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Price markups in oligopoly models with differentiated products

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Abstract

I show that the relationship between the toughness of price competition and market size in oligopoly models depends on assumptions about the shape of preferences. In a Perloff and Salop model of nonlocalized taste for variety, price-cost margins remain bounded above zero as market size grows infinitely large, even as the number of firms grows without bound. By contrast, a Salop circle model of localized preferences generates price-cost margins that fall to zero as market size grows large. The toughness of price competition never reaches competitive levels if nonlocalized preferences generate entry opportunities that expand the set of product variants. The toughness of price competition rises to competitive levels if localized preferences generate entry opportunities to "fill in" product space. I also outline an empirical test for boundedness of price-cost margins by examining boundedness of firm revenues in chain and non-chain restaurants in Census of Retail Trade data.

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1 Introduction

Two major approaches to modeling oligopoly with differentiated products focus either on consumers' nonlocalized taste for variety or on localized preferences for certain goods or product characteristics[1]. By working out simple polar models, I show that the relationship between market structure and price competition depends on the form of preferences and substitutability among products. In particular, as market size grows arbitrarily large, price-cost margins remain bounded above zero in a model of nonlocalized competition taken from Perloff and Salop (1985). However, price-cost margins decline to zero in a model of localized competition following Salop (1979). In both cases, the number of firms grows arbitrarily large with market size. Next, I propose an empirical test to examine the boundedness of price-cost margins in Census microdata, which is based on the inverse relationship between price-cost margins and firm revenues as derived in Campbell and Hopenhayn (2005) and exploits chain restaurants' unique product identity in a similar way as in Berry and Waldfogel (2003).

The main point of this paper is that price-cost margins can remain bounded above zero if consumers have sufficient taste for variety. The intuition behind this finding is that the structure of preferences determine whether profit opportunities arise in new niches or in intermediate niches as markets grow. If consumers have a taste for variety, entry occurs in new niches as markets expand. Entrants have new attributes, each product variant retains some market power and prices can remain above marginal costs even as the number of competitors grows large. If consumers have purely localized tastes, meaning that they prefer to consume products closest to their ideal types, then entry occurs in intermediate niches as markets expand. Entrants fill in product attributes space between existing products, each firm faces closer substitutes and prices fall to marginal costs as the number of competitors grows large.

My approach of defining testable predictions that differentiate between broad classes of models follows recent work on the relationship between concentration and market size. Sutton (1991) show that changes in competition with market size depend on how firms' investment decisions affect subsequent competition with rivals, specifically, that concentration remains bounded above competitive levels when sunk costs are endogenous. Berry and Waldfogel (2003) extend the "bounds approach" to vertical differentiation, showing that concentration is invariant to market size when product quality depends on fixed investments but falls with market size when product quality improves with marginal expenditures. Instead of comparing cost structures and bounds on concentration, I compare preference structures and bounds on markups or firm revenues, highlighting the implications for the relationship between the toughness of competition, market structure and market size.

This comparison generates testable predictions that build on empirical studies on competition and market size. In a classic series of papers, Bresnahan and Reiss (1987, 1990, 1991) show that a very small number of competitors is sufficient to generate prices close to competitive levels in small, isolated markets with few firms and homogeneous products. Campbell and Hopenhayn

1 Anderson et al (1992) provide extensive analysis of different models of consumer preferences, deriving formal links among representative consumer models, location models and discrete choice models of demand. They also discuss models that integrate both nonlocalized and localized preferences, which could form the basis for generalizing the results in this paper.

(2005) find that firm size increases with market size for several retail industries, indicating that competition is tougher in larger markets for a number of these industries. I use the relationship between firm size, price markups and market size that these authors derive to generate a preliminary empirical test.

