarket definitions: zip code and county. The sample of MSAs includes all markets in the dataset where γ is defined; any market which contains only one submarket must be dropped from the sample. Focusing first on γ calculated for the industry as a whole (store γ), I find that, for each market definition, γ is very close to zero. Since we expect retail firms to locate close to their consumers, this is not surprising.⁴⁰ For each definition of local market, the estimate of γ for the lead firm (top store γ) is smaller than γ for the industry as a whole (store γ), indicating that, in equilibrium, the store locations chosen by the top firm are not spatially clustered. However, because γ is a parameter estimate, the standard deviations of γ are much larger for the set of top firm stores, since fewer “darts” are being thrown. This is clearly illustrated in Figures 3-8 and 3-9, which plot the distribution of γ for the zip code markets (county markets are presented in the appendix).⁴¹ Using this statistical evidence, the hypothesis that γ is larger for the lead firm can be clearly rejected.

Table 10

Concentration in Local Markets - The Dartboard		
	All Markets	
	Zip Code	County
Store γ	-.013 (.035)	-.004 (.021)
Top Store γ	-.087 (.189)	-.015 (.111)
Observations	311	102

The preceding evidence indicates that competition in the supermarket industry indeed takes the form of natural oligopoly. This oligopolistic structure extends from the regional down to the local level, where firms face competition from rival stores at each location. However, whether the strategic interactions between oligarchs take the form of strategic complementarity

⁴⁰Ellison and Glaeser find that γ is closest to zero (no excess concentration) in markets where firms must locate close to their end users.

⁴¹Restricting the sample by population to include only large markets improves the precision of the estimates considerably. The hypothesis of greater agglomeration among the top firms is easily rejected.

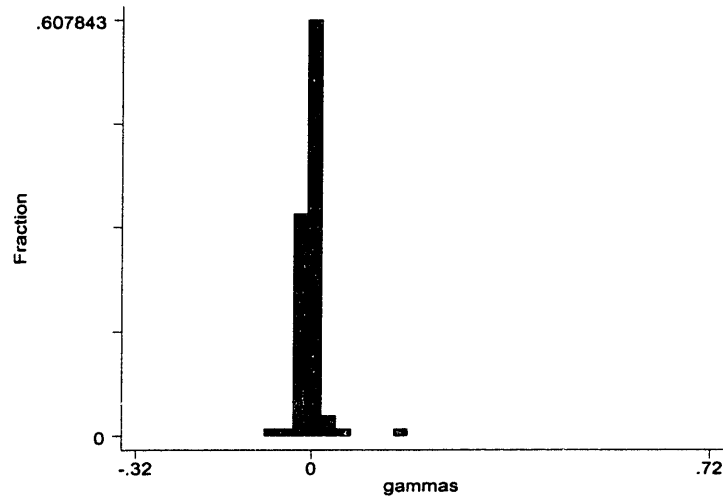


Figure 3-8: The distribution of γ (all stores)

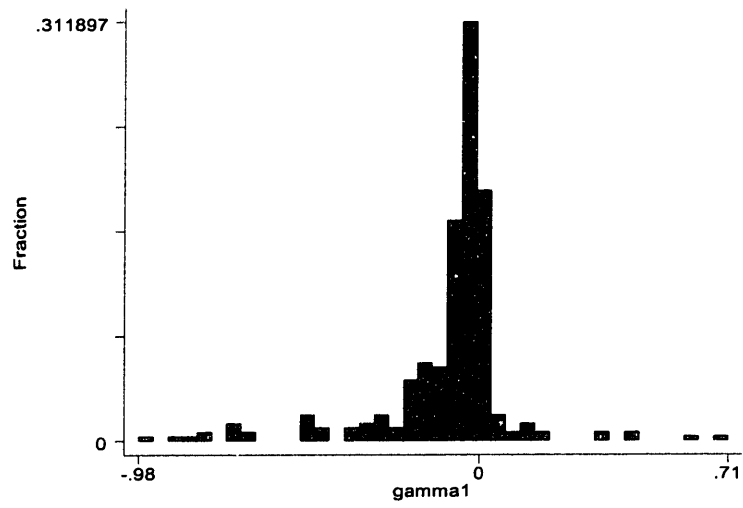


Figure 3-9: The distribution of γ (top store)

or substitution depends on whether quality enhancing investments increase the effective size of the market, which we evaluate in the following section.

3.6 Quality Competition in the Supermarket Industry

The empirical results presented in the previous section demonstrate that many of the predictions of the endogenous sunk cost VPD framework can be documented in the supermarket industry. Moreover, several features of the industrial structure are difficult to reconcile with alternative explanations where sunk costs are exogenously determined. The purpose of this second set of results is not only to further distinguish exogenous from endogenous sunk cost models, but to differentiate among the set of endogenous sunk cost models as well. Specifically, I demonstrate that firms' quality choices are strategic complements. In addition to being inconsistent with most models of exogenous sunk costs, this finding is also inconsistent with most models of cost reducing exogenous or *endogenous* sunk investments. However, it is consistent with the bandwidth model of quality enhancing sunk cost investment presented in chapter 4 and the model analyzed in Ronnen (1991). I begin by demonstrating that a central prediction of the VPD framework holds: that quality, market size and the number of entrants positively covary. As a result, we cannot estimate a firm's reaction function by simply regressing the firm's choice of quality on his opponents' choices. Therefore, I construct an instrument for the quality choices of competing firms and perform the analysis using instrumental variables (IV) regressions. Using this approach, I am able to demonstrate that quality choices by rival firms are strategic complements. This finding, together with the findings on the structure of local competition presented in the previous section, clearly demonstrates that the VPD framework provides a very accurate picture of competition in the supermarket industry. While the alternative explanations presented in section 3.3 may succeed in explaining one or even a few features of the industry, the VPD framework reconstructs the unique combination of all of these features.

Our first set of empirical results addresses the relationship between store size (quality), market size and the equilibrium number of entrants. According to the theory, larger markets should have a greater number of entrants (up to the oligopoly limit) and a higher level of

quality. To document this covariation, I focus on the zip code as a local market,⁴² and take quality choice to be a dependent variable. Starting from the dataset of store level observations for all 320 MSAs, I select out only those stores operated by firms which are in the top 4 at the MSA level.⁴³ Fringe firms are assumed not to strategically interact with the top 4 firms. A top 4 firm may then face between 0 and 3 other top 4 firms in a given zip code market. The following reduced form regression is specified:

$$\ln(\text{size}_{ij}) = \alpha_1 \cdot I_{1j} + \alpha_2 \cdot I_{2j} + \alpha_3 \cdot I_{3j} + \sum \alpha_4 \cdot \text{Market}_j + \sum \alpha_5 \cdot \text{MSA} + \varepsilon_j$$

where size_{ij} is the size of store i in zip code j , I_{1j} , I_{2j} , and I_{3j} are dummy variables indicating the presence of 1, 2 or 3 other top 4 firms in zip code j , and Market_j is a set of (logged) zip code level demographic and market characteristic variables. MSA is a full set of MSA level fixed effects and ε_j is an error term. Table 11 presents the regression results. The first two columns present results for zip code level regressions while the final two columns utilize the larger, 4 digit zip code market definition. Size is positively and significantly related to the presence of other top 4 firms. Moreover, the magnitude of the effect is monotonically increasing in the number of competitors. This suggests that either the true size of the market is not fully captured by our proxies or that some markets, for historical reasons, have fewer entrants and the lack of rivalry reduces both competition and the equilibrium level of quality. Size is also positively related to our measures of market size, population and income. In each case, the relationship is concave, although it is only significant for the larger market definition (suggesting that these measures are more accurate for the larger definition of a market). These results indicate that equilibrium quality levels are determined by a mechanism consistent with the VPD framework, where quality is an (endogenous) function of market size and the number of entrants. While this finding further justifies focusing on the VPD framework, it does not directly rule out any of the alternative mechanisms outlined in section 3.3. To do so, we must shift our focus to the strategic interaction between firms.

In order to isolate the pure escalation effect (and assess its magnitude) and understand

⁴²I will also present results for a larger local market definition (4 digit zip codes).

⁴³I preserved the total number of stores of any type in each zip code to use as a regressor.

the strategic interaction between firms, I must estimate the structural model underlying the competitive process. Specifically, I propose estimating the reaction functions of competing firms. The following regression is specified:

$$\ln(size_{ij}) = \alpha_1 \cdot \ln(Avgsize_{\setminus i}) + \alpha_2 \cdot \ln(Avgsize_i) + \sum \alpha_3 \cdot Market_j + \sum \alpha_4 \cdot MSA + \varepsilon_j$$

Here, $size_{ij}$ is again the size of a store j in zip code k . $Avgsize_{\setminus i}$ is the average size of store i 's competitors in zip code j . $Avgsize_i$ is the average size of the stores of the firm that owns store i , outside of this MSA. $Market_j$ is a set of zip code level demographic variables, MSA is a set of MSA fixed effects (included in select specifications) and ε_j is an error term. As I documented above, firm size decisions are clearly endogenous. Unobserved factors such as an advantageous location in a shopping district, a disproportionate share of commuters, or idiosyncratic consumer preferences might cause some zip codes to have larger or smaller stores on average. Not all of these effects will be captured by demographic variables. Furthermore, the solution of the overall game implies a positive correlation between store size, market size and the equilibrium number of entrants. We are interested not in the solution of the overall game, but the strategic interaction among quality choices in the second stage of the game. Therefore, an instrumental variables approach is warranted.

To perform this analysis, I propose instrumenting competitors store size using their average store size outside of the MSA market.⁴⁴ A similar approach is used to instrument for prices in the context of new good valuation in Hausman (1994). Here, a firm's store size is assumed to be correlated across markets for at least two reasons. First, there are clearly scale economies inherent in providing a wide variety of products that go beyond the single MSA (see section 3.5.1 and chapter 2 of this thesis). Second, the benefits of maintaining a reputation for high quality probably extend across markets, as do the returns from media advertising. However, the tendency to provide larger stores is probably not related to the idiosyncratic forces driving store size to be larger in any particular zip code market (such as elements of market size not fully captured by population (e.g. the presence of shopping malls or a high percentage of "soccer"

⁴⁴This instrument may be constructed in several ways, using a firm's average outside this zip code but within this MSA, across all stores outside this zip code (all MSAs) or across all stores outside this MSA. I explored each alternative and concluded that the latter is the most appropriate instrument.

moms and stay at home parents)).

The first column of Table 12 can be viewed as the first stage of a two stage regression and provides some justification for the choice of instrument. The remaining columns present several specifications of the regression proposed above. The second column of Table 12 contains a baseline specification involving only own size and competitor's size. The third and fourth columns test the robustness of this specification by adding MSA fixed effects and zip code demographics respectively. The fifth column contains both sets of controls. The magnitudes of the competitor's size coefficients are reduced but remain positive and significant for each specification. The final column presents the specification of column 5, using the larger 4 digit zip code market definition. The size effects are larger for the larger market size, which is not surprising. In every specification, the complementarity result is positive and significant at the 1% level. Together, these regression results provide strong evidence that the quality levels chosen by rival firms are strategic complements. While this results is consistent with several models of VPD which emphasize the demand expanding effect of quality enhancement, it casts a significant doubt on a number of competing explanations of market structure, particularly models of cost reducing investment. This evidence on the actual shape of firm's reaction functions, together with the picture of the competitive structure of local markets presented earlier, suggests that the competitive, rivalrous emphasis of the VPD framework accords well with the observed structure of the supermarket industry.

Table 11
Quality Regressions

	Log Size			
One Competitor	.086	.049	.162	.117
	(.010)	(.011)	(.017)	(.019)
Two Competitors	.147	.086	.192	.135
	(.011)	(.014)	(.017)	(.020)
Three Competitors	.175	.098	.220	.160
	(.015)	(.020)	(.017)	(.023)
Population		.090		.360
		(.079)		(.074)
(Population) ²		-.003		-.015
		(.004)		(.004)
Income		.244		1.69
		(.569)		(1.07)
(Income) ²		-.014		-.084
		(.027)		(.050)
Market Level Controls		Included		Included
MSA Fixed Effect		Included		
R^2	.15	.18	.15	.17
Observations	12554			

Standard errors in parentheses.

