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THE "STEINER EFFECT":

A PREDICTION FROM A MONOPOLISTICALLY COMPETITIVE MODEL

INCONSISTENT WITH ANY COMBINATION OF PURE MONOPOLY OR COMPETITION

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The views expressed in this paper are solely those of the author and do not necessarily reflect the views of the Commission or any other staff members. I trust my indebtedness to Robert L. Steiner will be obvious to any reader of the paper. While I have tried to capture some of the elements of his thinking, much has been left out. In any case Steiner should not be held responsible for my views as expressed in this paper. I am also heavily indebted to Jim Case for the market share theorem used extensively in this paper.

Milton Friedman, in his essay "On the Methodology of Positive Economics," asserted that Chamberlin's theory of monopolistic competition was <u>not</u> a useful generalization of Marshallian price theory. Although agreeing that a more general theory would be desirable, Friedman maintained that a general theory must have "implications susceptible to empirical contradiction of substantial interest and importance" that differ significantly from those produced from a Marshallian model.[1] Chamberlin's theory failed this test. Though this assertion was followed by substantial controversy [Archibald (1962, 1963), Friedman (1963), Stigler (1963)], in the end there seemed to be substantial agreement with Friedman's original proposition. No one, either then or later [Telser (1968)] came forward with a potentially refutable general implication from a monopolistically competitive model that would be inconsistent with the pure Marshallian models. In this paper I demonstrate that a model based on Robert L. Steiner's informal "dual stage" theory of manufacturing and retailing does have such an implication. It also constitutes a demonstration that a prediction generated by a monopolistic competition model need not lie "between" the poles of pure competition or pure monopoly; an analysis alternately employing both "polar" models need not produce predictions that will bracket those derived from a monopolistically competitive model.

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[1] Friedman's criticism is that despite the appearance of greater "realism" in the assumptions underlying Chamberlin's model, it fails to yield any refutable predictions that differ from Marshall's models. The stress on the need for different and potentially refutable predictions from competing models is very much in accord with the views brilliantly and persistently expressed by the philosopher Karl Popper (1959, 1975). Note that his argument is <u>not</u> that the empirical "realism" of the assumptions is irrelevant in judging the worth or truthfulness of the theory (what Samuelson calls the "F-twist"), but that the "more realistic" assumptions yield no additional or alternative predictions.

Models of pure competition or monopoly imply that there will be either no correlation or a positive correlation between the retail and manufacturing percentage gross margins of a given product, whereas the dual stage theory predicts that percentage gross margins at the two levels will be negatively correlated. "Percentage gross margin" is defined as the difference between selling price and marginal cost divided by price, where price and cost refer respectively to the manufacturing and retail levels. I call the negative correlation between gross margins at the retail and manufacturing levels, the "Steiner Effect." These differing predictions provide a conceptual basis for a "crucial" experiment: if margins at the two levels are in fact strongly negatively correlated then <u>any</u> Marshallian model of retailing is refuted.[2]

Robert L. Steiner, based in part on his own business experiences and in part of his study of business history since the advent of mass advertising, asserts that the following not only can occur but is the "normal" case for consumer products that succeed in becoming "leading national brands." A firm that succeeds in transforming a "no name" product into a brand whose name is recognized by a large portion of the public will find itself in the enviable situation where it can raise its own price and yet have its retail margin fall. Therefore the retail price will not rise by as much as the manufacturer's price increase and it may even fall. The reason for the decline in the retail margin is that the elasticity of demand, <u>as seen by the</u>

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2 Provided, of course, that other explanations consistent with a Marshallian model can be ruled out. For example, there could be a negative correlation if inventory costs were systematically lower on leading national brands because of their more rapid turnover; lower retail margins would be explained by lower retailing costs. The problems of designing a clean empirical test for the Steiner effect are substantial and will not be treated in this paper.

individual retailer, for the new "high profile" (HP) product is higher than for its "no name" or "low profile" (LP) substitutes. The reason for the higher retail elasticity of demand for the HP brand lies in its greater visibility. Consumers are more conscious of its price and are more likely to compare prices between one store and another (i.e., consumers are less ignorant of its price). One reason consumers are more likely to compare prices for an HP brand is that different stores may carry LP's with different names, with few or no stores carrying an LP brand with the same name. Thus, to compare LP's between different stores, consumers must evaluate both price and quality differences, whereas with HP's they can simply compare prices.