My analysis also suggests an additional angle on empirical findings that firms differentiate their products to reduce price competition with rivals. Berry and Waldfogel (2001) show that radio broadcasting monopolists fill up product space to preempt entry and reduce price competition. Mazzeo (2002) shows that motels choose different qualities to reduce price competition with rivals in the same market. Seim (2006) shows that video rental stores that are closer to each other in geographic space face tougher price competition. These papers examine the tradeoff between greater total demand if products are undifferentiated and weaker price competition if products are differentiated. My findings suggest that this tradeoff varies depending on how consumers rank differentiated products. The effect of weaker price competition can remain strong in large markets if consumers have a strong taste for variety. It becomes negligible in large markets if consumers view similar products as close substitutes.

Theoretical work by Gabaix et al (2005) indicates that the bounded markups result that I derive for a simplified version of this model can be generalized. These authors show that price markups are asymptotically bounded for a generalized symmetric preferences framework based on Perloff and Salop (1985), a result that is grounded in the preference structure, not analytical form or distributional form assumptions.

Section 2 compares the the relationship between price-cost margins, number of firms and market size in two polar models. Section 3 outlines and empirical test and preliminary results. Section 4 summarizes and concludes.

2 Polar Examples of Nonlocalized and Localized Preferences Models

I contrast the implications of two major approaches to modeling preferences for differentiated products. In the symmetric nonlocalized preferences approach, represented by models such as Chamberlin (1933), Spence (1976), Dixit and Stiglitz (1977), Sattinger (1984), Perloff and Salop (1985), consumers view all potential products as equal but imperfect substitutes for one another. Symmetric consumer preferences generate non-localized competition among firms. A price change by any firm in these models affects the profits of all other firms equally. Entry by a new product reduces all other firms' demand equally. Each firm retains some market power regardless of the number of competitors because all products are equally imperfect substitutes by assumption. Market prices and equilibrium structure depend on the intensity of consumers' preference for variety. In the first three papers listed above, firms' actions have a small enough impact on other firms' profits so that large groups are monopolistically competitive. The latter two papers contain true oligopoly models in the sense that firms behave strategically even in large groups. I focus on the common feature of symmetric preferences and solve a logit discrete choice Perloff and Salop model for free entry equilibrium prices and market structure.

Perloff and Salop's (1985) model of competition among differentiated products is based on a random utility model. Assume that there are S statistically identical and independent consumers, each of whom purchases one of n products that are available in the market. Assume that all products have the same quality index a and the firm selling product i charges price, p_i. The conditional indirect utility of a consumer who purchases product i is given by

$$\tilde{V}_i = y - p_i + a + \sigma \varepsilon_i$$

$$\varepsilon_i \sim \text{iid normalized extreme value}$$

Each consumer purchases the product that maximizes utility. The parameter σ represents the intensity of taste for variety; higher values denote greater variability of tastes. The probability that each consumer buys product i is given by

$$P_i = \frac{\exp(-p_i/\sigma)}{\sum_{j=1}^{n} \exp(-p_j/\sigma)}$$

The demand for product i is therefore

$$X_i = S \cdot P_i = S \cdot \frac{\exp(-p_i/\sigma)}{\sum_{j=1}^{n} \exp(-p_j/\sigma)}$$

Assume that each product is produced by a separate firm so that n now represents both the number of firms and amount of variety in the market. Assume that fixed cost, K, and marginal cost c are equal for all firms. Each firm maximizes profits taking other firms' prices as given.

Solving the first order conditions for a symmetric price equilibrium generates equilibrium prices p, output X and firm revenues R, as a function of n, the number of firms.

$$p - c = \frac{\sigma n}{n-1} \qquad X = \frac{S}{n} \qquad R = \frac{S}{n}\left(c + \frac{\sigma n}{n-1}\right)$$

Allowing for free entry generates the zero-profit condition for a symmetric equilibrium, which in turn generates the symmetric free entry equilibrium number of firms n^{NL}, prices p^{NL}, output X^{NL} and firm revenues R^{NL} given by the following expressions.

$$n^{NL} = \frac{\sigma S}{K} + 1 \qquad p^{NL} - c = \sigma + \frac{K}{S} \qquad X^{NL} = \frac{kS}{\sigma S + K} \qquad R^{NL} = K\left(\frac{cS}{\sigma S + K} + 1\right)$$

The comparative statics of each variable with market size S are typical. The equilibrium number of firms is increasing less than proportionately with market size. Price minus cost is decreasing with market size and revenues are increasing with market size.