3.7 Conclusions

This paper attempts to explain how retail industries become dominated by a few large firms in equilibrium. In particular, the high levels of concentration observed in the supermarket industry are explained using an endogenous sunk cost model of vertical product differentiation. In this framework, fierce competition leads to the emergence of a few dominant firms competing in quality enhancing sunk outlays. The predictions of this model accord well with the features of the supermarket industry documented here. Using a novel dataset of store level observations,

I demonstrate that the same number of high quality firms enter markets of varying sizes and compete side by side for the same consumers. In addition to documenting a local structure of competition consistent with the VPD framework, I demonstrate that the choice of quality by rival firms behaves as a strategic complement. This key finding, which is consistent with a VPD model of quality enhancing sunk outlays, eliminates several alternative explanations concerning the nature of supermarket competition, including most standard models of cost-reducing investment. As such, I conclude that the competitive mechanisms sustaining high levels of concentration in the supermarket industry are inherently rivalrous and unlikely to lead to the emergence of a single dominant firm.

These findings suggest several avenues of further research. First, the focus on providing a wide array of products is not unique to the supermarket industry. Data from other concentrated retail industries such as consumer electronics, book stores and video rentals might provide insight into whether similar forces are driving the emergence of dominant chains in other markets. Second, the types of endogenous sunk costs most often analyzed, R&D and advertising, have the property that firms can spend virtually infinite sums of money on them, albeit with diminishing returns. R&D has never played a role in supermarket competition and the importance of advertising appears to have decreased over time. Moreover, store size and product selection, which seem to play a central role in supermarket competition, are naturally bounded by physical constraints. Nevertheless, the high levels of concentration observed in the supermarket industry have remained relatively stable for at least 25 years, despite substantial changes in the identities of the dominant players. This suggests that competition may force firms to find new ways to raise quality, perhaps shifting the focus of competition from advertising to product selection. This can only be understood by building a truly dynamic model of quality competition with continuous investment. Finally, little is understood about the welfare implications of endogenous sunk cost investments. The equilibrium price charged by natural oligopolists is strictly less than the monopoly price, but is well above marginal cost. Moreover, natural oligopoly is consistent with high equilibrium profits. Do consumers benefit from the relentless investment in quality driving competition in these models? Examining the welfare properties of endogenous investment models is the subject of future research.

Table 12
IV Regressions

	Log Size				
Competitors' Size	.225	.224	.196	.190	.240
	(.026)	(.036)	(.027)	(.036)	(.054)
Own Size	.896	.866	.899	.851	.876
	(.020)	(.020)	(.026)	(.020)	(.026)
Population			-.076	-.104	.292
			(.098)	(.101)	(.111)
(Population) ²			.004	.005	-.014
			(.005)	(.005)	(.005)
Income			-.592	.172	1.24
			(.761)	(.819)	(1.25)
(Income) ²			.022	-.008	-.061
			(.036)	(.038)	(.059)
Constant	.327	-.372	4.74		
	(.072)	(.107)	(4.12)		
Market Level Controls			Included	Included	Included
MSA Fixed Effect			Included	Included	Included
<i>R</i> ²	.21	.23	.28	.23	.28
Observations			7867		8163

Standard errors in parentheses.

Chapter 4

Modeling Competition in Retail Industries: Cost Reduction and the Role of Quality

4.1 Introduction

In several retail industries, vigorous price competition and strategic investment in sunk outlays seems to lead to the emergence of a few dominant firms. The markets for books, video rentals, auto supplies, and consumer electronics are all dominated by a few national chains (or, more specifically, pairs of national chains) that invest heavily in advertising, information technology, bandwidth and a variety of cost reducing innovations. Recent work in industrial organizations argues that these concentrated equilibria follow from competition in cost-reducing investments (Bagwell et al., 1997) that lead to the emergence of a single low-price, low-cost leader. Advertising may be used to achieve coordination with uniformed consumers, guiding them to the eventual low-cost leader (Bagwell and Ramey, 1994). However, in both cases, competition eventually yields a single low-cost leader who, if re-entry is costly, will be able to charge the monopoly price. An alternative but related literature suggests that these investments may be endogenous (Sutton, 1991), leading to the emergence of a few low-cost or high-quality firms, but not monopoly. This prediction seems to accord well with evidence from several retail in-

dustries.¹ The goal of this paper is to formulate a model of retail competition with endogenous sunk investments where a few low-cost or high-quality firms – but not one firm – emerge in equilibrium. In addition, I will demonstrate that, when investments in quality increase consumers willingness-to-pay, the strategic interaction between firms can distinguish oligopoly models from mechanisms leading to a single dominant firm.

To understand this exercise more clearly, this paper first reviews the baseline endogenous sunk cost vertical product differentiation (VPD) model developed in Sutton (1991). I demonstrate that, in this model of quality differentiation, the level of quality chosen by rival firms behaves as a strategic substitute. Next, applying the central insight of Spence (1975, 1976) – that when services or quality are a perfect substitute for price reductions, so that consumers care only about price per unit of quality (efficiency units), quality increases are the equivalent of price reductions from the point of view of both buyer and seller – I demonstrate that Sutton’s quality differentiation model is equivalent to a model of cost reducing investment. Reinterpreted as a model of cost reduction, Sutton’s natural oligopoly result applies not only to models of quality differentiation, but to any industrial application where “rivalry is both tough and focused on fixed outlays, not on per-unit price-cost margins” (Schmalensee, 1992). This finding suggests that the natural oligopoly structure and the endogenous sunk cost framework extends beyond models of quality competition and VPD, having an impact on any industry where costs are reduced through fixed and sunk investments.

That Sutton’s baseline model can be reformulated as a model of cost reduction follows from the fact that quality and price enter consumer’s indirect utility functions as a ratio, so that consumers care only about the unit cost of quality. The central theoretical contribution of this paper is demonstrating that when the relationship between quality and price is non-linear (so that quality and price are no longer forced to be proportional) the strategic interaction between firms shifts from strategic substitutes to complements. This result follows from the fact that, with this modification, increases in quality induce consumers to substitute out of an outside good and devote a larger share of income to the quality good.² In effect, consumers are

¹Several retail industries are dominated by pairs of firms that often locate very close to one another; examples include Blockbuster and West Coast Video, Circuit City and Best Buy, Walmart and Kmart, and Staples and Office Depot. Several of these industries support smaller chains as well (e.g. Office Max and The Good Guys). Moreover, none of these industries appear to be converging to monopoly outcomes.

²In the baseline Sutton model, consumers allocate a constant share of their income to the quality good.

allowed to care about the overall level of quality, as well as quality per dollar. These results are comparable to findings by Ronnen (1991) and Lehmann-Grube (1997) using an alternative set-up based on Shaked and Sutton (1983).

These results on the strategic interaction between firms demonstrate that, by estimating firm's reaction functions, it is possible to distinguish models where quality increases expand consumer's willingness-to-pay from models of cost-reducing investment. This implication extends well beyond the specific examples presented here. Bagwell and Staiger (1994) demonstrate that investment into cost-reducing or quality enhancing R&D are strategic substitutes under fairly general conditions. Athey and Schmutzler (1999) extend these results to include several additional classes of models, including Bertrand or Cournot competition with differentiated goods, constant marginal costs and linear demand (e.g. Dixit, 1979), horizontal product differentiation (HPD) on the line (d'Aspremont et al., 1979) or the circle (Salop, 1979) with quadratic transportation costs, and the VPD model of Shaked and Sutton (1983). As such, it is therefore possible to predict whether certain retail markets will continue to be ruled by a few oligarchs or will eventually be served by only a single firm by simply observing the strategic interaction between firms. This exercise is applied to the supermarket industry in Chapter 3 of this thesis.

This paper is organized as follows. Section 2 reviews the baseline model of Sutton (1991), demonstrating how competitive investment in sunk outlays leads to a natural oligopoly of high quality firms. This result is contrasted with an example where costs are exogenously determined and the number of entrants increases proportionately with the size of the market. I demonstrate that, in the endogenous sunk cost case, the reaction functions of rival firms are always local strategic substitutes. In section 3, I demonstrate that the baseline Sutton model is equivalent to a model of cost reducing investment, where quality does not enter the consumer's utility function. Section 4 presents the bandwidth or demand expanding model of endogenous sunk investment, demonstrating how the strategic interaction among rival firms shifts to strategic complementarity. I conclude with a discussion of the results and topics for future research.

4.2 The Baseline Model

The goal of this first set of theoretical results is to provide an overview of the baseline model and principal empirical implications of Sutton (1991). In particular, I will identify the conditions that result in natural oligopoly and illustrate their implications for the equilibrium level of quality, number of entrants, and the level of sunk investments. These results are compared to the case where costs are exogenously determined, firms do not competitively invest in quality enhancing sunk outlays, and the number of entrants is unbounded (as market size expands). Finally, I demonstrate that, in the baseline endogenous sunk cost model, quality choices by rival firms are always local strategic substitutes.

In the baseline model, firms are assumed to produce a single product. Across firms, products may differ in an index of perceived quality z . Increasing in z raises the marginal utility of the differentiated good. The perceived quality z may be interpreted as the (advertising based) image of a product, a measure of a product's desirable physical characteristics, or any feature of the product which raises consumers' willingness to pay. The key assumption is that increases in perceived quality are achieved through investments which are both fixed and sunk, as they are incurred in the preliminary stage of the game and are independent of the volume of production. Typical examples include, but are not limited to, advertising and R&D. In the context of supermarket competition, a natural candidate for perceived quality is the range of products carried by a particular store. I will call this measure *bandwidth*. Bandwidth can affect consumers' choices in at least two ways. First, consumers may in fact be willing to pay more on average in a store that can fill all of their idiosyncratic needs. Second, faced with two stores charging identical prices, it is reasonable to conclude that consumers may unambiguously prefer the store with a greater variety. A store wishing to expand its bandwidth must construct a larger store and, perhaps investing in more advanced information technologies and distribution systems. In the current model, this enhancement of willingness to pay is captured through the single index z .

On the demand side, M identical consumers are assumed to have utility

$$u(x_1, x_2, z) = (1 - \alpha) \ln(x_1) + \alpha \ln(zx_2) \tag{4.1}$$

defined over two goods: a Hicksian composite commodity x_1 and the quality differentiated good x_2 which is the focus of our analysis. Increases in the perceived quality of x_2 enter the utility function multiplicatively. I assume each consumer is endowed with Y units of good 1. Take the composite good to be the numeraire ($p_1 = 1$) (so that, ignoring any distribution of profits, each consumer has wealth Y) and let $p(z)$ be the price of a differentiated good of quality z .

If a consumer chooses to consume a differentiated good of quality z , the quantities demanded will be $x_1 = (1 - \alpha)Y$ and $x_2 = \frac{\alpha Y}{p(z)}$ yielding indirect utility

$$V(p(z), Y, z) = (1 - \alpha) \ln[(1 - \alpha)Y] + \alpha \ln \left(\frac{\alpha Y z}{p(z)} \right) \quad (4.2)$$

Note that quality and price enter the indirect utility function as a ratio. Quality enhancements increase consumers' indirect utility through an increase in "quality per dollar." I assume there are N identical firms, where firm j uses input $F(z_j) + cq_j$ of the composite good to produce quantity q_j of the differentiated good of quality z_j . Competition is modeled as a three stage game. In the first stage firms choose whether or not to enter and incur a fixed entry cost σ . In the second stage, firms choose a level of quality z , incurring the fixed cost $F(z)$. In the third and final stage, firms compete in the product market. Product market competition is modeled as Cournot. Using this basic framework, I can now illustrate both the exogenous and endogenous sunk cost subcases.