Despite its lower retail margin, retailers may be more likely to carry the now more visible HP item. If a substantial portion of potential customers will now patronize only those stores that carry the particular HP brand, then retailers will have little choice but to carry it. Specialized retailers (gasoline stations, shoe stores) will require a retail price that at least covers variable costs. However, non-specialized retailers, those whose customers on average purchase several different items per shopping trip, may carry the HP brand even if its retail price does not cover variable costs.

A relatively low price on the HP product may attract more customers into a store, not only because some consumers wish to purchase it at an attractive price, but also because some may use the store's rank on the HP product to judge it's overall pricing policy, that is, to form their "price image" of the store; if it's low on HP, perhaps it's low on all, or most items. The additional customers may purchase both HP and LP items. The HP item is a "traffic builder" and may increase sales of all other items carried by the retailer. Failure to carry the HP product carries a substantial risk of losing customers.

The HP manufacturer's demand has therefore become less elastic, and so he raises his price and margin, whereas the retailer faces a more elastic demand and therefore lowers his margin on the HP brand. In Steiner's view, HP brands will have relatively high manufacturer margins and low retail margins, whereas the reverse will be true for LP items, that is, margins at the two levels will be negatively correlated (the "Steiner effect"). But this result is inconsistent with either a purely competitive or a purely monopolistic retailing sector facing a monopoly supplier. Why? Because in either of the "pure" cases the manufacturers' demand is derived from the retail level and the derived demand theorem [3], says that if retail demand is less elastic after the brand attains a "high profile," so also is the manufacturer's demand. [4]

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[3] James Ferguson (1982) observed that Steiner's scenario is inconsistent with the derived demand theorem and concluded that it must be wrong. He added "that because it is not based on maximizing behavior on the part of producers, retailers, or consumers, Steiner's dual-stage model is not a model at all but rather an interesting description of possible events during the life cycle of a brand or a product category." The model presented here shows that the Steiner effect is consistent with profit maximizing behavior on the part of all market participants, but is inconsistent with either pure competition or monopoly in the retail sector.

[4] Marshall's (1920, note XV, 853) proof of this theorem assumes perfect competition in the downstream market, parametric input prices and a production function with fixed coefficients. Hick's (1963, 241-246 and 373-378) somewhat more general proof still assumes perfect competition and constant returns to scale, but allows for substitutability of factors in the production function. Maurice and Ferguson (1973) provide an analytic expression for the elasticity of derived demand when the downstream industry is monopolized and when no scale restrictions are placed on the production function. The elasticity of the downstream demand does not enter directly into this expression, whereas the difference between the elasticities of marginal revenue and marginal cost does. Maurice and Ferguson state (p.185) that although the latter term "is unquestionably related" to the elasticity of final demand, the relation is a "tenuous one, and

It is easy to see why, in the case of a final product, the derived demand at the manufacturer's level must mirror the final retail demand. If the manufacturer raises his price, costs at the retail level increase. Some or all of this cost increase will be passed on in the form of a higher retail price. Retail sales of the brand will fall and the fall as seen by the manufacturer must be equal to the retail elasticity of demand multiplied by the percentage increase in the retail price induced by the increase in the manufacturer's price. If marginal costs are constant, then the retail price will increase by the precisely the amount of the factory price increase if the retailing sector is competitive, whereas if the retailer is a monopolist, the retail price will increase by the "monopoly multiplier"[5] times the factory price increase.[6] In either case, the percentage increase induced in the retail price by a small percentage increase in the factory price will be equal to the ratio of the factory price to the retail price. If, for example, the elasticity of consumer demand is 3 and the factory price is 70% of the retail price, then the elasticity of the derived demand as seen by the manufacturer

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it cannot be stated explicitly in meaningful economic terms." However, the derived demand theorem when the "factor" of production is a particular brand is generally true whether the downstream market is competitive or a monopoly. The reason is that this is by necessity a "fixed proportions" case, one unit of the manufacturer's brand being necessary for each unit sold at the retail level.

[5] If e stands for consumer elasticity of demand, then the Lange-Lerner multiplier is (e /e-1).