The key point of this paper relates to bounds as market size grows infinitely large. The number of firms also grows unboundedly, fitting with the assumption of exogenous fixed costs. Price minus cost, however, is bounded at σ , greater than 0 and revenues are bounded at c/σ . Table 1 displays these limits and compares them to limits from the localized preferences equilibrium. This means that prices remain bounded above perfectly competitive levels even in large markets, with a corresponding bound on firm revenues. The inverse relationship between price-cost margins and revenues will be useful in estimation. This result should generalize to models in which additional firms represent additional product types that are strictly preferred by some consumers. That is, variety increases by expanding the dimensions of produced characteristics space, rather than by filling in between existing products. If this is true, each firm retains some market power even if the number of rivals is infinitely large and price will be bounded above marginal costs.

Table 1. Limits in the Nonlocalized and Localized Models

(Perloff and Salop) Nonlocalized Preferences	**(Salop) Localized Preferences**
$\lim_{S\to+\infty} n^{NL}(S)=+\infty$	$\lim_{S\to+\infty} n^{L}(S)=+\infty$
$\lim_{S\to+\infty} (p^{NL}(S)-c)=\sigma>0$	$\lim_{S\to+\infty} (p^{L}(S)-c)=0$
$\lim_{S\to+\infty} R^{NL}(S)=\frac{c}{\sigma}<+\infty$	$\lim_{S\to+\infty} R^{L}(S)=\lim_{S\to+\infty}\left(\frac{p^{L}(S)-c}{p^{L}(S)}\right)^{-1}=+\infty$

An alternative preference structure assumes idiosyncratic, localized preferences, meaning that consumers have unique ideal products and increasing disutility of consuming products depending on their distance from ideal types. Seminal papers in this tradition include Hotelling (1929), Kaldor (1935), Salop (1979) and d'Aspremont et al (1979). In these models, consumers view products that closely located in product space as better substitutes than products that are located far apart. Localized consumer preferences generate localized competition among firms. A price change by any firm affects demand for its neighbors in product space more than it affects demand for firms that are located far away. Entry by a new firm reduces demand more for firms that are located closer to it in product space. Equilibrium prices and market structure depend on the intensity of consumers' preferences for their favorite product type. Each firm has market power because there are consumers who strictly prefer its product to others in the market. However, as more firms enter the market, each firm competes with closer substitutes and its market power declines to nil in the limit. I solve a simple Salop circle model to show that price-cost margins decline to zero with free entry in large markets.

Salop (1979) assumes that product space is described by a circle of circumference L. Consumers are uniformly distributed around the circle with density S/L and indexed by their location z in a clockwise direction. There are n firms in the market, spaced equally around the circle so that the distance between any two firms is L/n. Without loss of generality, index the firms in a clockwise direction so that firm i is located at $z_i = (i-1)\frac{L}{n}$. Each consumer purchases one unit from the firm that generates the highest utility. The indirect utility of a consumer located at z who purchases from firm i is given by

$$\tilde{V}_i = y - p_i + a - \tau\,|z - z_i|^2$$

Assuming that all consumers choose to purchase and that each firm has positive demand, the market segment for firm i is defined by an arc between the locations of consumers who are indifferent between purchasing from firm i or firm i-1 and consumers who are indifferent between purchasing from firm i or firm i+1. The marginal consumer located between firm i and firm i-1 is given by the following expressions.

$$p_{i-1} + \tau \left|\hat{z} - z_{i-1}\right|^2 = p_i + \tau \left|\hat{z} - z_i\right|^2$$

$$\hat{z}(p_{i-1}, p_i) = \frac{p_i - p_{i-1}}{2\tau \, L/n} + (2i - 1)\frac{L}{n}$$

The marginal consumer located between firm *i* and firm *i+1* is given by the following.