4.2.1 The Exogenous Sunk Cost Case

In the exogenous sunk cost case, quality is fixed and no longer a decision variable for the firm. Firms still must pay a fixed cost of entry, which can be thought of as the minimum efficient scale of a plant (or in the context of supermarket firms, a store), the level of which is determined exogenously by the industry's underlying technology. Without loss of generality, I assume all firms produce output of the quality $z_j = 1$ and let $p(z) = p$. Market demand and supply are therefore $\frac{\alpha Y M}{p}$ and $\sum_{j=1}^N q_j = Q$, respectively. Since quality is fixed in this case, fixed costs are not a function of z . Fixed cost are given by $F(1) = \sigma$, the (exogenous) fixed cost of entry. Consequently, firm j maximizes profit $\pi_j = \frac{\alpha Y M}{Q} q_j - cq_j - \sigma$ yielding the first order condition

$$\alpha Y M (Q - q_j) = cQ^2$$

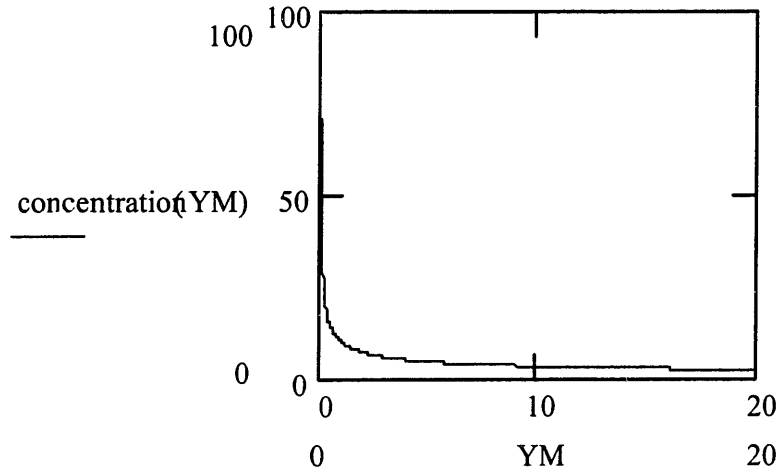


Figure 4-1: Concentration $\left(\frac{1}{N}\right)$ versus market size: fragmentation

for all j . I conclude by symmetry that $q_j = q$ for all j and hence $Q = qN$. The resulting equilibrium quantities and price are

$$q = \left(\frac{N-1}{N^2}\right) \frac{\alpha YM}{c}$$

and

$$p = \left(\frac{N}{N-1}\right) c$$

Each firm j earns equilibrium profit $\pi_j = \frac{\alpha YM}{N^2} - \sigma$. Assuming there will be entry as long as $\pi_j \geq 0$ and ignoring the constraint that N be an integer, the equilibrium number of entrants is $N = \sqrt{\frac{\alpha YM}{\sigma}}$. Figure 4-1 shows the relationship between concentration (measured by $\frac{1}{N}$) and market size (measured by YM) for the case with $\alpha = \frac{1}{2}$ and $\sigma = 50$. The figure illustrates the limit theorem that obtains in the exogenous sunk cost case, “where scale economies become unimportant as a constraint on equilibrium structure in large economies” (Sutton, 1991). Alternatively, for market size αYM greater than $\frac{\sigma}{16}$, there are at least four firms in equilibrium. The four firm concentration ratio is then given by $C_4 = 4\sqrt{\frac{\sigma}{\alpha YM}}$ which declines monotonically to zero as the ratio of market size to set up costs $\frac{\alpha YM}{\sigma}$ increases.

4.2.2 The Endogenous Sunk Cost Case

I now allow firm j to vary its quality z_j , making the level of perceived quality an endogenous choice variable of the firm. I continue to assume Cournot competition in the third (product market competition) stage. As before, I proceed via backwards induction, analyzing the final product market competition stage first. It follows from the indirect utility function (4.2) that consumers will choose a product that maximizes that quality-price ratio $\frac{p(z_j)}{z_j}$. Because the qualities z_j are treated as fixed in the final stage, Cournot competition forces the equilibrium prices of all goods with positive market share to be proportionate to their perceived qualities such that $\frac{p(z_j)}{z_j} = k$ for all j . Using this relationship between price and quality, I can now solve for the market clearing price.

Let the number of consumers purchasing from firm j be m_j . Then, using the demand functions derived earlier and substituting in for price, I conclude that

$$q_j = \frac{m_j \alpha Y}{p(z_j)} = \frac{m_j \alpha Y}{k z_j}$$

Since $M = \sum_{j=1}^N m_j = \frac{k}{\alpha Y} \sum_{j=1}^N z_j q_j$ I can solve for $k = \frac{\alpha Y M}{\sum_{j=1}^N z_j q_j}$ and substitute this back into the price relationship, yielding $p(z) = \frac{\alpha Y M z}{\sum_{j=1}^N z_j q_j}$.

I am now in a position to solve for the equilibrium quantities selected in the final stage. Differentiating the profit function with respect to q_j yields the first order condition

$$z_j \left(\sum_{j' \neq j}^N z_{j'} q_{j'} \right) = \frac{c}{\alpha Y M} \left(\sum_{j=1}^N z_j q_j \right)^2 \quad (4.3)$$

Following Sutton (1991) I focus on identifying a symmetric equilibrium in both quantity and quality. For the two firm case, it is the unique equilibrium. Alternative models emphasize asymmetric equilibria (in quality) along with several modifications to the structure of the game. In both Shaked and Sutton (1983) and Ronnen (1991), income is heterogeneous, competition is Bertrand, and consumption is restricted to unit demand.³ In equilibrium, a finite number of firms enter, each offering a unique quality and price combination and targeting a distinct “income band” of consumers. Lehman-Grube (1997) establishes a similar asymmetric *natural*

³This restriction is particularly troubling in the context of supermarket competition.

oligopoly result when entry is sequential rather than simultaneous.⁴ However, in the context of retail competition, asymmetric equilibria in quality do not seem to reflect observed firm behavior. In several retail industries, symmetric strategies are common. For example, the stores operated by Circuit City and Best Buy, Walmart and Kmart, Office Depot and Staples, and the dominant supermarket chains are often difficult to distinguish and are frequently located close to their competitors' stores, suggesting that these firms are not targeting distinct consumer segments, as the asymmetric models imply, but competing instead for the same customers. Since the focus here is on explaining firm behavior in these industries, I follow Sutton (1991) in characterizing symmetric equilibria in quality.

Assuming $q_j = q$ and $z_j = z$ for all j , equation (4.3) reduces to $z(N-1)zq = \frac{c}{\alpha Y M} N^2 z^2 q^2$. Consequently,

$$q = \left(\frac{N-1}{N^2} \right) \frac{\alpha Y M}{c}$$

and

$$p = \left(\frac{N}{N-1} \right) c$$

which are the same results obtained for the exogenous sunk cost case, but here they hold irrespective of the level of z . Identifying the symmetric equilibrium level of quality requires solving for each firm's best response function. I proceed by assuming that a single firm deviates from this symmetric equilibrium to offer quality z_1 while the remaining $N-1$ firms offer quality z . The first order conditions (4.3) reduce to

$$z_1(N-1)zq = \frac{c}{\alpha Y M} (z_1 q_1 + (N-1)zq)^2 \quad (4.4)$$

and

$$z(z_1 q_1 + (N-2)zq) = \frac{c}{\alpha Y M} (z_1 q_1 + (N-1)zq)^2 \quad (4.5)$$

yielding equilibrium quantities

$$q_1 = \frac{\alpha Y M}{c} \left[\frac{(N-1)z_1 - (N-2)z}{[(N-1)z_1 + z]^2} \right] (N-1)z$$

⁴The first entrant chooses the highest level of quality and earns the largest profit in equilibrium.

$$q = \frac{\alpha Y M}{c} \frac{(N-1)z_1 z}{[(N-1)z_1 + z]^2}$$

and price $p(z_1) = \frac{[(N-1)z_1 + z]c}{(N-1)z}$. Therefore, the profit function of the deviant firm is

$$\pi(z_1) = \alpha Y M \left[\frac{(N-1)z_1 - (N-2)z}{(N-1)z_1 + z} \right]^2 - F(z_1) \quad (4.6)$$

Using this expression for profits, I can now solve the game as a whole and identify the symmetric equilibrium level of quality z . Differentiating the profit function (4.6) yields the first order condition

$$\frac{\partial \pi(z_1)}{\partial z_1} = 2\alpha Y M (N-1)^2 \frac{[(N-1)z_1 - (N-2)z]z}{[(N-1)z_1 + z]^3} - F' = 0 \quad (4.7)$$

To proceed it is necessary to select a functional form for the fixed cost function. I follow Sutton (1991) in specifying the function $F(z) = \sigma + \frac{s}{\gamma}(z^\gamma - 1)$, which includes both the exogenous fixed entry cost σ and a second term that depends on the level of quality chosen. To solve for the symmetric equilibrium⁵ in quality, I let $z_j = z$ and solve (4.7) for z yielding

$$z = \left(\frac{2\alpha Y M (N-1)^2}{N^3 s} \right)^{\frac{1}{\gamma}} \quad (4.8)$$

Figure 4-2 shows z and $F(z)$ as a function of market size for the case where $\alpha = \frac{1}{2}$, $\gamma = 2$, $s = 1$, $N = 2$, and $\sigma = 10$. While varying each of the parameters has an effect on both z and $F(z)$, the natural oligopoly result turns most directly on the value of γ . Figure 4-3 presents a graph of $F(z)$ for γ equal to 2 ($f(YM)$) and 7 ($f2(YM)$) respectively (the other parameters are the same as Figure 4-2). Since fixed costs grow proportionately with market size (they were constant in the exogenous case), it should not be surprising to find an equilibrium where the number of firms does not expand with the size of the market. Furthermore, since fixed costs grow more slowly for larger values of γ , we might also expect a larger number of entrants when γ is larger. To make this intuition precise requires solving for the equilibrium number of entrants.

⁵Again, the symmetric equilibrium seems to accord well with the strategies of dominant firms observed in several retail industries.

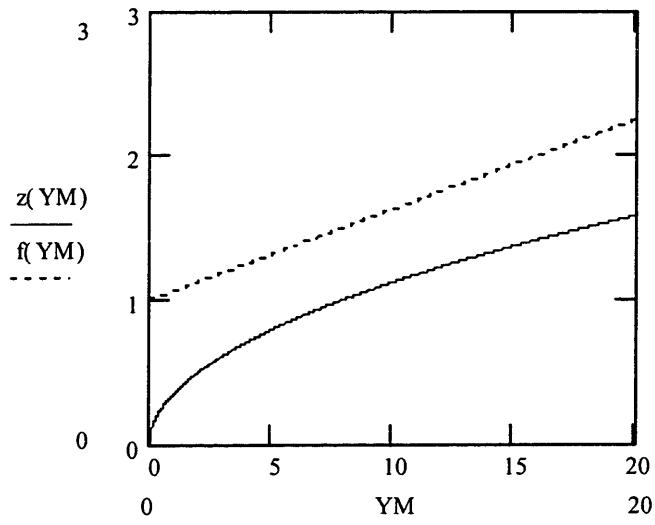


Figure 4-2: Quality and the cost of quality versus market size

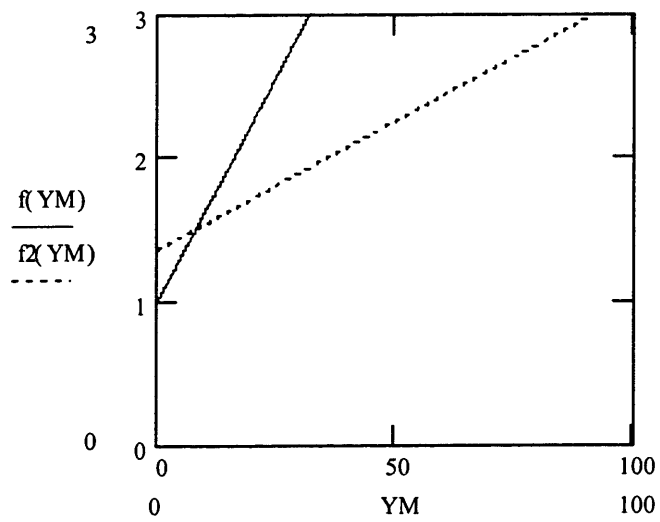


Figure 4-3: The relationship between γ and $F(z)$

The equilibrium profit with N firms is

$$\pi = \frac{\alpha Y M}{N^2} - F(z)$$

Assuming that firms will enter as long as $\pi_i \geq 0$, the non-negative profit condition is

$$\frac{\alpha Y M}{\gamma N^3} \cdot f(N) - \left(\sigma - \frac{s}{\gamma} \right) \geq 0 \quad (4.9)$$

where $f(N) = (4 + \gamma)N - 2(N^2 + 1)$. Dividing through by $\alpha Y M$ yields

$$\frac{f(N)}{\gamma N^3} - \frac{\sigma - \frac{s}{\gamma}}{\alpha Y M} \geq 0 \quad (4.10)$$

which provides a clear illustration of the mechanism determining the equilibrium number of firms: the largest N such that the first term is greater than or equal to the second. Figure 4-4 plots each component of equation 4.10 as a function of N for the example where $\gamma = 2$, $\alpha = \frac{1}{2}$, $s = 4$, $\sigma = 1$, and $Y M = 10$. The effect of each parameter is easy to identify. Whether the second term $\left(\frac{\sigma - \frac{s}{\gamma}}{\alpha Y M} \right)$, which does not depend on N , lies above or below zero depends on the sign of $\left(\sigma - \frac{s}{\gamma} \right)$. For $\left(\sigma - \frac{s}{\gamma} \right) > 0$, as in Figure 4-4, the second term is positive. Therefore, increases in market size (measured by $\alpha Y M$ or $Y M$) shift this horizontal line down, increasing the level of N at which the functions intersect. That the asymptotic number of firms is finite is clear from the fact that the first term asymptotes (as $n \rightarrow \infty$) to a level below zero, while the second term converges to zero (as $\alpha Y M \rightarrow \infty$). For $\left(\sigma - \frac{s}{\gamma} \right) < 0$ the behavior is more complicated since the second term is now negative. In this case, increasing market size actually shift the second term up (toward 0), so that the equilibrium number of entrants may actually *increase* and then *decrease* as market size expands.