[6] This assumes that other per unit retailing costs are unaffected by the increase in the factory price. Inventory costs are affected, of course, but the practical effect is small.

will be 2.1, regardless of whether the retail sector is competitive or a monopoly.[7]

It is now clear why the Steiner effect is inconsistent with the standard Marshallian models of monopoly and competition. If retailing is assumed to be perfectly competitive, then demand curves as seen by the retailer cannot be made more elastic; they are already infinitely elastic. Margins, at the retail level, will <u>not</u> reflect the consumer elasticity of demand and therefore margins at the two levels will be uncorrelated. If the retail sector is assumed to act as if it were a single monopoly, then if advertising makes consumer demand for the product less elastic then it also makes the derived demand less elastic and margins will either be indeterminate or positively correlated.[8]

In this paper, I present a formal model of retailing and manufacturing that is consistent with the Steiner effect. It focuses on a set of retail stores that compete for the same set of potential customers, but where a store does not necessarily lose all of its customers if its price is above that of any one of the other stores. Different stores have different non-price advantages and disadvantages with different customers. The model assumes

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[7] Of course, a given factory price will be a smaller percentage of the retail price if the retail sector is a monopoly than if it is competitive. In the case of constant marginal costs at both levels, it is easy to show that the elasticity of derived demand will be e times the ratio of the factory price to the sum of factory price and retail marginal costs if retailing is competitive and (e - 1) times the ratio of cost if it is monopolistic. Thus, for the same underlying costs, derived demand appears less elastic when the retail sector is monopolistic than when it is competitive.

[8] In the relatively implausible case where both the manufacturer and the retailer are modeled as monopolists ("bilateral-monopoly") prices and margins are indeterminate. If it is assumed that whatever determines the "split" between retailer and manufacturer is unaffected by the manufacturer's advertising then margins will be positively correlated, since the total profit to be split increases as the retail elasticity decreases.

profit maximizing behavior on the part of all actors, free entry, and Nash-Cournot equilibrium. For simplicity, only one product is explicitly considered when consumers are choosing stores. Thus the model is best thought of as applying to a branded item carried in virtually all stores, where the retailer is specialized enough that customers generally only buy that item. The more interesting and important case of general retailers, where an average customer may be expected to buy several items is treated in a companion paper.[9] Starting with only a single product has a side benefit; it demonstrates that the Steiner effect does not require inter-related demands or "traffic builder" effects for its existence. The latter are probably important in many kinds of retailing and would tend to strengthen any Steiner effect. The model, based on a fairly general market share theorem, may also have more general interest. In spite of its complexity, it is sufficiently tractable to yield some general results and seems well suited for simulation and perhaps even for direct empirical testing. It may well be useful for analyzing problems of entry barriers and price dispersion.

The Model

The Retail Stage: Consumers

In this simple model, consumers have only two choices to make: where to shop and, given the store and the price it charges, how much to buy. Consumers decide which of the R retail stores to shop at on the basis of relative price and convenience (near to home or work, parking facilities,

[9] See Lynch (1986). The extended model allows for the "traffic builder" effects of an HP product, but still assumes that all stores carry the same set of HP products. A truly satisfactory model would contain an explicit account of how retailer's choose the items they carry.

speed of checkout etc.). There is a maximum number of customers, N, in the retail market area. The number of customers store i attracts is equal to s_i times N, that is, s_i is its <u>market share</u> of customers. A store "market share function" is defined to be a continuous function of the prices charged by all stores,

$$s_i = f(p_1, p_2, \ldots p_R) \text{ for } i=1,..R \quad .$$

The individual shares must be nonnegative and add to one.

If we impose three additional conditions on this market share function, then it can be shown to be uniquely determined.

Assumption I. For all $s_j > 0$ and $R \geq 3$, the ratio of s_i to s_j is a function of p_i and p_j alone. In other words, the market share of store i relative to the market share of store j depends only on the prices at these two stores. At least three stores are required for this assumption to impose any restrictions on the form of the market share function.

Assumption II. The market share function, f, is homogeneous of degree 0 in all prices; that is, market shares are unaffected by equiproportional changes in all store prices.

Assumption III. s_i is a strictly decreasing function of p_i, holding all other prices constant.

