

## **Product Differentiation**

New Palgrave Dictionary contribution

Simon P. Anderson  
Commonwealth Professor of Economics,  
University of Virginia,  
PO Box 400182,  
Charlottesville VA 22904-4128,  
USA.  
sa9w@virginia.edu

This version March 31<sup>st</sup> 2005.

COMMENTS WELCOME

### **Abstract**

Product differentiation is pervasive in markets. It is at the heart of structural empiricism and it smoothes jagged behavior that causes paradoxical outcomes in several theoretical models. Firms differentiate their products to avoid ruinous price competition. Representative consumer, discrete choice, and location models are not necessarily inconsistent, but performance depends crucially on the degree of localization of competition. With (symmetric) global competition, rents are typically small and market variety near optimal. With local competition, profits may be protected because entrants must find profitable niches. These rents lead firms to competitively dissipate them, and performance may be poor.

## 1. Overview

Consumer goods are available in a variety of styles and brands. Product differentiation refers to such variations within a product class that (some) consumers view as imperfect substitutes. The store Foods of all Nations in Charlottesville, VA (area population 120,000) carries 118 varieties of hot pepper sauce, 41 balsamic vinegars, and 121 different olive oils (these figures include variations such as flavorings and different package sizes from the same manufacturer). There are 82 other retail grocers listed in the area. Charlottesville is served by 23 rated radio stations which differ by format choices (18 are commercially operated).

Product differentiation offers firms market power. This enables them to transcend the *Bertrand Paradox* for pricing homogeneous products. In the Bertrand Paradox, two or more firms sell goods that consumers perceive as identical, so goods are perfect substitutes. Assume that marginal costs are common and constant, and market demand has a finite price intercept. Then one good cannot carry a price premium over another while retaining positive sales. Any lowest price above marginal cost would then profitably be undercut. This logic impels us to marginal cost pricing as the only equilibrium under Bertrand competition.

Product differentiation resolves the paradox naturally. When products are imperfect substitutes, a price-cutting firm cannot take all of its rivals' customers with an infinitesimally small price cut. This means that firms have some market power (due to the special features that distinguish them from their rivals' products); they can set prices without a completely elastic response by consumers. It also means that the product itself becomes a choice variable and firms differentiate to avoid the Bertrand outcome.

However, many models of product differentiation do not treat this choice explicitly, and instead assume a framework (representative consumer, discrete choice, and symmetric location models) that generates a demand system. It is not so much the framework used but rather the structure of product differentiation that is critical to the predictions and results. Indeed, common models of one type may be recast within another framework and be formally equivalent. Instead, the important feature for performance is whether each product is equally substitutable with all others or if each has only few close substitutes which are chain-linked to other products in the industry. Equal substitutability describes *global competition* where each firm competes with each other firm. Chain-linking corresponds to *local competition*. Local competition models naturally apply in geographical space since nearby stores are closer substitutes for consumers than distant ones. Likewise, in a characteristics setting, a consumer with a sweet tooth will find sugary products closer substitutes for any sweet product than for a saltier one.

The next section describes models of product location (in geographical space or its characteristics analogue) and distinguishes horizontal from vertical differentiation. Section 3 compares the common approaches to product differentiation used to analyze the market provision of variety. In these models, product decisions are suppressed and product selection is determined by entry. Section 4 describes how the market variety diverges from the equilibrium one. Section 5 elaborates on this theme for local competition. Section 6 indicates how product differentiation is used elsewhere in economics.

## 2. Product choice

Hotelling (1929) wrote the seminal paper treating the product specification as endogenous. Applications beyond Industrial Organization include marketing, economic geography (spatial competition), political science (the "Hotelling-Downs" model), and media economics. The basic paradigm is that consumers are differentiated by their locations ("addresses") and dislike distance. Products, too, are locations in this space (geographic, characteristics, etc.). When products are priced at marginal cost, consumers differ by which they like best, a situation known as *horizontal differentiation*. The simplest version of the model has two ice-cream sellers locating on a beach (with fixed prices). The Nash equilibrium is back-to-back pairing at the median of the consumer distribution, a result christened the *Principle of Minimum Differentiation*. It has been used to explain striking similarities in colas, gas station location, political parties' platforms, and the timing of television programs.