To illustrate the behavior of the equilibrium number of entrants more clearly, consider the following exercise that treats the number of firms as a continuous variable. Under this assumption, I can rewrite the zero-profit condition (4.9) as

$$\left(\frac{s - \gamma \sigma}{\alpha Y M} \right) N^3 - 2N^2 + (4 + \gamma)N - 2 = 0 \quad (4.11)$$

The fact that the number of firms will not increase indefinitely with the size of the market

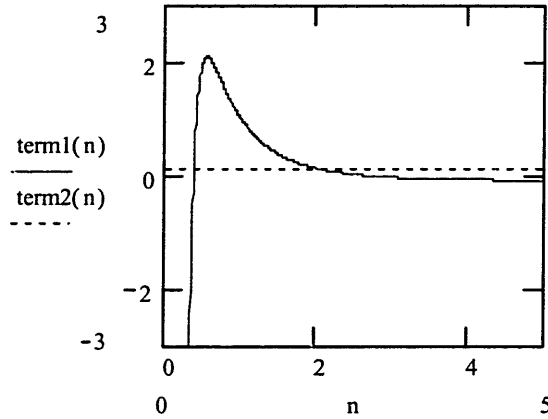


Figure 4-4: Determining the equilibrium number of entrants

is immediately obvious from equation (4.11). As market size (measured by YM) increases to infinity, the lead term drops out, leaving a quadratic polynomial with root⁶

$$N = 1 + \frac{1}{4}\gamma + \frac{1}{4}\sqrt{8\gamma + \gamma^2} \quad (4.12)$$

which depends only on γ and is finite for all finite γ . This result follows from the fact that z , and therefore $F(z)$, grows more slowly with larger values of γ . This allows more firms to “fit” into the market, reflecting the lower level of fixed costs that must be recovered in equilibrium.

For finite values of YM , the solution of (4.11) depends on the sign of the lead term. In particular, whether the equilibrium number of entrants approaches the limit (4.12) from above or below depends on whether $s - \gamma\sigma$ is positive or negative. Figure 4-5 shows a graph of (4.11) using parameters for which $s - \gamma\sigma$ is negative ($Nn(n)$), zero ($No(n)$), and positive ($Np(n)$), illustrating how the shape of the polynomial depends on the sign of the lead term. The root determining the equilibrium number of firms corresponds closely to the root of the quadratic (4.12). Figure 4-6 shows profit as a function of N for the case where the lead term $s - \gamma\sigma$ is negative. Since profit approaches the negative limit $-\sigma + \frac{s}{\gamma}$ from below, it is clear that the second root is not viable.

⁶The second root is always less than 1.

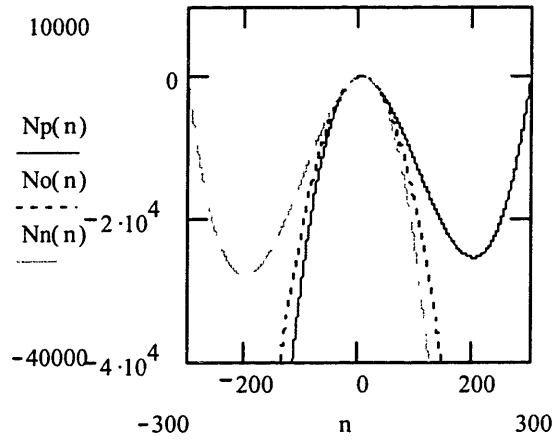


Figure 4-5: The solution of polynomial (1.12)

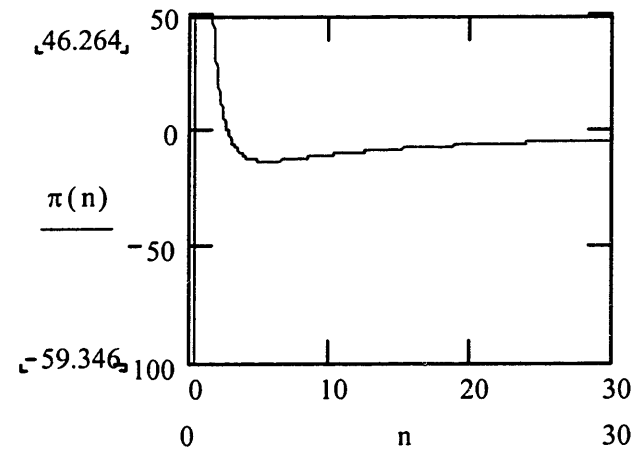


Figure 4-6: Profit in equilibrium

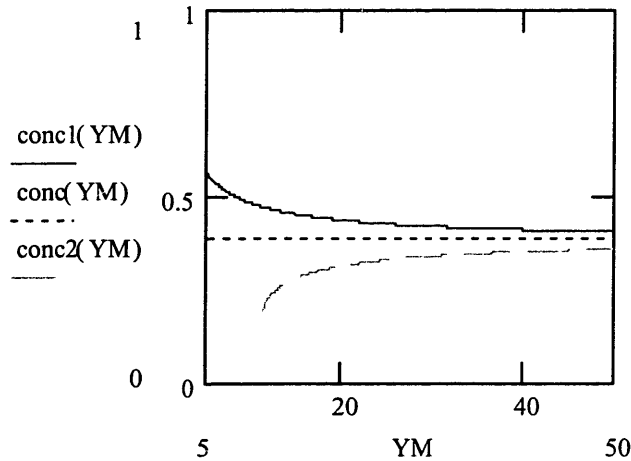


Figure 4-7: Concentration as a function of market size

Finally, using analytical solutions of equation (4.12), I can illustrate the non-fragmentation result. Figure 4-7 shows the relationship between concentration (measured by $\frac{1}{N}$) for the cases where the lead term is negative (*conc1*), zero (*conc*), and positive (*conc2*). The fact that the relationship between market size and concentration is non-monotonic when the lead term is positive is a sharp departure from static formulations of scale economies, where concentration falls monotonically as market size expands. Empirical studies of endogenous sunk cost industries have uncovered two types of behavior. The studies of Sutton (1991) and Robinson and Chiang (1996) find behavior consistent with a negative lead term, where concentration monotonically declines to the asymptotic lower bound. In chapters 2 and 3 of this thesis, I present data on firm concentration in the supermarket industry that seems to fit the non-monotonic case where concentration first falls and then increases.

The purpose of this first set of theoretical results is to illustrate Sutton's (1991) model of quality competition and highlight the forces that drive the non-fragmentation and natural oligopoly results. The comparative statics presented here can be tested using data from a variety of industries. The focus on symmetric equilibria in quality make retail industries a particularly attractive candidate. In the following subsection, I examine the strategic interaction between firms and demonstrate that quality choices by rival firms are always strategic substitutes near the equilibrium. This result distinguishes Sutton's (1991) model of quality competition from

alternative formulations where quality enhancements increase consumers' willingness to pay.

4.2.3 The Behavior of Best Response Functions

Sutton (1991) argues that industries in which firms competitively invest in endogenous sunk investments will converge to concentrated equilibria by way of a *quality escalation mechanism*. In this process, outcomes which are “too fragmented” will be broken as markets tend toward equilibrium. In particular, “as market size increases, the incentives to escalate spending on fixed outlays rises. Increases in market size will be associated with a rise in fixed outlays by at least some firms and this effect will be sufficiently strong to exclude an indefinite decline in the level of concentration” (Sutton, 1997). This follows from the fact that the relative increase that a firm can achieve through an increase in fixed outlays is correspondingly greater as each firm's market share is relatively smaller. However, the quality escalation mechanism *cannot* refer to the strategic interaction between firms in equilibrium and attempts to interpret it in this way are misleading.

In fact, the strategic interaction between firms in the baseline Sutton model has not been discussed explicitly in prior work,⁷ despite the fact that it is both theoretically interesting and empirically informative to understand how quality choices interact within equilibrium. The following proposition demonstrates that quality choices between rival firms are always strategic substitutes in the baseline model.

Proposition 2 *In the baseline model of Sutton (1991), quality choices by rival firms are always strategic substitutes near the equilibrium.*

Proof. While the baseline model does not afford an analytical solution for a firm's best response function, it is possible to calculate its slope by evaluating the cross partial derivative of the profit function (4.6):

$$\frac{\partial^2 \pi(z_1)}{\partial z_1 \partial z} = 2\alpha Y M (N-1)^2 \frac{[(N-1)^2 z_1^2 - 2(N-1)^2 z_1 z + (N-2)z^2]}{[(N-1)z_1 + z]^4} \quad (4.13)$$

⁷Ronnen (1991) evaluates the strategic interaction between firms in the Shaked and Sutton (1983) set-up. However, competition in that model is Bertrand, equilibria are asymmetric, and there is no notion of market size.

Evaluated at $z_1 = z$, equation (4.13) reduces to

$$\frac{2\alpha YM(N-1)^2}{N^4 z^2}(-N^2 + 3N - 3)$$

which is strictly negative. Therefore, locally (around the equilibrium), quality choices are always strategic substitutes. ■

Away from equilibrium, quality choices may be either substitutes or complements, as the following example illustrates. Choosing parameters $\alpha = \frac{1}{2}$, $s = 1$, $\sigma = 1$, $YM = 512$ and $\gamma = 2$, equation (4.8) yields equilibrium $z = 8$ and equation (4.9) yields 2 equilibrium entrants. Solving for firm 1's best response as a function of firm 2's quality yields

$$br(z_2) = 8\sqrt[3]{z_2} - z_2$$

Figure 4-8 shows the best response functions of each firm. They are clearly negatively sloped at the equilibrium and the portions over which they are positively sloped occur quite far from the equilibrium. Nonetheless, if the fixed cost functions for rival firms are sufficiently different, it is possible for the reaction functions to cross at a point where quality is a complement for the low cost firm and a substitute for the high cost firm (imagine shifting the dotted curve in figure 4-8 far to the left). This outcome recalls the Bulow et al. (1985a) model of capacity competition with extremely convex demand functions, where the strategic interactions are also asymmetric and the reaction functions are nearly identical to those presented here.

Substitutability at the equilibrium can be further illustrated by analyzing the first order conditions for the equilibrium level of quality (equation (4.7)) and signing the slope of the firms reaction functions indirectly (this is the method I will use in section 4, where closed form solutions are not feasible). Figure 4-9 plots the right hand side (*RHS*) and left hand side (*LHS*) of equation (4.7) as a function of z_1 . $LHS(z_1)$ uses the equilibrium level of z , while $LHS2(z_1)$ uses $z + 1$. The effect of an increase in z is to shift $LHS(z_1)$ down, decreasing the point of intersection and the equilibrium level of z_1 , illustrating how a firm's optimal choice of quality falls when a rival chooses a higher level of quality.

