Measuring Brand Value in an Equilibrium Framework*

Avi Goldfarb
University of Toronto

Qiang Lu
University of Sydney

Sridhar Moorthy
University of Toronto

August 2007

*We thank Ronald Cotterill, Director of the Food Marketing Policy Center at University of Connecticut for providing us the data. Aviv Nevo, Scott Neslin, Don Lehmann, Brian Ratchford, Vithala Rao, K. Sudhir and, especially, Sachin Gupta offered many useful comments and suggestions, as did the editors and reviewers of this journal. The paper also benefited from presentations at University of Toronto, Columbia University, Dartmouth College, University of Connecticut, INSEAD, HKUST, Marketing Science Conference at Rotterdam 2004, the 2005 QME conference, and YCCI 2007. All remaining errors are ours alone. This research was supported by Social Sciences and Humanities Research Council of Canada Grant # 410–2005–0824 to the third author.

Abstract

We propose a structural approach to measuring brand (and sub-brand) value using observational data. Brand value is defined as the difference in equilibrium profit between the brand in question and its counterfactual unbranded equivalent on search attributes. Our model allows us to make this computation rigorously, taking into account competitors' and retailers' reactions in the real and in the counterfactual situations. We illustrate our method using quarterly city-level data on ready-to-eat breakfast cereals, and compare our brand value estimates with those obtained from previously used reduced-form methods. A key advantage of our methodology is that it provides estimates of the value of brands to firms—manufacturers and retailers—taking into account the brand's value to consumers as well as its impact on firm decisions.

1 Introduction

Brand equity is perhaps the single most important asset that marketing contributes to a firm. In this paper we develop procedures for measuring brand value in an equilibrium framework using observational data on sales, prices, product attributes and advertising.[1]

In our framework, brand value is the extra profit earned by a brand over and above what it would have earned based on its search attributes. Search attributes are the attributes that the consumer can see for herself before buying the product (Nelson 1970; Ford, Smith and Swasy 1990). The distinguishing feature of our approach is that we view the excess profit earned by a brand as a comparison between two *equilibria:* the equilibrium with the brand as it is, and a counterfactual equilibrium where the brand has "lost" its brand equity but retained its search attributes. In both equilibria the firm is assumed to be doing the best it can using the brand resources it has at its disposal—the difference is in the resources. Thus our approach tracks the full implications of brand equity, its impact on the demand side—on consumers' brand choices—as well as its impact on the supply side—on manufacturer and retailer pricing decisions. This contrasts sharply with the previous literature in brand equity/value estimation which ignores firm decision-making all together.[2]

Because we use observational data, our brand value estimates reflect the actual choices of consumers, manufacturers and retailers, not what they reported in surveys. And because we interpret the observed data as the product of an equilibrium, we take into account the interactions among consumers, manufacturers and retailers, and recognize the endogeneity of prices (Villas-Boas and Winer 1999; Chintagunta 2001; Shugan 2004). Our structural model allows us to (a) separate the effect of brand equity from other influences on sales such as the product's search attributes, prices, and advertising, (b) simulate the consequences of a brand losing its equity on the decisions of consumers, manufacturers, and retailers, and (c) measure brand and sub-brand values from both the manufacturer's and the retailer's perspectives. This is the first paper to measure brand *and* sub-brand values from observational transaction data. It is also the first paper to report brand and sub-brand values from the *retailer*'s perspective. As we discuss later in the paper, brand values for a retailer may be quite different from brand values for a manufacturer.

We illustrate our methodology on ready-to-eat breakfast cereal brands. From the IRI Infoscan Database, we have data on the quarterly market shares and prices of a variety of cereals in several U.S. cities over 20 quarters. In addition, we have data on the search attributes of the cereals, quarterly national advertising expenditures, and city demographics.

[1] By brand equity we mean what the brand does for the consumer; by brand value we mean what the brand does for the firm. The two are obviously related—a brand can't do much for the firm if it doesn't do much for the consumer. This paper is concerned with brand value estimation, but as a by-product we get brand equity estimates as well.

[2] Kamakura and Russell (1993), Swait et al. (1993), Park and Srinivasan (1994), and Agarwal and Rao (1996) are primarily concerned with consumers and brand equity estimation. Ailawadi, Lehmann and Neslin (2003) and Simon and Sullivan (1993) are primarily concerned with firms and brand value estimation without modeling firm behavior. The literature can also be distinguished on whether the techniques rely on consumer survey data (Swait et al. 1993; Park and Srinivasan 1994; Agarwal and Rao 1996; Srinivasan, Park, and Chang 2005) or observational marketplace data (Kamakura and Russell 1993; Simon and Sullivan 1993; Ailawadi, Lehmann and Neslin 2003). For a comprehensive review of the literature, please see Ailawadi, Lehmann and Neslin (2003).