The <u>only</u> function that satisfies these conditions is,

$$(1) \qquad s_i = \frac{m_i p_i^{-u}}{\sum m_k p_k^{-u}} \qquad , \text{for } i = 1, 2 \ldots R, \;\; u > 0$$

The appendix contains a brief history and a sketch of the proof of this theorem. [10] I will first briefly discuss the assumptions, then the meaning

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[10] The author first learned of this theorem from Jim Case (1983), and the proof sketched in the appendix follows Case. I subsequently learned that Luce (1959) had used an axiom similar to assumption I, which he called

of the market share function they imply.

The first assumption is the key to the theorem. It is clearly not always true and may well be implausible if applied to other types of market shares, for example, to products related in demand.[11] In this context, its use implies, for example, that if store 3 lowers its price, but stores 1 and 2 do not change theirs, the relative market shares of 1 and 2 will be unchanged. In conjunction with assumption III, it implies that stores 1 and 2 will lose market share in proportion to their existing market shares. I adopt the assumption here on the pragmatic basis that it is not demonstrably false and that it seems like a good place to start.

Assumption II, although common in economic models, is also made here more for mathematical convenience than out of logical compulsion. Although there could be no objection if all prices in the economy were included (for then it would simply amount to assuming that a change in units would have no effect on market shares), there can be an objection here, because a proportional change in the prices of the one item modeled, changes the average price of this item relative to all other items and that could conceivably affect shopping patterns.

The market share function given by equation (1) has several parameters: the exponent to which all prices are raised (-u) and the m_k's which multiply each store's price. These parameters can be readily interpreted in terms of Steiner's description of retailing given above.

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the "choice axiom," to prove a theorem much like the market share theorem given above. For further details, see the appendix.

[11] See Pfanzagl (1968, 180-184) for a critical discussion of this assumption and references to other theoretical and empirical work, some critical, some supportive, by economists and psychologists.

The parameter u is a measure of the HP brand's visibility. Logarithmic differentiation of (1) shows that the percentage change in market share with respect to a percentage change in own price is equal to (negative) u times one minus the store's market share.

$$(2) \quad -\frac{p_i}{s_i}\frac{\partial s_i}{\partial p_i} = u(1 - s_i)$$

Thus, the inter-store market share elasticity is directly proportional to u, or the product's visibility. The higher u, the more sensitive consumers are to price differences for that brand across stores and the better the brand serves as a traffic builder. As u approaches infinity, the retail model approaches the pure competitive case. As u approaches zero, the item becomes increasingly invisible or "blind" [12] and the model collapses into one in which price plays no role in allocating customers among stores. [13]

Market shares are affected by changes in a product's visibility parameter. The partial derivative of market share with respect to u is,

$$(3) \quad \frac{\partial s_i}{\partial u} = s_i[\sum s_k lg(p_k) - lg(p_i)]$$

If p_i is equal to the share weighted geometric mean of all the prices in the market, the expression in (3) is equal to zero. Thus, a store will gain market share with an increase in product visibility if its price is below the weighted geometric mean for all stores and, conversely, it will lose share if its price is above the mean.

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[12] See Steiner (1977) on the use of term "blind merchandise" in the retail trade.

[13] In a more general model which allows for many products stocked by each store, each with a different u, one can define an LP product to be an item with "u" or visibility equal to zero. See Lynch (1986).

I assume that u is a fixed parameter from the retailer's point of view, but that advertising by the manufacturer can increase its value. Steiner's successful advertising campaign makes the product more visible (though subject to diminishing returns).

The m_k's in equation (1) can be interpreted as measures of the non-price convenience or reputation aspects of the store. If all prices are equal then store i's market share is given by m_i divided by the sum of all of the m_j's. Thus, the higher a store's own m_i relative to the average of all the m_k's, the greater the non-price attractiveness of the store (more convenient location, more parking, faster checkouts, better reputation). If there are four stores in the market and one store has twice the "m" value of all the others, then it will garner 40% of the market compared to 20% for each of the others, if all charge equal prices. [14]

To simplify the argument, I now make the additional assumption that individual shoppers have identical demand functions with constant elasticity. Given that a store has been chosen, consumers choose quantity (q) according to a constant elasticity (e) demand function evaluated at the chosen store's price.

$$q = p_k^{-e}$$

Customers perceive the product to be homogeneous and the stores to be heterogeneous. In general, an aggregate "retail level" consumer demand curve will not exist in this model, because different stores will charge different prices and thus consumers do not all face the same price at the same time.