The goal of this first theoretical section is to present the Sutton (1991) model of quality competition and to demonstrate that, in this model, quality choices by rival firms behave as

strategic substitutes. In the following section, I demonstrate that this model of quality competition is equivalent to a model of cost-reducing investment, where quality never enters a consumer's indirect utility function. The strategic substitute result (Proposition 2) continues to hold. This finding is significant for two reasons. First, the fact that Sutton's model of quality competition can be reformulated as a model of cost-reduction suggests that his non-fragmentation and natural oligopoly results are applicable to a much broader class of industries than the advertising and R&D intensive industries emphasized in Sutton (1991). This result implies that, for markets to exhibit endogenous sunk cost behavior, "what does seem to be necessary is that market share be sufficiently sensitive to variations in *fixed* costs, so that rivalry is both tough and focused on fixed outlays, not on per-unit price-cost margins" (Schmalensee, 1992). This condition is likely to hold in several retail industries, where firms invest extensively in both information technology and firm specific distribution systems (e.g. Walmart). Second, recasting quality competition as cost-reduction connects this endogenous sunk cost framework up to the broader class of cost-reduction models, where strategic substitution in investment is the norm in most standard models (Bagwell and Staiger, 1994; Athey and Schmutzler, 1999). In the final theoretical section of this paper, I present a model of quality competition where investments are strategic complements, illustrating how estimating reaction functions can provide a useful way of distinguishing between alternative models of competition. This exercise is applied to the supermarket industry in chapter 3 of this thesis.

4.3 Natural Oligopoly and Cost Reduction

In this section, I demonstrate that the baseline model can be reformulated as a model of cost-reducing investment, where quality does not enter consumers' utility functions at all. Nevertheless, all of the equilibrium properties presented in section 4.2 are preserved. In the baseline model, quality and price enter the indirect utility function (4.2) as a ratio. As a result, consumers care about quality enhancements only in as much as they increase "quality per dollar." Since consumers cannot distinguish between an increase in the quality-price ratio stemming from an increase in the perceived level of quality and an increase in the ratio due to a fall of the "price of quality," the central insight of Spence (1975, 1976) applies directly to this

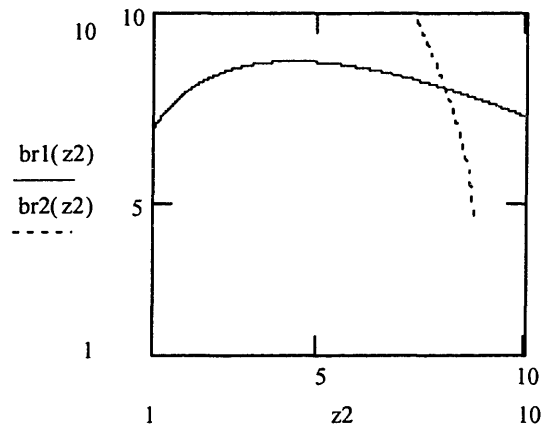


Figure 4-8: Best response functions

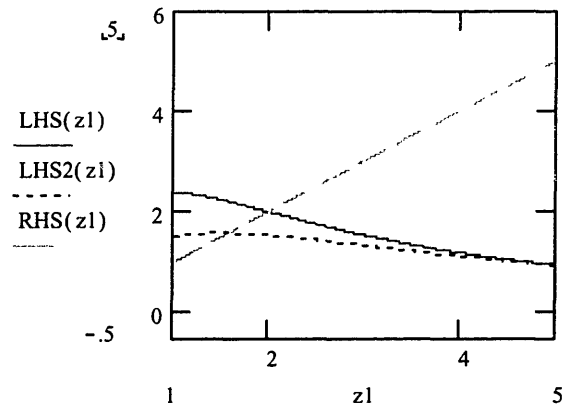


Figure 4-9: The effect of a unilateral increase in quality

model. Specifically, quality increases are equivalent to price reductions from the viewpoint of both buyer and seller. Consequently, the baseline model is equivalent to a model of cost reduction. This following proposition establishes that all of the equilibrium properties of the baseline model continue to hold in this case.

Proposition 3 *The baseline endogenous sunk cost model of Sutton (1991) is equivalent to a model of cost reducing investment.*

Proof. Assume again that firms produce and single good but the M identical consumers each have utility

$$u(x_1, x_2) = (1 - \alpha) \ln(x_1) + \alpha \ln(x_2) \quad (4.14)$$

where x_1 is the quantity consumed of the composite good and x_2 the quantity of the differentiated good under analysis. There are N identical firms, where firm j uses input $F(z_j) = \sigma + \frac{c}{z_j} q_j$ of the composite good to produce quantity q_j of x_2 . In particular, the firm may invest in fixed costs in order to reduce marginal costs by a fraction $\frac{1}{z_j}$. For example, a supermarket building larger stores faces lower inventory costs per item and a microchip producer building a larger fabrication plant produces chips with a lower cost per bit. Although x_2 does not appear to be a differentiated good to consumers, it is clearly differentiated on the input side. Let $p(z)$ be the price of the differentiated good with cost reducing parameter z . If a consumer chooses to consume the differentiated good with parameter z , the quantities demanded will be

$$x_1 = (1 - \alpha)Y \text{ and } x_2 = \frac{\alpha Y}{p(z)}$$

yielding indirect utility

$$V(p(z), Y, z) = (1 - \alpha) \ln[(1 - \alpha)Y] + \alpha \ln\left(\frac{\alpha Y}{p(z)}\right) \quad (4.15)$$

Market demand and supply are $\frac{\alpha Y M}{p}$ and $\sum_{j=1}^N q_j$. Firm j maximizes profit

$$\pi_j = \frac{\alpha Y M}{\sum_{j=1}^N q_j} q_j - \frac{c}{z_j} q_j - F$$

yielding first order condition

$$z_j \left(\sum_{j=1}^N q_j \right) - q_j = \frac{c}{\alpha Y M} \left(\sum_{j=1}^N q_j \right)^2 \quad (4.16)$$

for all j . Therefore, if $q_j = q$ and $z_j = z$ for all j , we have $z(Nq - q) = \frac{c}{\alpha Y M} (Nq)^2$ yielding

$$q = \left(\frac{N-1}{N^2} \right) \frac{\alpha Y M z}{c}$$

and equilibrium price

$$p = \left(\frac{N}{N-1} \right) \frac{c}{z}$$

I now allow firm j to vary its cost reducing parameter z_j . I continue to assume Cournot competition. Suppose a single firm deviates from this symmetric equilibrium to choose parameter z_1 while the remaining $N - 1$ firms choose the parameter z . The first order conditions (4.12) reduce to

$$z_1(N-1)q = \frac{c}{\alpha Y M} (q_1 + (N-1)q)^2 \quad (4.17)$$

$$z(q_1 + (N-2)q) = \frac{c}{\alpha Y M} (q_1 + (N-1)q)^2 \quad (4.18)$$

with solutions

$$q_1 = \frac{\alpha Y M}{c} \left[\frac{(N-1)z_1 - (N-2)z}{[(N-1)z_1 + z]^2} \right] (N-1)z_1 z \quad (4.19)$$

$$q = \frac{\alpha Y M}{c} \frac{(N-1)z_1 z^2}{[(N-1)z_1 + z]^2} \quad (4.20)$$

Using $p(z_1) = \frac{\alpha Y M}{\sum_{j=1}^N q_j}$ I conclude that

$$p(z_1) = \frac{[(N-1)z_1 + z]c}{(N-1)z_1 z}$$

yielding profit

$$\pi(z_1) = \alpha Y M \left[\frac{(N-1)z_1 - (N-2)z}{(N-1)z_1 + z} \right]^2 - F(z_1) \quad (4.21)$$

which is identical to model 1 (equation (4.6)). The remaining calculations, including both the non-fragmentation and strategic substitutability results are unchanged from section 4.2. ■

This proposition demonstrates that the emphasis on product quality in Sutton (1991) is not a requirement for non-fragmentation or natural oligopoly. In particular, it is possible for competition to be focused on endogenously determined sunk outlays and for the number of equilibrium entrants to be bounded when the product of the sunk outlays is simply a reduction in marginal costs. Therefore, it is not the case that, for the number of entrants to be bounded, sunk outlays must increase consumers willingness to pay, as argued in Sutton (1991). It is simply the case that competition be focused on sunk outlays, not price cost margins, as argued in Schmalensee (1992). This finding suggests that the endogenous sunk cost framework may be applied to any industry where sunk investments are the focus of competition. For example, in several retail industries, the rise of dominant chains that invest heavily in advertising, information technology and advanced distribution systems (Bagwell et al., 1997) may reflect the endogenous nature of the sunk, cost-reducing investments necessary to compete in those industries. Consequently, the long run equilibrium structure of those industries may be natural oligopoly, not the monopoly outcomes suggested by Bagwell et al. (1997). In the following section, I demonstrate that quality competition can be distinguished from cost-reduction by focusing on the strategic interaction between firms, and in so doing, identify the role of increasing consumers' willingness to pay in the endogenous sunk cost framework.

4.4 A Model of Demand Enhancing Brandwidth

In this final theoretical section, I present the principal theoretical contribution of this paper: a formal model of retail competition where quality choices by rival firms behave as strategic complements. This result follows from the fact that, when quality and price enter the indirect utility function non-linearly, quality increases induce consumers to devote a larger fraction of their income to the quality good (in the baseline model this share of income is constant). This

expansion of the market for the quality good causes the strategic interaction between rival firms to shift from substitution to complementarity.

In the baseline model, quality enters the indirect utility function as the ratio of quality to price such that consumers care only about the per unit cost of quality or “efficiency units.” Since consumers cannot distinguish an increase in the quality-price ratio stemming from an increase in the perceived level of quality from an increase in the ratio due to a fall in the “price of quality,” the baseline model is really a disguised form of cost reduction, as demonstrated in Section 4.2. Furthermore, in both specifications, the quantity consumed and the fraction of income spent on the differentiated good are independent of the level of quality (cost reducing parameter), leading to the strategic substitute property demonstrated in Section 4.2.3. I now modify the utility function of the baseline model so that quality and price no longer enter as a ratio and, as quality increases (with price held fixed), consumers spend a higher fraction of their income on the differentiated good. As a result, I identify regions of the parameter space for which quality is a strategic complement. Unfortunately, the derivation no longer permits a closed form solution. As a result, this example relies on a graphical presentation.

Starting with the direct utility function

$$u(x, z) = (1 - \alpha) \ln x_1 + \alpha z \ln x_2 \quad (4.22)$$

I let $p_1 = 1$ and $p_2(z) = p(z)$, yielding demand functions

$$x_1 = \left(\frac{1 - \alpha}{1 - \alpha + \alpha z} \right) Y$$

and

$$x_2 = \left(\frac{\alpha z}{1 - \alpha + \alpha z} \right) \frac{Y}{p(z)}$$

Defining the function

$$\alpha(z) = \frac{\alpha z}{1 - \alpha + \alpha z}$$

such that the demand functions can be written

$$x_1 = (1 - \alpha(z)) Y \quad x_2 = \frac{\alpha(z) Y}{p(z)}$$

it is clear that, for a fixed price, the effect of an increase in quality is an expansion of the fraction of income spent on the quality good. Since indirect utility is given by

$$V(p(z), z, Y) = (1 - \alpha) \ln \left(\frac{(1 - \alpha)Y}{1 - \alpha + \alpha z} \right) + \alpha \ln \left(\left(\frac{\alpha z}{1 - \alpha + \alpha z} \right) \frac{Y}{p(z)} \right) \quad (4.23)$$

I can show that

$$p(z) = \frac{kz}{(1 - \alpha + \alpha z)^{1/\alpha}}$$

where k is a constant which depends only on α and Y . Defining

$$\phi(z) = \frac{z}{(1 - \alpha + \alpha z)^{1/\alpha}}$$

I conclude that

$$p(z) = k\phi(z)$$

Following along the steps of the derivation of the baseline model, I calculate the first order conditions for the equilibrium quantity selected in the final stage

$$\phi(z_j) \left(\sum_{j' \neq j} \psi(z_{j'}) q_{j'} \right) = \frac{c}{YM} \left(\sum_{j=1}^N \psi(z_j) q_j \right)^2 \quad (4.24)$$

where $\psi(z) = \frac{\phi(z)}{\alpha(z)}$. Consider again a symmetric equilibrium in which $q_j = q$ and $z_j = z$. Equation (4.25) reduces to

$$\phi(z)(N - 1)\psi(z)q = \frac{c}{YM} N^2 (\psi(z)q)^2$$

Consequently,

$$q = \left(\frac{N - 1}{N^2} \right) \frac{\alpha(z)YM}{c} \quad (4.25)$$

and

$$p(z) = \left(\frac{N}{N - 1} \right) c \quad (4.26)$$

which are identical to the baseline model with $\alpha(z)$ replacing α . Supposing a single firm deviates, the first order conditions (4.25) reduce to

$$\phi(z_1)(N - 1)\psi(z)q = \frac{c}{YM} [\psi(z_1)q_1 + (N - 1)\psi(z)q] \quad (4.27)$$

and

$$\phi(z) [\psi(z_1)q_1 + (N-2)\psi(z)q] = \frac{c}{YM} [\psi(z_1)q_1 + (N-1)\psi(z)q] \quad (4.28)$$

yielding equilibrium quantities

$$q_1 = \frac{\alpha(z_1)YM}{c} \left[\frac{(N-1)\phi(z_1) - (N-2)\phi(z)}{[(N-1)\phi(z_1) + \phi(z)]^2} \right] (N-1)\phi(z) \quad (4.29)$$

and

$$q = \frac{\alpha(z)YM}{c} \left[\frac{(N-1)\phi(z_1)\phi(z)}{[(N-1)\phi(z_1) + \phi(z)]^2} \right] \quad (4.30)$$

and price

$$p(z_1) = \left[\frac{(N-1)\phi(z_1) + \phi(z)}{(N-1)\phi(z)} \right] c \quad (4.31)$$