However, the Principle dissolves when firms locate in rational expectation of ensuing equilibrium prices (i.e., seeking a sub-game perfect equilibrium to a two stage price-then-location game). Indeed, if two products were collocated, Bertrand competition would drive prices to marginal cost. Firms will avoid this ruinous result by differentiating to retain market power attributable to location advantage. The equilibrium trades off two opposing factors. Getting closer to a rival provokes more intense price competition so firms differentiate in order to relax price competition, but getting close to a rival attracts more customers.

The equilibrium locations are outside the optimum ones (which are at the quartiles for a uniform consumer density) for the central case of quadratic distance disutility costs, but otherwise there is no fundamental reason for excessive market differentiation. More elaborate models can rapidly become quite intractable and are hamstrung by non-existence of (pure-strategy) price equilibria due to fundamental failure of quasi-concavity of the profit functions in prices.

The case above of horizontal differentiation has consumers with fundamental preference differences across different varieties. In *vertical differentiation*, all consumers have the same preference ordering (when goods are priced at marginal cost). More preferred goods are often described as having higher "quality," (with different individuals having different willingness to pay for quality). In vertical differentiation models, firms are to choose their product qualities. Choosing the same quality is avoided because of ruinous price competition, and the same trade-off operates as under horizontal differentiation. Under vertical differentiation though, the firm producing a higher quality product earns more profit than a firm with lower quality. This result is an extension of the Bertrand paradox. One firm differentiates itself by a low quality, but this puts it at a disadvantage. Indeed, it may not be able to escape the shadow of the high quality firm and earn a positive profit in equilibrium. This result implies the finiteness property that only a finite number of firms can survive in equilibrium even as fixed costs become arbitrarily small. By contrast, in a horizontal model, a firm may always find a niche between existing firms that gives it an advantage over some consumers (so finiteness cannot hold). Finally, if the costs of improving quality are mainly sunk, a firm may invest more heavily in quality in a larger market because the benefit accrues over a larger consumer base (so sunk costs are endogenous).

Quite similar in spirit to the above approaches, Lancaster's (1966) model of *characteristics* was a quite revolutionary approach to consumer theory. It posited that consumers care about the characteristics intrinsic to goods and purchase goods because they deliver the desired characteristic mix, adjusting appropriately for prices. Lancaster's theory answers the question of why goods are desirable by formulating fundamental preferences over characteristics. The approach is intuitively appealing and is at the heart of hedonic models in Econometrics, state preference and mean variance models in portfolio choice problems in Finance, and structural econometric work in Industrial Organization. However, the approach is rather cumbersome for generating much theoretical insight into firms' location decisions, i.e., the choice of which characteristics to embody in products.

### 3. Modeling (horizontal) product differentiation

There are three basic families of product differentiation models that are typically used for modeling equilibrium with free entry and comparing optimal to equilibrium diversity. *Representative consumer* models start by positing a utility function intended to portray aggregate preferences. This preference ordering generates the demand system for differentiated products and it measures welfare for the optimality analysis. Such functions typically embody global competition insofar as demands for varieties of the differentiated product are symmetric substitutes. Models in this class include the often-used CES preference formulation and the quadratic utility that gives rise to a linear demand system. These are parameterized utility functional forms that embody taste for variety in that more variety raises welfare even when total consumption is fixed.

The *discrete choice approach* is founded in econometric and probabilistic models of consumer behavior. Each individual has an idiosyncratic taste (or "match value") for each product. Aggregating individual choices yields the demand function and aggregating the surpluses yields the welfare function. Any i.i.d. tastes yield global competition in that products are symmetric substitutes (e.g., the logit model).

Discrete choice models are not constrained to symmetric substitutability among variants. Models such as the nested logit embody closer substitutability between products within the same nest and the general probit model embodies quite elaborate substitutability patterns through the variance-covariance matrix of the match terms. These models are commonly used in the new structural empirical industrial organization literature.

*Location models* explicitly describe product specifications and consumer preferences as addresses and assume that consumers dislike distance "traveled" between ideal type and product. Location models may also be viewed as discrete choice models because individuals make discrete choices and have idiosyncratic match values. There is a difference in interpretation: location models typically assume the population of consumers to be given and deterministic, while discrete choice models suppose that an individual's taste is a realization from a probability distribution.

In models such as the circle model, the emphasis is on the number of products produced in equilibrium and exogenous symmetric locations are effectively imposed:

however, the standard symmetric location pattern can be proved to be a location equilibrium under some circumstances.