$$p_i + \tau \left|\hat{z} - z_i\right|^2 = p_{i+1} + \tau \left|\hat{z} - z_{i+1}\right|^2$$

$$\hat{z}(p_i, p_{i+1}) = \frac{p_{i+1} - p_i}{2\tau \, L/n} + (2i + 1)\frac{L}{n}$$

The demand for firm *i* is the distance between these two marginal consumers, multiplied by the density of consumers around the circle. It has the form

$$X_i = \frac{S}{L}\left(\frac{p_{i-1} - 2p_i + p_{i+1}}{2\tau \, L/n} + \frac{L}{n} \right)$$

Each firm maximizes profits taking other firms' prices and locations as given. Solving the first order conditions for a symmetric price equilibrium generates prices *p*, output *X* and firm revenues *R*.

$$p - c = \tau \left(\frac{L}{n}\right)^2 \qquad X = \frac{S}{n} \qquad R = \frac{S}{n}\left(c + \tau\left(\frac{L}{n}\right)^2\right)$$

Allowing for free entry for an integer number of firms generates the symmetric equilibrium number of firms n^L, prices p^L, and output X^L. The expression for revenues R^L is inversely proportional to the price-cost markup.

$$n^L = \left(\frac{S\tau L^2}{K}\right)^{1/3} \qquad p^L - c = \tau^{1/3}\left(\frac{KL}{S}\right)^{2/3} \qquad X^L = \left(\frac{KS^2}{\tau L^2}\right)^{1/3}$$

The comparative statics of each variable with market size *S* are again typical. The equilibrium number of firms is increasing with market size. Price minus cost is decreasing with market size and revenues are increasing with market size.

In the limit as market size approaches infinity, the number of firms increases unboundedly as in the model with nonlocalized preferences. However, in contrast to that model, price minus marginal cost drops to zero as market size grows infinitely large. Firm revenues increase unboundedly with market size.

This result should generalize to any model in which entry results in filling in of product space so that products are within ε-distance of one another in the limit. Each firm is flanked by neighbors who are negligibly distant from consumers' point of view and is not able to raise its price above marginal cost without losing all its customers. Price competition approaches perfectly competitive levels in this case.

In summary, Perloff and Salop's model of nonlocalized competition predicts that price-cost margins are bounded above zero while Salop's model of localized competition predicts that they drop to zero in large markets. This translates to bounds on firm revenues. Therefore, the mode of non-price competition among firms, whether nonlocalized or localized, can be distinguished empirically by examining if firm sizes are bounded in large markets.

3 Empirical Test

For a simple empirical test, I assume that preferences for national chain restaurants correspond to the symmetric model while preferences for independent restaurants correspond to the localized model and test the prediction that firm revenues should hit an upper bound for the first group but grow unboundedly with market size for the second group.

This assumption is based on the idea that national restaurant chains' products are differentiated from competitors through branding, in addition to physical product attributes. Since each chain enjoys a unique brand identity, consumers view different chains as imperfect substitutes for each other, even if they serve similar food items. This matches the assumption of the symmetric preferences model that consumers' taste for variety allows each product variant to retain some market power regardless of the competition. As market size grows larger, entry of a new restaurant chain represents expansion of product space to include a new combination of brand and product attributes, rather than "filling-in" of product space between existing brands. If consumers have strict preferences for restaurant brands, then chain restaurants should face increasingly tough price competition in larger markets but remain insulated from direct competition through (brand) product differentiation. This fits with the way that entry increases competition evenly for all product variants in the symmetric preferences model but never reaches perfectly competitive levels. My assumption of national restaurant chains' uniform product identity across markets is inspired by Berry and Waldfogel's (2003) assumption of national restaurant chains' uniform product quality to infer relative quality rankings across markets.

By contrast, I assume that independent restaurants do not possess significant idiosyncratic attributes that differentiate them from other restaurants regardless of market size. Therefore, consumers rank independent restaurants as substitutes based on their product or service attributes. This corresponds to a localized preferences model in which consumers can be ordered by their tastes for particular product characteristics and choose to purchase from firms closest to their ideal types. As market size grows larger, entry of a new independent restaurant represents a new combination of product characteristics that is a closer substitute for some existing restaurants than for others, increasing price competition more for the closer substitutes. In very large markets, each independent restaurant competes with extremely close substitutes and cannot raise its prices much above marginal costs. This fits with the idea that entry fills in intermediate niches in product space in the localized preferences model, raising the toughness of price competition to perfectly competitive levels in the limit.