Consequently, the profit function of the deviant firm is given by

$$\pi_1 = \alpha(z_1)YM \left[\frac{(N-1)\phi(z_1) - (N-2)\phi(z)}{(N-1)\phi(z_1) + \phi(z)} \right]^2 - F(z_1) \quad (4.32)$$

which is simply the baseline model profit equation (4.6) with $\alpha(z)$ replacing α and $\phi(z)$ replacing z . Solving the game as a whole, I differentiate the profit function (4.33) to find the first order condition determining the equilibrium level of quality

$$\begin{aligned} \frac{\partial \pi_1}{\partial z_1} = & \\ & \alpha'(z_1)YM \left[\frac{(N-1)\phi(z_1) - (N-2)\phi(z)}{(N-1)\phi(z_1) + \phi(z)} \right]^2 \\ & + 2\alpha(z_1)YM(N-1)^2 \phi'(z_1) \frac{[(N-1)\phi(z_1) - (N-2)\phi(z)]\phi(z)}{[(N-1)\phi(z_1) + \phi(z)]^3} \\ & - F'(z_1) = 0 \end{aligned}$$

Choosing the functional form of $F(z)$ used in the baseline model and setting $z_1 = z$ yields

$$\frac{\alpha z YM [N(1 - \alpha z) + 2(N-1)^2(1 - \alpha)(1 - z)]}{(1 - \alpha + \alpha z)^2 N^3} = sz^\gamma \quad (4.33)$$

as the fundamental equation which determines equilibrium bandwidth z given the number of entrants N .

4.4.1 The Behavior of Best Response Functions

In section 4.2, I was able to show that, in the baseline model, a firm's choice of quality behaves as a strategic substitute near the equilibrium. While an analytic solution for each firm's best response function is still unavailable, it is possible to calculate its slope by evaluating the cross partial derivative of the profit function (4.33):

$$\begin{aligned} \frac{\partial^2 \pi_1}{\partial z_1 \partial z} = & \\ & -2\alpha'(z_1)YM[(N-1)\phi(z_1) - (N-2)\phi(z)] \left[\frac{(N-1)^2 \phi'(z)\phi(z_1)}{[(N-1)\phi(z_1) + \phi(z)]^3} \right] \\ & + 2\alpha(z_1)YM(N-1)^2 \phi'(z_1)\phi'(z) \frac{[(N-1)^2 [\phi(z_1)]^2 - 2(N-1)^2 \phi(z)\phi(z_1) + (N-2)[\phi(z)]^2]}{[(N-1)\phi(z_1) + \phi(z)]^4} \end{aligned}$$

Evaluated at $z_1 = z$, equation this reduces to

$$-\frac{2\alpha'(z)YM(N-1)^2 \phi'(z)}{N^3} \frac{\phi'(z)}{\phi(z)} + \frac{2\alpha(z)YM(N-1)^2(-N^2 + 3N - 3)}{N^4} \left[\frac{\phi'(z)}{\phi(z)} \right]^2$$

which can be rewritten as

$$\frac{2\alpha YM(N-1)^2 \phi'(z)}{(1-\alpha + \alpha z)^2 N^3} \frac{\phi'(z)}{\phi(z)} \left[-(1-\alpha z) + \frac{2N-3}{N}(1-\alpha)(1-z) \right] \quad (4.34)$$

The term outside the brackets is strictly positive. Inside the brackets, the second term is negative for all $N > 1$ and $z > 1$, while the first term depends on the level of z , yielding an analog of the income and substitution effect. The following example demonstrates a case in which the effect of the first term outweighs the second. Choosing parameters $\alpha = \frac{1}{2}$, $s = 1$, $\sigma = \frac{85}{8}$, $YM = 75$ and $\gamma = 2$, yields 2 equilibrium entrants ($N = 2$) and equilibrium $z = 1.5$. Figure 4-10 plots the right hand side (*rhs*) and left hand side (*lhs*) of the first derivative of profit as a function of z_1 . $lhs(z_1, 1.5)$ uses the equilibrium level of z , while $lhs(z_1, 2)$ uses $z = 2$. The effect of an increase in z is to shift $lhs(z_1, z)$ up, increasing the point of intersection and the equilibrium level of z_1 . Therefore, at least locally, the slope of the reaction function is positive. As such, the optimal response to a rival's quality increase is to increase own quality. Unlike the model of cost-reducing investment presented in sections 4.2 and 4.3, investment by rival firms actually increases the return to own investment, resulting in strategic complementarity.

Moreover, the complementarity result is not limited to this particular example. Analogous findings are presented in Ronnen (1991) and Lehmann-Grube (1997). In Ronnen's example,

consumers' incomes are allowed to vary and competition is Bertrand. In the resulting equilibrium, firms offer a staggered set of qualities. In the two firm case, when the high quality firm raises its quality, the low quality firm follows suit and vice versa. The result follows from the fact that the market is not fully covered in equilibrium so that changes in quality induce consumers who previously consumed the outside good to join the market. Again, quality enhancements effectively increase the available "pie". Lehmann-Grube presents similar results to Ronnen in a model with sequential entry. However, neither of these models contain a notion of market size and consumers are restricted to consuming only a single unit of the quality good. The resulting equilibria are also asymmetric.

The theoretical results presented in this section illustrate that models of quality competition where quality enhancements increase consumers' willingness to pay involve different strategic interactions among firms than models where these enhancements simply reduce the perceived cost of quality. However, as the models in sections 4.2 and 4.3 illustrate, increasing willingness to pay is not a requirement for non-fragmentation. Nonetheless, the finding of complementarity provides a method of distinguishing between models of endogenous sunk investment by estimating reaction functions. Moreover, because strategic complementarity in investment is relatively rare among standard investment models (Athey and Schmutzler, 1999), a finding of complementarity eliminates several alternative models of competition, including most standard models of capacity competition, horizontal product differentiation, cost-reducing investment and product proliferation. This exercise is applied to the supermarket industry in chapter 3 of this thesis.

4.5 Conclusions

This paper demonstrates that the manner in which quality enters the indirect utility function plays a key role in determining how firms strategically interact. Using Sutton's (1991) model of quality differentiation, I demonstrate that quality choices are always strategic substitutes near the equilibrium. Furthermore, I demonstrate that this model is equivalent to a form of cost reducing investment. Then, by modifying the utility function, I identify parameters for which quality choices are strategic complements. The result follows from the fact that quality

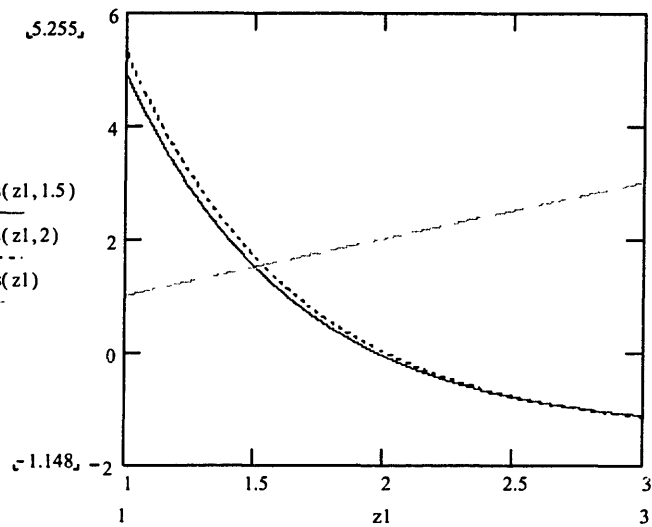


Figure 4-10: An example of strategic complementarity

enhancements induce consumers to spend a higher fraction of their income on the quality good. I call this demand enhancing property the bandwidth effect. These results suggest that when quality is bandwidth, VPD models can be distinguished by estimating firm reaction functions. Since most standard models of cost reduction imply strategic substitution in investment (Bagwell and Staiger, 1994; Athey and Schmutzler, 1999), a finding of complementarity can rule out broad classes of competing models of industrial structure. This exercise is applied to the supermarket industry in chapter 3 of this thesis.

This framework invites several extensions. First, I would like to identify general conditions under which cost reducing investment results in a natural oligopoly of firms. In particular, it should be possible to identify the modifications necessary for the model of Bagwell et al. (1997) to yield natural oligopoly, instead of a single dominant firm. Second, by allowing consumers to vary in income, it should be possible to derive a complementarity result analogous to Ronnen (1991), where a finite number of firms produce a staggered set of qualities. However, using the current approach I can relax the assumption that consumers only demand a single unit and directly incorporate a measure of market size. Third, by allowing firms to enhance quality through distinct investments at both the store and firm level, it should be possible to derive comparative static results concerning the optimal size of a chain of stores and, therefore, esti-

mate the size distribution of retail chains. These predictions could then be tested using location and ownership data from a variety of retail industries.

Chapter 5

Appendix

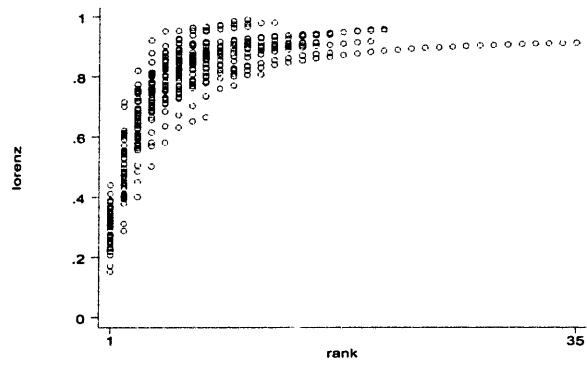


Figure 5-1: Lorenz Curves – Western Markets (MSAs)

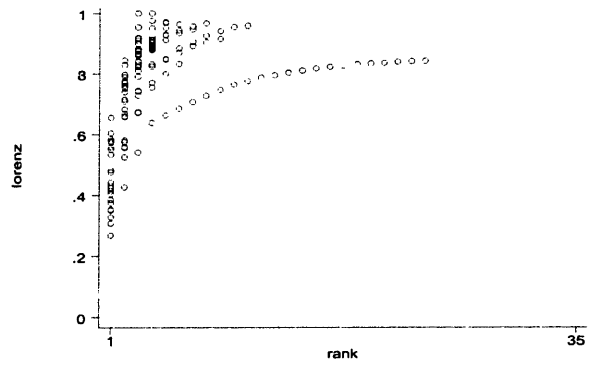


Figure 5-2: Lorenz Curves – Northwestern Markets (MSAs)

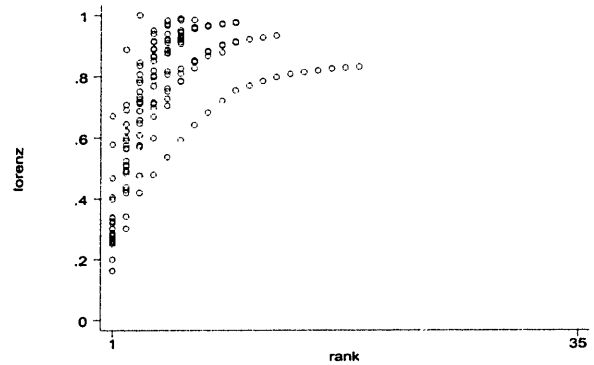


Figure 5-3: Lorenz Curves – Southwestern Markets (MSAs)