Using these data, we estimate brand and sub-brand values of the major cereal brands—Kellogg's, General Mills, Post, and Quaker—relative to Nabisco, and compare them with those obtainable from two existing reduced-form methods: Ailawadi, Lehmann, and Neslin's (2003) revenue-premium method, which calculates brand value as the difference between brand revenues and private-label revenues, and hedonic regression (Rosen 1974; Holbrook 1992), which estimates brand value as a price premium after controlling for various non-brand factors. There are similarities and differences between our estimates and those from these alternative methods, suggesting both validity and consequentiality for our equilibrium approach. For instance, while the top two brands in cereal are ordered the same in all methodologies, the rankings of the bottom three differ. The gaps in brand values are also different. Two points are worth noting about these results. First, the difference in measures: profits in our case, price or revenue premiums in the others. Second, the difference in modeling approaches: structural in our case, reduced-form in the others. Thus, while we think that our profit premium approach has better foundation than price or revenue premiums, our methodology provides price and revenue premiums as a by-product, and it is interesting to see if our structural estimates of these quantities differ from their reduced-form estimates. Indeed, they do. For instance, price premiums computed structurally are uniformly lower than price premiums computed by hedonic regression, and the differences are large enough to change the ordering of Post vis-a-vis Quaker.

More important than the estimates themselves, our structural approach reveals interesting insights in the ways brand equity works to generate value at the firm level:

1. Some of a brand's value may come from its ability to signal the experience attributes of a product—things a consumer can't see before purchasing the product (Nelson 1970, Ford, Smith, and Swasy 1990). Controlling for experience attributes in the regression—as in Kamakura and Russell (1993), Park and Srinivasan (1994), and Kartono and Rao (2005)—amounts to assuming that even without the brand consumers will know these attributes before purchasing the product. To the extent brands are differentiated on these attributes, this assumption will influence measured brand value. Using data on an experience attribute of cereals—their "mushiness" in milk—we show that Post's and Quaker's relative brand values fall significantly when we include mushiness in the regression. These brands are relatively "unmushy" in milk, and by including mushiness in the regression we usurp brand's role in providing this information to consumers.

2. Brand equity gives pricing power to a firm, and its loss is inevitably accompanied by a wholesale price drop. Naturally, the largest price drops are suffered by the brands that have the most to lose—the strongest brands.

3. Our simulation experiments provide an interesting commentary on retail pass-through. The usual story on pass-through is that retailers do not pass on all of the price decreases they get at wholesale (Chevalier and Curhan 1976; Moorthy 2005). But these findings have been documented in settings where brand equities are not changing. In our experiments, brand equity losses are the triggering events. Wholesale prices

fall, but this is often accompanied by a retail price drop of an even greater magnitude. Retailer margins get squeezed. Seen in pass-through terms, retailer pass-through on wholesale price reductions stemming from brand equity loss are often greater than 100%.

4. When a brand loses its equity, it is not just brand switching that may occur. Category sales may fall as well. For example, people may only like a particular brand of cereal, and when that brand loses equity they may not buy cereal at all. Said differently, brand equity affects market shares within the category as well as category sales.

5. Manufacturers get more value for their brands than retailers. This may reflect the specific structure of the cereal industry. Generally speaking, retailers, being consumer-facing ought to value brands more; however, retailers derive profits from many more brands than manufacturers, and have more ways to maneuver. In categories with many brands, no single brand is likely to be very valuable to them.

The remainder of this paper is organized as follows. Section 2 presents our framework for estimating brand value in the context of an oligopolistic category in which multiple manufacturers sell through common retailers. Section 3 describes our data set and empirical methodology. Section 4 provides estimation results. Section 5 discusses limitations and Section 6 concludes.

2 Framework

The starting point for any measurement of brand value is the idea that brands are productive assets for a firm, just as buildings and machinery are. They are assets in the sense that they are fixed in the short-term, and produce long-term benefits. For a brand to become productive it must be built, i.e., develop brand equity, a process that takes time and money. Interest in brand value estimation comes precisely from the fact that once brand equity has been developed, it doesn't deplete itself instantly, continuing to deliver benefits over a period of time even after the investments that created it have been withdrawn.