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[14] The "m_k's" are determined only up to a ratio scale.

The Retail Stage: Stores

Retailers are assumed to choose price to maximize their profit (π), given the prices of their rivals. The only variable costs in the short run are assumed to be the invoice costs of the items for sale (p_m stands for the invoice cost or manufacturer's price). All other costs (f_i) are fixed. Retailer i's problem is

$$\text{Max}\,\pi_i = s_i N[(p_i - p_m)q_i] - f_i$$

Taking the partial derivative of π_i with respect to p_i and equating it to zero, we obtain,

$$\frac{\partial \pi_i}{\partial p_i} = s_i N[q_i + (p_i - p_m)\frac{\partial q_i}{\partial p_i}] + N[(p_i - p_m)q_i]\frac{\partial s_i}{\partial p_i} = 0$$

By subtracting the rightmost term in the middle expression from both sides of the last equation and dividing through by N we find

$$q_i + (p_i - p_m)\frac{\partial q_i}{\partial p_i} = \frac{-1\,\partial s_i}{s_i\,\partial p_i}\,,\quad [(p_i - m)q_i]$$

Now divide both sides by $(p_i - p_m)q_i$ and multiply by p_i.

$$\frac{p_i - p_m}{p_i} + \frac{p_i\,\partial q_i}{q_i\,\partial p_i} = \frac{-1\,\partial s_i}{s_i\,\partial p_i}$$

The second expression on the left hand side is just the negative of the elasticity of final demand (-e) and the expression on the right hand side is the market share elasticity given by (2) above. Rearranging, we obtain

$$(4)\qquad \frac{p^*_i - p_m}{p^*_i} = \frac{1}{u(1-s_i) + e}$$

Equation (4) is analogous to the Lerner-Lange monopoly multiplier. It says that a profit-maximizing price (p^*) must be such that the percentage retail gross margin must be equal to the inverse of the elasticity of retail store demand. The elasticity of retail store demand is equal to the <u>sum</u> of the elasticity of consumer demand and the market share elasticity. Equivalently, retail price is equal to a multiplier times the brand's factory price. The multiplier is $k_i/(k_i-1)$, where k_i is the sum of final demand and the market share elasticities. [15]

An equilibrium is attained if a set of prices (p^*_i) can be found such that equation (4) holds for all R stores simultaneously with nonnegative store profits. In general, one cannot explicitly solve (4) for the equilibrium prices, but specific cases can be simulated. [16] The number of stores (R) can be made endogenous if free entry is assumed. For equilibrium, we require that the "marginal store" be such that its equilibrium gross margin times its customer share times the amount each customer buys be just sufficient to offset its fixed cost. For given fixed costs, the equilibrium

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[15] An interesting consequence of equation (4) is that the store with the highest market share will have the highest percentage gross margin, that is, there will be a strong positive correlation between market share and gross margins. Marion et al. (1979, chap. 4) report a significant positive correlation between retail grocery chain market shares in an SMSA and the cost of a "market basket" of groceries. Of course, if "mom and pop" and "convenience" stores had been included in the analysis, the results may well have been different. The model in this paper is silent on how to decide which stores compete in the "market."

[16] The symmetric case (m_i = m, all i), with identical prices at all stores, can be explicitly solved. This case is somewhat unsatisfactory, however, since the stores now are mathematically indistinguishable, raising the question of why u is not required to be infinite if consumers perceive stores to be identical in all respects, except the price charged. One answer; though market shares are equal at equal prices, stores are not perceived as identical to different customers because, for example, each store could have an equal pool of "nearby" customers.

number of stores will vary inversely with the product visibility parameter (u), that is, the more visible the product, the fewer the number of stores in equilibrium.

I now turn to the manufacturer.