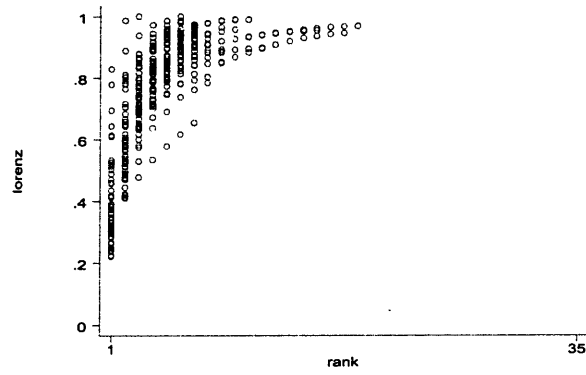


Figure 5-4: Lorenz Curves – Southern Markets (MSAs)

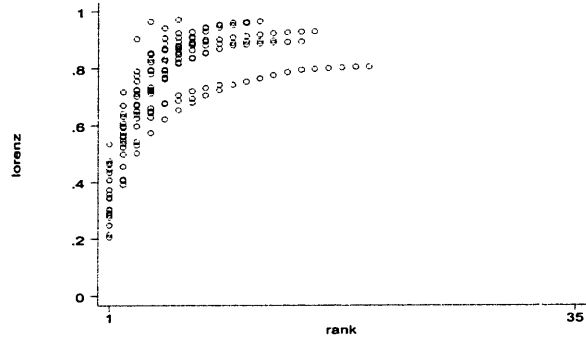


Figure 5-5: Lorenz Curves – Ohio Valley Markets (MSAs)

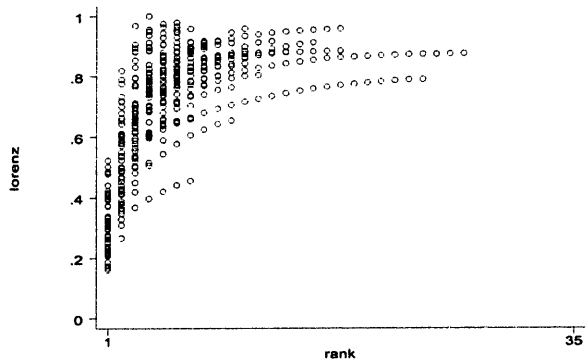


Figure 5-6: Lorenz Curves – Great Lakes Markets (MSAs)

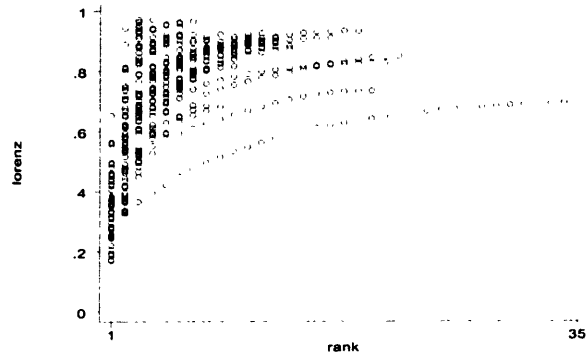


Figure 5-7: Lorenz Curves – Northeastern Markets (MSAs)

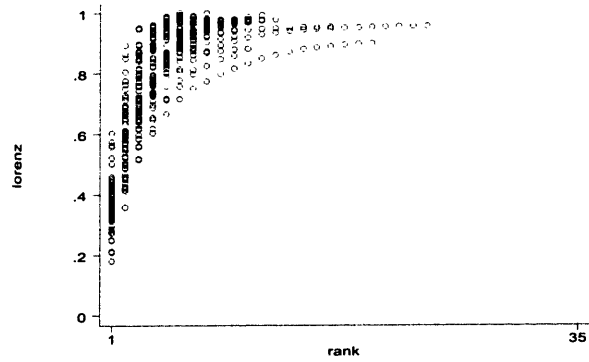


Figure 5-8: Lorenz Curves – South Atlantic Markets (MSAs)

Concentration in the Supermarket Industry: Tampa, Florida

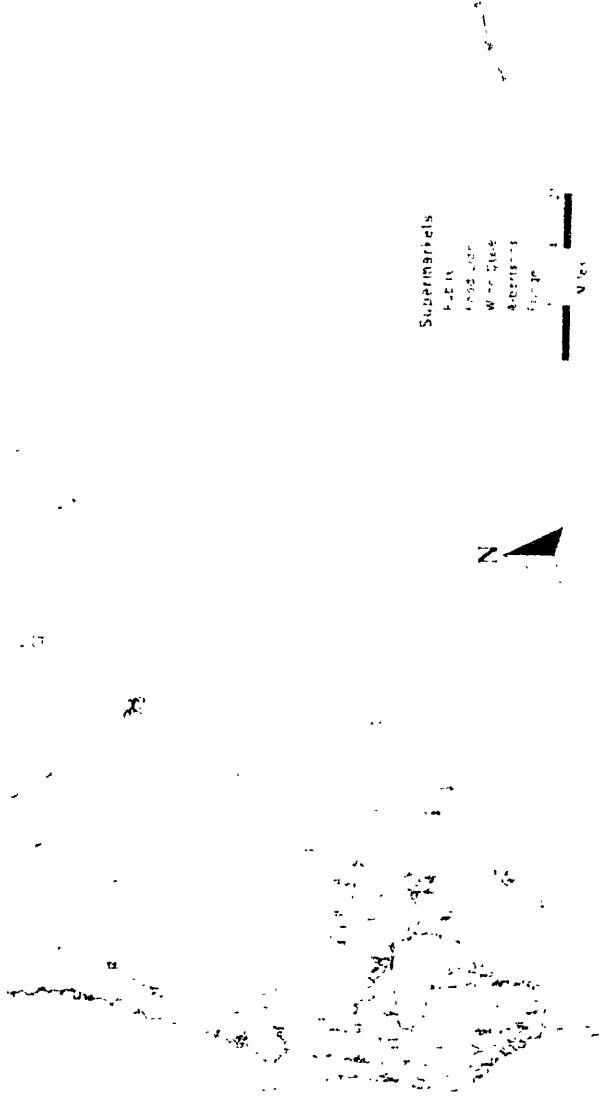


Figure 5-9: Map of Tampa, Florida

Concentration in the Supermarket Industry: Los Angeles, California

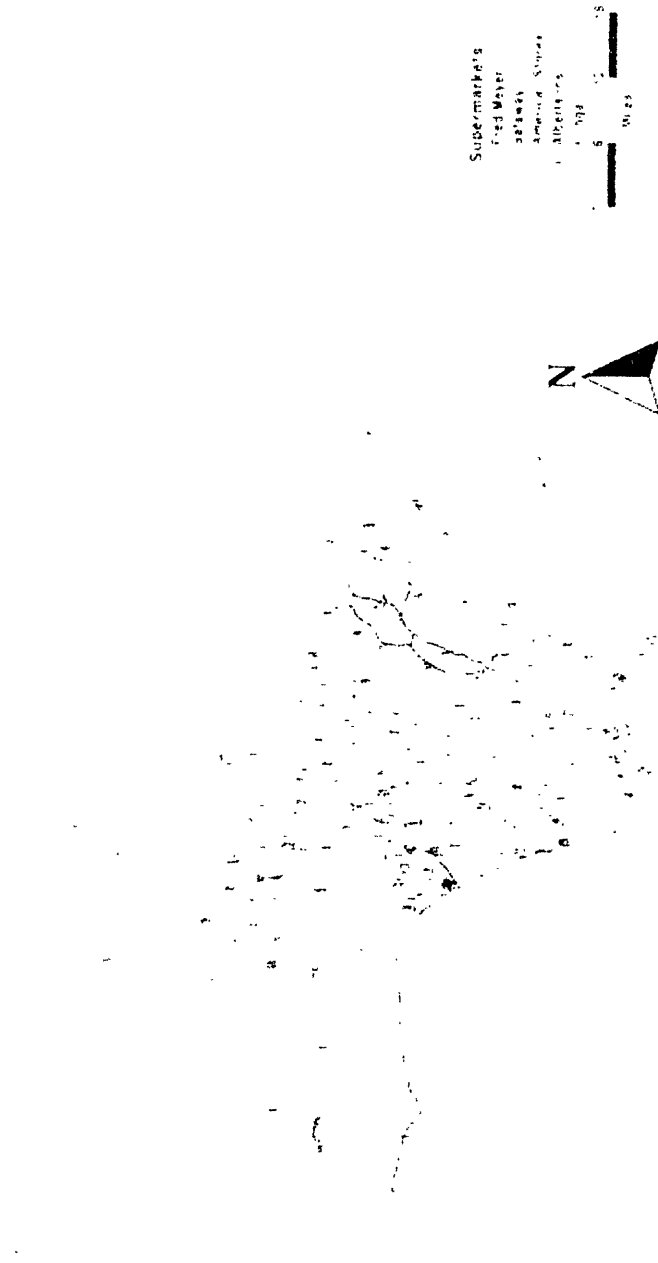


Figure 5-10: Map of Los Angeles, California

Concentration in the Supermarket Industry: Sacramento, California



Figure 5-11: Map of Sacramento, California

Concentration in the Supermarket Industry: Eugene, Oregon

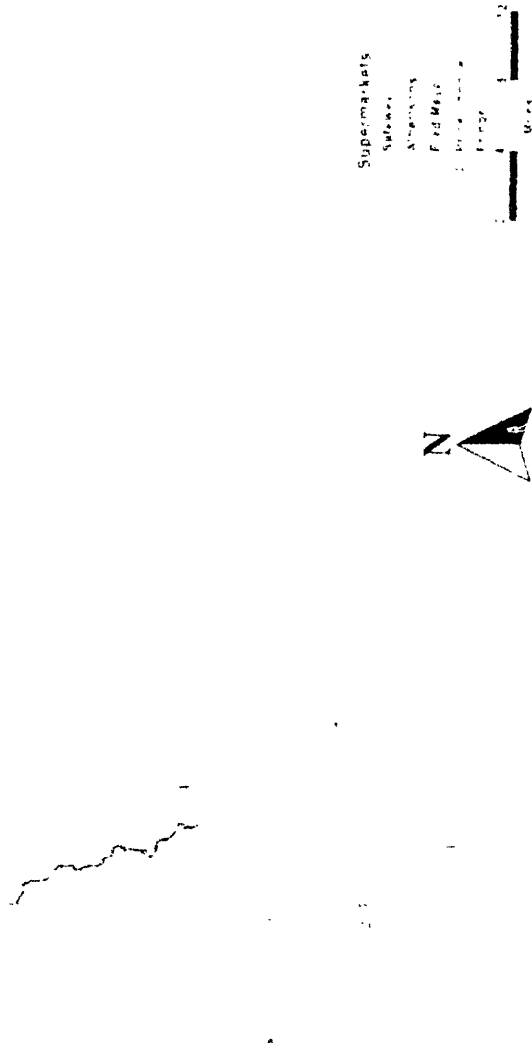


Figure 5-12: Map of Eugene, Oregon

Chapter 6

Bibliography

Athey, S. and Schmutzler, A., 1999, 'Innovation and the Emergence of Market Dominance, Working Paper, MIT.

Adelman, M.A., *A&P: A Study in Price-Cost Behavior and Public Policy*, Harvard University Press, Cambridge, MA, 1959.

Anderson, S., De Palma, A. and Thisse, J.F., 1992, *Discrete Choice Theory of Product Differentiation*, (MIT Press, Cambridge).

Baer, W., 1999, 'A Study of the Commission's Divestiture Process', Federal Trade Commission Report.

Bagwell, K. and Ramey, G., 1994, 'Coordination Economies, Advertising, and Search Behavior in Retail Markets', *American Economic Review*, 84, pp. 498-517.

Bagwell, K., Ramey, G. and Spulber, D., 1997, 'Dynamic Retail Price and Investment Competition', *RAND Journal of Economics*, 28, pp. 207-227.

Bagwell, K. and Staiger, R., 1994, 'The Sensitivity of Strategic and Corrective R&D Policy in Oligopolistic Structures,' *Journal of International Economics*, 36, pp. 133-150.

Bain, J.S., 1951, 'Relation of Profit Rate to Industry Concentration: American Manufacturing, 1936-1940', *Quarterly Journal of Economics*, 65, pp. 293-324.

Bain, J.S., 1956, *Industrial Organization*, Wiley (New York).

Bain, J.S., 1962, *Barriers to New Competition, Their Character and Consequences in Manufacturing Industries*, Harvard University Press (Cambridge).

Berry, S., 1992, 'Estimation of a model of entry in the airline industry', *Econometrica*, 60, pp. 889-917.

Bonano, G., 1987, 'Location Choice, Product Proliferation, and Entry Deterrence', *Review of Economic Studies*, 54, pp. 37-46.