The productivity of brand assets comes from both the demand and supply sides. On the demand side it comes from the fact that an established brand encapsulates all of the marketing that has gone on for the brand since its inception, plus all of the experiences that consumers have accumulated since the brand was introduced. Now, as a result, people are aware of the brand, it is familiar (Hoyer and Brown 1990), has a personality (Aaker 1997), evokes emotional responses (Keller 2003; p. 90), and in general serves as a vehicle for recalling all the advertising-induced imagery that marketing has associated with it. On the functional side, an established brand serves as a signal of quality for the experience and credence attributes provided by the product—things that the consumer cannot see before buying the product (Nelson 1970; Wernerfelt 1988; Ford, Smith and Swasy 1990; Erdem 1998). This is true both on the first purchase as well as on repeat purchases. The bonding and reputational mechanisms by which brands provide these signaling functions are the subjects of papers by Klein and Leffler (1981), Shapiro (1983), Milgrom and Roberts (1986), and Wernerfelt (1988); for a review see Erdem and Swait (1998).

The demand-side role of brands is well articulated in the literature. Starting with Allison and Uhl (1964), a long series of studies has noted the different responses of consumers in blind versus branded tests of products. In the Allison-Uhl study, consumers' overall opinions of beers were higher, by as much as 21%, when they were tasted branded than when they were tasted blind. Since the consumers were rating the beers immediately after tasting them, brand's role here was not one of signaling product performance. Rather, the familiarity of the brand, the imagery associated with it, and perhaps the brand's personality were responsible for enhancing consumers' ratings of the beers. Farquhar (1990) finds that in "matched product tests with corn flakes cereal, choice increased from 47 percent when the brand name was not known to 59 percent when the Kellogg's name was identified." Sullivan (1998) shows that the market prices of twin automobile brands—automobiles described by *Consumer Reports* as identical or "essentially similar"—are different in the used-car market. For example, a Chevy Nova sold for 35% less than an identically-specified Toyota Corolla of the same vintage, even though both were made in the same factory in Fremont, California. Smith and Park (1992) find that brand extensions have a greater effect on market share for experience goods than for search goods. This is presumably because "with search goods, consumers can obtain useful information about quality through visual inspection and thus the importance of inferences based on a known brand name is reduced."

The supply-side effects of brand equity are less well recognized in the brand valuation literature, a deficiency we wish to correct in this paper. The basic point is easy enough to see. Consider a monopoly seller selling directly to consumers. Its demand function is $D(\beta_b; x; p)$, where β_b represents the demand-side effects of brand equity (discussed in the previous paragraph), x the search attributes of the product, and p price, and it maximizes a profit function of the form

$$\Pi = (p - c)D(\beta_b; x; p) - F, \tag{1}$$

with respect to p. Here c and F are marginal and fixed costs, respectively, and we are assuming that x, the search attributes, and β_b, the effect of brand on demand, are not changeable in the short-run. Assuming that the profit function satisfies the requisite differentiability and concavity conditions, and interior solutions exist, the profit-maximizing choice of p is determined by the first-order condition

$$(p - c)\frac{\partial D(\beta_b; x; p)}{\partial p} + D(\beta_b; x; p) = 0. \tag{2}$$

Clearly, the firm's optimal choice of p must be a function of β_b. In other words, if demand is a function of brand equity, then the variables supplied by the firm—price and other variables that affect demand—must also be. The firm with brand equity "rides" on it and sets other variables that affect demand recognizing that they will work in conjunction with brand equity. For example, in the aforementioned study of Sullivan (1998), owners of Toyota Corollas took advantage of the superior brand equity of Toyota by pricing their cars higher than Chevy Novas of the same vintage and specifications. In other words, endogeneity is a built-in feature of demand estimation for brands.

If we treat brand assets as analogous to other business assets, then they must be evaluated analogously as well. From financial theory, business assets are evaluated on the basis of the discounted net present value of cash flows they produce.[3] The starting point for an evaluation of brand value must therefore be the assessment of profit flows *due to* brand.[4] What this really means we discuss next.

2.1 Definitions and counterfactuals

Brand value, in almost any conception, involves a comparison between a factual and a counterfactual. As Keller (2003, p. 42) writes:

> Although a number of different specific views of brand equity may prevail, most observers are in agreement that brand equity should be defined in terms of marketing effects that are uniquely attributable to a brand. That is, brand equity relates to the fact that different outcomes result from the marketing of a product or service because of its brand than if that same product or service had not been identified by that brand.