The Manufacturing Stage

The manufacturer chooses price and advertising expenditure. He chooses his factory price (p_m) to maximize profits, given knowledge of his demand derived from the retail level.[17] The latter is given by

$$(5)\quad Q = N[\sum s^*_i q^*_i],$$

where s^*_i and q^*_i are functions of the optimal retail prices given by equations (4). The optimal factory price will again be given by the product of the "monopoly multiplier" and the manufacturer's marginal costs (mc). The multiplier, in turn, will be determined by the elasticity of the derived demand curve, which I proceed to derive. The derivative of Q with respect to p_m is

$$\frac{dQ}{dp_m} = N\left[\sum s^*_i \frac{\partial q^*_i}{\partial p^*_i}\frac{dp^*_i}{dp_m} + \sum q^*_i \frac{\partial s^*_i}{\partial p_i^*}\frac{dp_i^*}{dp_m}\right].$$

This expression simplifies dramatically, because the second term in the bracket on the right hand side is identically zero. The reason for the simplification is that <u>equilibrium market shares are unaffected by the</u>

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17 Note that the derived demand curve is well defined despite the nonexistence of an aggregate retail demand curve. The reason is that retailers are all assumed to face the same manufacturer price.

manufacturer's price. This can be seen by substituting the equilibrium prices from (4) in (1):

$$s^*_i = \frac{m_i(\{k^*_i/k^*_i-1\}p_m)^{-u}}{\sum m_j(\{k^*_j/k^*_j-1\}p_m)^{-u}}$$

and observing that p_m can be factored out of both numerator and denominator and cancelled. Hence, $s^*_i/\ p_m$ is zero for all p_m. Therefore, the elasticity of derived demand is,

$$\frac{-\ p_m\ dQ}{Q\ \ dp_m} = \frac{-N}{N\sum s^*_j q^*_j}\left(\sum s^*_i\ q^*_i\left[\frac{p^*_i \partial q^*_i}{q^*_i \partial p^*_i}\right]\ \frac{p_m\ dp^*_i}{p^*_i\ dp_m}\right)$$

or,

$$= e\sum_i\left[(s^*_i q^*_i/\sum_j s^*_j q^*_j)\ (p_m/p^*_i)\ (dp^*_i/dp_m)\right]$$

But since the product of the terms in the last two parentheses is always one for every i [equation (4)], and since the sum of the terms in the first parenthesis is then one, the final result is that the elasticity of derived demand as seen by the manufacturer is exactly equal to consumer elasticity of demand.[18] This is so, because each of the R retail prices will increase by the same percentage as the factory price increases. Thus, a 10% increase in the factory price will lead to a 10% increase in each retail price, which will result in a 10%xe fall in quantity sold. The elasticity of derived demand is completely independent of the inter-store elasticity, since equilibrium market shares are unaffected by a change in the factory price to

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[18] The result is easily generalized to handle constant retailing costs other than invoice costs and a variable elasticity consumer demand function.

all stores. Hence, the manufacturer's monopoly multiplier depends only on the elasticity of consumer demand.

Now suppose that by increasing his advertising budget, the manufacturer can both reduce e and increase u, the price sensitivity parameter. The Steiner effect will obtain if the increase in u is algebraically greater than e. For example, if initially both e and u equal 2 and R equals 5, then the average retail percentage gross margin will be about 28% and the manufacturer's gross margin will be 50%. If, through a successful advertising campaign, e falls to 1.5 and u rises to 5, then retail margins will fall to about 22% and the factory margin will rise to 67%.[19]

Conclusion

The model developed in this paper shows that if retail stores face downward-sloping demand curves and if advertising, by enhancing the visibility of a product, can increase the likelihood of consumers choosing stores on the basis of price comparisons while at the same time decrease the individual's elasticity of demand for the product, then products with high manufacturing margins can be expected to have low retail margins. This negative correlation of margins cannot occur in a Marshallian world where either competitive retailers face infinitely elastic demands or a monopoly retailer faces the consumer demand curve directly. This paper demonstrates that a monopolistically competitive model can produce predictions that are

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[19] This example indicates the unsatisfactory nature of the model for explaining the behavior of LP brands. For these, the manufacturing margin is low (reflecting a highly elastic factory demand), yet retail margins are high (reflecting the low visibility of the brand and hence its low market share elasticity). The high elasticity perceived by the manufacturer is a consequence of retailers switching freely among no-name brands on the basis of price, rather than a reflection of high elasticity of individual consumer demand elasticities. A fully satisfactory treatment of LP brands will require an explicit model of the retailer's choice of which items to stock.

qualitatively different than Marshallian models and so provides a basis for a crucial experiment to determine whether the interaction between retailing and manufacturing can be satisfactorily described in Marshallian terms.