One major benefit of discrete choice and location models is that the explicit micro foundations indicate how to introduce some economic phenomenon of interest. For example, network externalities may be incorporated into consumer utility and a consistent set of demands is then generated. Representative consumer models are less satisfactory since they do not start with a population of differentiated individuals.

The different approaches are not necessarily inconsistent with or substitutes for each other. Rather, they may frequently be twinned and one approach may be reinterpreted within the setting of the others. The CES model is a variant of the logit model, and a representative consumer does exist for the circle model and for probabilistic discrete choice models. Indeed, although global competition is typically generated from models such as the CES representative consumer or models of discrete choice with i.i.d. errors, it can also be derived from a spatial model if there are sufficiently many dimensions (so that each good can be a “neighbor” to each other one).

These models are also useful for comparative static analysis of changing patterns in industries in response to structural changes in cost structures, population growth, transportation costs, and consumer tastes. These descriptions are useful for Urban Economics, Industrial Organization, International Trade, and Economic Geography.

#### **4. Monopolistic competition and optimal variety**

In Chamberlin's (1933) monopolistic competition model, products have downward sloping individual demands, yet there are so many firms that a free entry condition reasonably applies. With increasing returns to scale in production, there is a social trade-off between the benefits from variety and the costs of producing further varieties. The market equilibrium roughly embodies the same type of trade-off insofar as more firms enter if fixed costs are lower. Chamberlin concluded (although without explicit analysis) that the market equilibrium would reach "a sort of ideal."

Under symmetric global competition, each entrant carves out its market share equally from established firms. Then, the number is the largest whole number at which profits are positive. This number of firms is tied down uniquely and zero profit is a reasonable approximation. Strategic behavior by firms is scarcely relevant since there are virtually no profits to be had.

Later work showed Chamberlin to be right that the market would settle on the same amount of product diversity as the (zero-profit constrained) optimum in the central case of CES preferences (and for the logit model). Other discrete choice models lead to overentry: this is exacerbated with asymmetric product qualities. The market may also bias against products with high fixed costs and inelastic demands. Multi-product firms choose inefficiently narrow product ranges in order to relax price competition: this effect exacerbates excessive entry of firms.

Although the symmetric CES/logit results (asymmetries aside) suggest that product differentiation is not much cause for performance concern, the alternative framework of the circle model typically generates substantial overentry of firms.

The divergence between equilibrium and optimum product variety depends on the balance between two opposing forces. When a firm chooses to enter, it does not consider that its entry will benefit consumers. This *non-appropriation of consumer surplus* is therefore a positive externality that the firm does not internalize insofar that it cannot capture this surplus in its revenue. This force favors insufficient entry into the market place. It is the only force governing a multiproduct monopolist's choice of how many products to introduce, so it provides too few products. However, in a competitive setting, a firm's entry can also reduce the profits of existing firms. This *business stealing* is also not accounted for by the firm in its entry calculus because other firms' profits do not affect its own bottom line. This negative externality encourages too many firms in equilibrium. For the CES model, these two forces exactly cancel out. For the circle model of localized competition, business stealing dominates and so there are too many firms. Loosely, prices fall quite slowly with entry in the circle model meaning that too many firms are attracted.

## 5. Localized competition

Vickrey (1964) can be credited with developing several important themes of spatial competition. He formulated the circle model, finding overentry at the equilibrium, and noting that there may be multiple equilibria under localized competition because a new entrant must fit in a niche between existing firms. An entrant's expected market space is substantially smaller than an incumbent's. This effect is exacerbated because entrants rationally expect incumbent firms will react to new entry (in a new Bertrand-Nash price equilibrium) by cutting prices. Incumbents may earn substantially higher gross profits than the cost of entry that would be incurred by an entrant. There are then multiple equilibria. These range from the tightest packing at which incumbents just earn zero profits (and so are not induced to exit), to a loosest packing at which incumbents earn substantial profits (and entrants will not wish to set up).

The normative economics are very sensitive to the particular equilibrium selected. Typically, the equilibrium where the incumbents just make zero profits involves too many firms while the loosest packing equilibrium involves too few firms. It is therefore crucial to determine which equilibrium is the reasonable description. The possibility of positive profits is also very important for market conduct because firms will strive to capture the rents attributable to advantageous locations. The deadweight losses due to rent seeking should be added to any inefficiency in location choice per se. Firms may commit capital early to a market that is growing over time in order to stake claim to locations that will later be profitable. Such capacity may be sunk before it is economically viable in terms of flow profit. The equilibrium locations are those of minimum packing (maximal spacing). However, a subsidy to encourage more entry might simply raise the amount of rents that are dissipated.