Bresnahan, T., 1989, 'Empirical Methods for Industries with Market Power', In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. II, North-Holland (Amsterdam).

Bresnahan, T., 1992, 'Sutton's Sunk Cost and Market Structure: Price Competition, Advertising, and the Evolution of Concentration', *RAND Journal of Economics*, 23, pp. 137-152.

Bresnahan, T. and Reiss, P., 1987 'Do entry conditions vary across markets?', *Brookings Papers on Economic Activity*, 3, pp. 531-53.

Bresnahan, T. and Reiss, P., 1990, 'Entry in monopoly markets', *Review of Economics Studies*, 57, pp. 531-53.

Bulow, J., Geanakoplos, J., and Klemperer, 1985, 'Holding Idle Capacity to Deter Entry,' *Economic Journal*, 95, pp.178-82.

Bulow, J., Geanakoplos, J., and Klemperer, 1985, 'Multimarket Oligopoly: Strategic Substitutes and Complements', *Journal of Political Economy*, 93, pp. 488-511.

Chevalier, J.A., and Scharfstein, D.S., 1996, 'Capital-market imperfections and countercyclical markups: theory and evidence', *American Economic Review*, 86, pp. 703-725.

Chevalier, J.A., 1995, 'Capital structure and product-market competition: empirical evidence from the supermarket industry', *American Economic Review*, 85, pp. 415-435.

Chevalier, J.A., 1995, 'Do LBO supermarkets charge more? An empirical analysis of the effects of LBOs on supermarket pricing', *Journal of Finance*, 50, pp. 1095-1112.

Cotterill, R.W., 1986, 'Market Power in the Retail Food Industry: Evidence from Vermont', *Review of Economics and Statistics*, pp. 379-386

Cotterill, R.W., 1999, 'Market Power and the Demsetz Quality Critique: An Evaluation for Food Retailing', *Agribusiness*, 15(1), pp. 101-118.

Cotterill, R.W., and Haller, L.E., 1992, 'Barrier and Queue Effects: A Study of Leading U.S. Supermarket Chain Entry Patterns', *Journal of Industrial Economics*, 40(4), pp. 427-440.

d'Aspremont, C., Gabszewicz, J., and Thisse, J., 1979, 'On Hotelling's Stability in Competition', *Econometrica*, 17, pp. 1145-51.

de Palma et al., 1985, 'The Principal of Minimal Differentiation Holds Under Sufficient Heterogeneity', *Econometrica*, 53, pp. 767-82.

Demsetz, H., 1973, 'Industry Structure, Market Rivalry, and Public Policy', *Journal of Law and Economics*, 16, pp. 1-10.

Demsetz, H., 1974, 'Two Systems of Belief About Monopoly', In H.J. Goldschmid, H.M. Mann, and J.F. Weston, eds., *Industrial Concentration: The New Learning*, Little Brown (Boston).

Dixit, A., 1979, 'A Model of Duopoly Suggesting a Theory of Entry Barriers', *Bell Journal of Economics*, 10, pp. 20-32.

Dixit, A., 1980, 'The Role of Investment in Entry Deterrence', *Economic Journal*, 90, pp.

95-106.

Dixit, A. and Stiglitz, J., 1977, 'Monopolistic Competition and Optimum Product Diversity', *American Economic Review*, 67, pp. 297-308.

Eaton, B.C. and Lipsey, R.G., 1979, 'The Theory of Market Preemption: The Persistence of Excess Capacity and Monopoly in Growing Spatial Markets', *Econometrica*, 47, pp. 149-58.

Eaton, B.C. and Lipsey, R.G., 1982, 'An Economic Theory of Central Places', *Economic Journal*, 92, pp.56-72.

Eaton, B.C. and Lipsey, R.G., 1989, 'Product Differentiation', In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. I, North-Holland (Amsterdam).

Ellison, G., and Glaeser, E., 1997, 'Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach', *Journal of Political Economy*, 105(5), pp. 889-927.

Federal Trade Commission, *Economic Report on the Structure and Competitive Behavior of Food Retailing*, Federal Trade Commission, 1966.

Fisher, F.M., 1989, 'Games Economists Play: A Noncooperative View', *RAND Journal of Economics*, 20, pp. 113-124.

Fudenberg, D. and Tirole, J., 1984, 'The Fat Cat Effect, the Puppy Dog Ploy and the Lean and Hungry Look', *American Economic Review: Papers and Proceedings*, 74, pp. 361-68.

Gabszewicz, J.J. and Thisse, J.F., 'Entry (and Exit) in a Differentiated Industry', *Journal of Economic Theory*, 22, pp. 327-338.

Genesove, D., and Mullin, W., 1998, 'Testing Static Oligopoly Models: Conduct and Cost in the Sugar Industry, 1890-1914', *RAND Journal of Economics*, 29, pp. 355-77.

Greif, A., 1993, 'Contract Enforceability and Economic Institutions in Early Trade: the Magribi Traders' Coalition', *American Economic Review*, 83, pp. 525-48.

Gilbert, R.J., 1989, 'Mobility Barriers and the Value of Incumbency', In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. I, North-Holland (Amsterdam).

Gilbert, R.J. and Harris, R., 1984, 'Competition with Lumpy Investment', *RAND Journal of Economics*, 15, pp. 197-212.

Gilbert, R.J. and Newberry, D., 1982, 'Preemptive Patenting and the Persistence of Monopoly', *American Economic Review*, 72, pp. 514-26.

Grinnel, G.E. et al., *Grocery Retailing Concentration in Metropolitan Areas, Economic Census Years 1954-72*, Federal Trade Commission, 1979.

Hausman, J., 1994, 'Valuation of New Goods Under Perfect and Imperfect Competition', MIT Working Paper No. 94-21.

Hotelling, H., 1929, 'Stability in Competition', *Economic Journal*, 39, pp. 41-57.

Kaufman, P., Newton, D. and Handy, C., 1993, 'Grocery Retailing Concentration in Metropolitan Areas, 1954-82', Commodity Economics Division, Economic Research Service. U.S. Department of Agriculture, Technical Bulletin No. 1817 (August).

Koenker, R., Ng, P. and Portnoy, S., 1994, 'Quantile Smoothing Splines', *Biometrika*, 81, pp. 673-680.

Lebhar, G.M., *Chain Stores in America: 1859-1962*, Chain Store Publishing Corporation, N.Y., 1952.

Lehmann-Grube, U., 1997, 'Strategic Choice of Quality When Quality is Costly: the Persistence of the High-Quality Advantage', *RAND Journal of Economics*, 28, pp. 372-84.

Lancaster, K., 1996, 'Product Differentiation in Two-Tiered Industries', In K. Lancaster, *Trade, Markets, and Welfare*, Elgar (U.K.).

Lyons, B. and Matraves, C., 1995, 'Industrial Concentration and Endogenous Sunk Costs in the European Union', Economics Research Centre Discussion Paper No. 9505, University of East Anglia.

Manchester, A., 1992, 'Rearranging the Economic Landscape: The Food Marketing Revolution, 1950-91', Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 660 (September).

Messinger, P.R. and Narasimhan, C., 1995, 'Has power shifted in the grocery channel?', *Marketing Science*, 14, pp. 189-223.

Ordover, J.A. and Saloner, G., 1989, 'Predation, Monopoly and Antitrust,' In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. I, North-Holland (Amsterdam).

Prescott, E. and Visscher, M., 1977, 'Sequential Location Among Firms with Foresight', *Bell Journal of Economics*, 8, pp. 378-93.

Progressive Grocer, 'Annual Report of the Supermarket Industry', selected April issues.

- Progressive Grocer**, *Market Scope*, MacLean Hunter Media: White Plains, N.Y., 1997.
- Progressive Grocer**, *Marketing Guidebook*, MacLean Hunter Media: White Plains, N.Y., 1997.
- Reinganum, J.**, 1989, 'The Timing of Innovation: Research, Development and Diffusion', In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. I, North-Holland (Amsterdam).
- Reynolds, S.**, 1987, 'Capacity Investment, Preenption and Commitment in an Infinite Horizon Model', *International Economic Review*, 28, pp. 69-88.
- Robinson, W.T. and Chiang, J.**, 1996, 'Are Sutton's Predictions Robust?: Empirical Insights into Advertising, R&D, and Concentration', *Journal of Industrial Economics*, 64, pp. 389-408.
- Ronnen, U.**, 1991, 'Minimum Quality Standards, Fixed Costs, and Competition', *RAND Journal of Economics*, 22(4), pp. 490-50.
- Salop, S.**, 1979, 'Monopolistic Competition with Outside Goods', *Bell Journal of Economics*, 10, pp. 141-156.
- Schmalensee, R.**, 1978, 'Entry Deterrence in the Ready-to-Eat Breakfast Cereal Industry', *Bell Journal of Economics*, 9, pp. 305-327.
- Schmalensee, R.**, 1985, 'Econometric Diagnosis of Competitive Localization', *International Journal of Industrial Organization*, 3, pp. 57-70.
- Schmalensee, R.**, 1989, 'Inter-Industry Studies of Structure and Performance', In R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization*, Vol. II, North-Holland (Amsterdam).
- Schmalensee, R.**, 1992, 'Sunk Costs and Market Structure: A review article', *Journal of Industrial Economics*, 60, pp. 125-133.
- Shaked, A. and Sutton, J.**, 1982, 'Relaxing price competition through product differentiation', *Review of Economic Studies*, 51, pp. 3-13.
- Shaked, A. and Sutton, J.**, 1983, 'Natural Oligopolies', *Econometrica*, 51, pp. 1469-1484.
- Shaked, A. and Sutton, J.**, 1987, 'Product Differentiation and Industrial Structure', *Journal of Industrial Economics*, 60, pp. 889-917.
- Shaked, A. and Sutton, J.**, 1990, 'Multiproduct Firms and Market Structure', *RAND*

Journal of Economics, 21, pp. 45-62.

Shaked, A. and Sutton, J., 1997, 'One Smart Agent', *RAND Journal of Economics*, 28, pp. 605-28.

Simpson, J.D. and Hoskin, D., 1998, 'Are Retailing Mergers Anticompetitive? An Event Study Analysis', Working Paper, Federal Trade Commission.

Smith, R.L., 1994, 'Nonregular Regression', *Biometrika*, 81, pp. 173-183.

Spence, M., 1975, 'Monopoly, Quality and Regulation', *Bell Journal of Economics*, 6, pp. 417-29.

Spence, M., 1976, 'Product Differentiation and Welfare', *American Economic Review*, 66, pp. 407-14.

Spence, M., 1976, 'Product Selection, Fixed Costs and Monopolistic Competition', *Review of Economic Studies*, 43, pp. 217-35.

Spence, M., 1977, 'Entry, Capacity, Investment and Oligopolistic Pricing', *Bell Journal of Economics*, 8, pp. 534-44.

Spence, M., 1979, 'Investment Strategy and Growth in a New Market', *Bell Journal of Economics*, 10, pp. 1-19.

Spence, M., 1984, 'Cost Reduction, Competition and Industry Performance', *Econometrica*, 52, pp. 101-22.

Stackelberg, H., 1934, *Marktform und gleichgewicht*, Vienna: Julius Springer, Reprinted in *The Theory of the Market Economy*, Trans. A.T. Peacock, William Hodge (London).

Stigler, G.J., 1949, *Five Lectures on Economic Problems*, London School of Economics (London).

Stigler, G.J., 1968, *The Organization of Industry*, University of Chicago Press (Chicago).

Supermarket News, *Distribution Study of Grocery Store Sales*, Fairchild Annual, 1996.

Sutton, J., 1997, 'Game-theoretic models of market structure', in D.M. Kreps and K.F. Wallis (eds.), *Advances in Economics and Econometrics: Theory and Applications*, Vol. I, (Cambridge University Press, New York).

Sutton, J., 1991, *Sunk Cost and Market Structure: Price Competition, Advertising, and the Evolution of Concentration* (MIT Press, Cambridge).

Sutton, J., 1998, *Technology and Market Structure: Theory and History* (MIT Press,

Cambridge).

Tedlow, R.S., 1990, *New and Improved: The Story of Mass Marketing in America*, (Basic Books, New York).

Tirole, J., 1988, *The Theory of Industrial Organization*, MIT (Cambridge).

U.S. Department of Agriculture, 1992, 'Food Marketing Review, 1991', Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 657 (March).