I use firm revenues in the data as an indicator of price-cost markups. This is based on Campbell and Hopenhayn's (2005) derivation of the following relationship between price-cost margins and firm revenues from the zero profit condition for n firms, where R represents firm revenues and K represents fixed costs.

$$R = K\left(\frac{p-c}{c}\right)^{-1}$$

Therefore, variation in firm revenues reflects the amount of price competition faced by firms. The equality sign in the zero profit condition generates a strong relationship between bounded price-cost margins and bounded revenues. Revenues may or may not be bounded when price-cost margins are bounded if the condition holds with a weak inequality. However, revenues are unbounded as long as prices are equal to marginal costs.

I test the following predictions from the polar cases in Section 2. For national chain restaurants, nonlocalized competition generates an upper bound on firm revenues since price markups are bounded strictly above zero regardless of market size. In contrast, for independent restaurants, localized competition leads to unbounded firm revenues as the toughness of price competition increases with market size towards perfectly competitive levels.

I examine these predictions in establishment-level data from the 1997 Census of Retail Trade (CRT) for MSAs. To show how revenues vary with market size in chain and non-chain establishments, I run linear regressions of the following forms for two samples.

$$\log(\text{chain establishment revenue}) = 7.580\ (0.371) + 0.003\ (0.009)\ \log(\text{total population}) + \gamma X$$

$$\log(\text{non-chain establishment revenue}) = 8.401\ (1.158) + 0.048\ (0.021)\ \log(\text{total population}) + \gamma X$$

In the equations above, the numbers represent constant and coefficient estimates with standard errors in brackets. X represents a vector containing the MSA demographic variables from 1994 County and City Data Book (CCDB) and establishment characteristics such as seasonality, average wage and first year in operation. Chain stores include franchisees and company stores. Dummies for each national chain control for chain-specific revenue effects in the chain sample[2]. I abstract from size effects of single-unit franchisees and independents by examining just multi-unit operations. The chain sample contains 59,896 establishments while the non-chain sample contains 30,726 establishments. *R-squared* values are 0.60 and 0.17 for chains and non-chains, respectively. The first equation shows that chain establishment revenues are invariant to total market population, with an estimated coefficient that is statistically equivalent to zero. The second equation shows that non-chain establishment revenues are increasing in total market population, with statistical significance at the 1% level.

These results provide an indication that price-cost markups do not fall with market size for national chain restaurants but fall towards competitive levels for independent restaurants. This would be consistent with the hypothesis that national chain stores face nonlocalized competition that is bounded in toughness and independent stores face localized competition that grows unboundedly tough in larger markets.

4 Conclusion

This paper shows that different assumptions about how consumers rank product variants lead to different predictions for equilibrium price-markups and market structure. In a simplified

2 Since the Census microdata are protected by confidentiality rules, I cannot reveal information about specific chains in my sample. However, the list of national chains are drawn from Nation's Restaurant News' 2003 Top 200 chain rankings and should included most relevant large national chains.

version of Perloff and Salop's (1985) model of symmetric competition, price-cost margins are bounded above zero as market size grows arbitrarily large. By contrast, in a simple version of Salop's (1979) model of localized competition, price-cost margins decline to zero as market size increases to infinity. This adds a new angle on traditional studies of cost structure and bounds on market concentration by showing how preference structure can generate bounds on price-cost margins and firm size.

Innovations in oligopoly theory by authors such as Anderson et al (1992) and Gabaix et al (2005) suggest that the results from this polar comparison can be generalized in a model embedding both preferences for variety and localized preferences. The empirical section suggests an approach to differentiating between taste for variety and localized tastes by examining boundedness of firm revenues and provides preliminary support that the prediction generated by polar models can be detected in firm level data.

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