Thus, while performance under global competition may not generate much cause for concern, there may be substantial welfare losses in situations characterized by a strong degree of localized competition.

## 6. Further applications

Product differentiation explains and resolves some other paradoxical results that obtain when products are assumed to be perfect substitutes. The *Diamond Paradox* holds that the monopoly price prevails in the presence of small search costs even with many firms. Suppose consumers expected the monopoly price to be charged everywhere. Any firm pricing lower can raise its price and lose no consumers: a lower price attracts no consumers from other firms because a lower price is not expected. Any (rationally expected) price below the monopoly one is not an equilibrium because a firm can raise its price by an amount up to the search cost without losing any consumer who encounters it first. There is thus a striking discontinuity between the Bertrand and Diamond paradoxes as the search costs go from zero to a small positive value. Product differentiation smoothes the transition by allowing the consumers to shop for attributes other than purely price. A consumer may indeed find the price she expected at the first store sampled but still search further if she expects to find a better match. Her continued searching effectively brings firms into competition with each other. Firms therefore reduce prices to retain consumers who search for better matches.

The existence of a (pure strategy) price equilibrium in the original Hotelling model can be restored (through restoring profit function quasiconcavity) if there is sufficient non-locational product differentiation (through idiosyncratic preferences for products). This mechanism can restore the Principle of Minimum Differentiation in locations, even with endogenous prices.

The standard Bertrand-Edgeworth pricing problem treats capacity constraints and, with homogenous products, has only mixed strategy equilibria. With sufficient product heterogeneity, pure strategy equilibria re-emerge since the benefits from undercutting are reduced. Likewise, standard models of positive network externalities typically exhibit multiple equilibria or no pure strategy equilibria. Unique pure strategy equilibria result with enough differentiation of products.

In International Trade, product differentiation explains the empirical paradox of intra-industry trade; much bilateral trade is in the same product class. Furthermore, product differentiation is a source of gains from trade (in addition to the traditional comparative advantage in production and factor difference reasons) because of access to larger markets supporting more variety. Endogenous growth theory relies on product differentiation (typically with CES preferences or “quality ladders” based on vertical differentiation) to rationalize continued Research and Development of new varieties. It is also a predominant feature as an agglomerative force in recent models of New Economic Geography. In macroeconomics, product differentiation models have been used to introduce imperfect competition. This is useful for providing micro-underpinnings to New Keynesian analysis. For example, in conjunction with “menu costs” to switching prices, it gives rise to real effects to monetary policy.

## References

- Anderson, Simon P., de Palma, Andre, and Jacques-François Thisse [1992] *Discrete Choice Theory of Product Differentiation*. MIT Press, Cambridge, Mass.
- Archibald, G. Chris, Eaton, B. Curtis, and Richard G. Lipsey [1986] Address Models of Value Theory. In *New Developments in the Analysis of Market Structure*, Joseph S. Stiglitz and G. Frank Mathewson (eds.) Cambridge: MIT Press, 3-47.
- Berry, Steven, James Levinsohn, and Ariel Pakes [1995] Automobile Prices in Market Equilibrium. *Econometrica*, 63, 841-890.
- Chamberlin, Edwin [1933] *The Theory of Monopolistic Competition*. Cambridge: Harvard University Press.
- D'Aspremont, Claude, Jean Jaskold Gabszewicz, and Jacques-François Thisse [1979] On Hotelling's 'Stability in Competition.' *Econometrica*, 47, 1145-50.
- Hotelling, Harold [1929] Stability in Competition. *Economic Journal*, 39, 41-57.
- Lancaster, Kelvin J. [1966] A New Approach to Consumer Theory. *Journal of Political Economy*, 74, 132-157.
- Spence, A. Michael [1976] Product Selection, Fixed Costs and Monopolistic Competition. *Review of Economic Studies*, 43, 217-235.
- Vickrey, William S., [1964] *Microstatics*. Harcourt, Brace and World, New York.
- Selection "Spatial Competition and Monopolistic Competition," reprinted (with foreword) in *International Journal of Industrial Organization*, 17, (1999) 953-963.