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APPENDIX

A MARKET SHARE THEOREM

In this appendix I sketch a proof of the market share theorem stated in the text and provide some references to its earlier history, especially of the relation of assumption II or the "pairs only" axiom to Luce's "choice axiom" and Arrow's "independence of irrelevant alternatives" axiom.

Consider the case for three firms. Assumption II or the pairs only axiom implies,

$$(1)\quad s1=g(p1,p2)\cdot s2=g(p1,p3)\cdot s3$$

$$(2)\quad s2=g(p2,p3)\cdot s3$$

Substituting for s2 in equation (1) from equation (2), the last two equalities become,

$$(3)\quad g(p1,p2)\cdot g(p2,p3)=g(p1,p3) \text{ or}$$

$$(4)\quad g(p1,p2)=g(p1,p3)/g(p2,p3)$$

But since the l.h.s. of 4 is independent of p3, so is the r.h.s. Thus (4) must hold when $p3=1$, so we may define $g(p1,1) = f(p1)$, $g(p2,1) = f(p2)$ etc. Therefore the pairs only axiom implies,

$$(5)\quad g(p1,p2)=f(p1)/f(p2) \text{ etc.}$$

In conjunction with the "shares add to one" axiom we obviously get,

$$(6)\quad s1 = f(p1)/(f(p1)+f(p2)+f(p3)) \text{ etc.}$$

If, in addition, we assume that the shares are homogeneous of degree zero in all prices, then

$$(7)\quad s1/s2 = f(p1)/f(p2) = f(\lambda p1)/f(\lambda p2) = f(\lambda\sigma p1)/(\lambda\sigma p2)$$

or,

$$(8)\quad f(\lambda p1)/f(\lambda\sigma p1) = f(\lambda p2)/f(\lambda\sigma p2), \text{ for all } p1,p2,\lambda,\sigma > 0.$$

But the r.h.s. is independent of p1, so the l.h.s. must also be independent of p1. A similar argument shows that both sides are also independent of p2. We are free then to choose any values for p1 and p2. Set $p1 = 1$ and $p2 = 1/\lambda$. Then (8) becomes,

$$(9)\quad f(\lambda)/f(\lambda\sigma) = f(1)/f(\sigma) \text{ or,}$$

(10) $f(\lambda\sigma) = (1/f(1)\cdot f(\lambda)\cdot f(\sigma)$, for all λ, $\sigma > 0$.

A simple transformation $h(x) = (1/f(1))\cdot f(x)$ converts (10) into Cauchy's well known functional equation (see Aczel, equation (3) on p. 37 and the proof on pp. 38 - 39). The only nontrivial solution to this equation for positive arguments is,

(11) $f(pi) = cp_i{}^u$

I first came across assumption II and its role in the market share theorem in Case (1983), but I subsequently discovered that it is an immediate consequence of Luce's "independence" axiom (1959, p.6), which he used to formulate his probabilistic theory of choice. Assumption II is equivalent to Luce's lemma 3 (p. 9) which follows directly fromm his axiom. In discussing Arrow's "independence of irrelevant alternatives" axiom, Luce comments,

> "The actual gist of the idea is that alternatives which <u>should be</u> irrelevant to choice are in fact irrelevant, ... Exactly what should be taken as the probabilistic analogue of this idea is not perfectly clear, but one reasonable possibility is the requirement that the ratio of the probability of choosing one alternative to the probability of choosing the other should not depend upon the total set of alternatives available, i.e., the assertion of lemma 3. In this sense, then, we can say that axiom 1 is <u>a</u> probabilistic version of the independence-from-irrelevant-alternatives idea".

Luce later mentions (pp.44-45), but does not explicitly prove, that if in addtion to satisfying axiom 1, the scaling function is homogenous of degree zero then then the only solution is the power function as given in (11) above.

In our terms, Luce's axiom 1 amounts to assuming that the probability that store 1 is chosen when all three stores are available is equal to the probability that store 1 is chosen when 1 & 2 available, multiplied by the probability that the final choice will be among stores 1 & 2, when all three are available. It is thus similar to a probabilistic independence assumption (see Luce's lemma 2, p.7).