The central conceptual problem in measuring brand value lies in defining the counterfactual, i.e., in specifying those "different outcomes" that would result if the "same product or service had not been identified by that brand." What happens to a product when it is shorn of its brand elements? Answering this question is not as straightforward as it may seem. It means taking a position on what things a brand should get credit for and what it shouldn't get credit for. Measured brand value will be affected by these decisions. For instance, if we assume that a product shorn of its brand elements loses "everything"—awareness, imagery, attributes—and hence zero sales, then we are perhaps taking an overly strong position on the importance of branding. After all, even "no name" brands achieve sales and sometimes succeed in the marketplace. Moreover, taking this position precludes the need to estimate brand value: by definition, every brand's value will be its current profits. At the other extreme, one could assume that a product loses nothing when it goes from branded to unbranded. This position, too, doesn't make much sense: every brand's value would be zero by definition.

What assumptions are more reasonable? A product shorn of its brand elements cannot possibly be the beneficiary of any of the imagery that marketing has associated with the

[3]The Financial Accounting Standards Board's new standard for accounting for goodwill and indefinite-lived intangible assets, FAS 142, recommends this criterion.

[4]If we had reliable means of extrapolating from current profits to future profits, then it would be a simple matter to capitalize these profits into a net present value of the brand. For example, if current period profit flows π are expected to continue into the indefinite future, then brand value in NPV terms will be π/r where r is the cost of capital. Estimating the future profit potential of a brand is not straightforward, however. Besides the usual difficulties attendent on prediction of future revenues and costs—product category growth or decline, entry and exit of competitors, changes in technology—there is also the particular problem of assessing the leveraging potential of a brand—line extensions, brand extensions, and co-branding. Quantifying these opportunities and threats often requires making speculative assumptions. We refrain from doing so here, choosing to rest our brand value estimates on current period profits grounded in observed data.

brand. This includes user imagery, usage imagery, emotional benefits, status benefits, brand personality, etc. For example, a carton of Kellogg's Frosted Flakes without its distinctive branding elements—name, logo, pictures, color—cannot possibly evoke the imagery associated with Tony the Tiger ("They're Gr-r-reat!"). An unbranded product also cannot, in the short run, signal the attributes that are hidden from the consumer at the time of purchase. For example, a carton of Kellogg's Frosted Flakes without its distinctive branding elements cannot inform consumers about how the cereal will taste, or how "mushy" it will be with milk. On the other hand, it seems reasonable to assume that the product even in an unbranded state retains its search attributes—the attributes that a consumer can see for herself without using the product—and generates enough awareness to get into consumers' consideration sets—assuming otherwise would imply brand value equal to current brand profits, as noted above. For example, in the case of Kellogg's Frosted Flakes, even absent the Kellogg's brand elements, government-mandated disclosure requirements mean that the consumer can still see that a 3/4 cup serving size of the cereal has 120 calories, 12g of sugars, etc. In short, it seems reasonable that a brand should get credit only for the imagery associated with it and for signaling its experience and credence attributes.[5][6]

It is thus that we arrive at our definition of brand value as the equilibrium profit earned by a brand in its branded state minus the equilibrium profit it would have earned if it were unbranded but considered and retained its search attributes. Figure 1 represents this framework.

2.2 Measuring brand value in an oligopoly with a common retailer

In real-world consumer goods markets, manufacturers typically have competitors and distribute through common retailers. Most brand value estimations are carried out in such institutional contexts. In this section we describe how we can implement our framework in

[5] The previous literature on brand equity/value measurement doesn't discuss these issues, but implicitly takes a variety of positions. Park and Srinivasan (1994) define brand equity as "the difference between an individual consumer's overall brand preference and his or her multiattributed preference based on objectively measured attribute levels." This definition implies the following counterfactual: the brand upon losing its equity retains its objectively measured attribute levels, including those of experience attributes. Thus, in their toothpaste application, they assume that brands retain their *Consumer Reports*-reported levels of "antiplaque," "cavity prevention," "teeth whitening," and "breath freshening" in their unbranded states. If consumers use brands to infer such attributes, the effect is to underestimate brand equity. Swait et al. (1993) define brand equity as the "equalization price"—the price at which a consumer will be indifferent between buying versus not buying the brand. This definition implicitly gives credit to the brand for everything: brand elements as well as *all* product elements—including search attributes. Brand equity will be biased upward. Kamakura and Russell (1993) offer two measures: brand value and brand intangible value. The former, defined as the "value assigned to the brand by the particular segment after adjusting for situational factors (short-term price and recent advertising)" is analogous to Swait et al.'s (1993) definition. The latter they define as the part of brand value not explained by "physical attributes," which, in their detergent application, were brightness, whiteness and stain removal—all experience attributes. So their brand value measure over-reports brand equity and their intangible brand value measure under-reports brand equity.

[6] An alternative way to think about these issues is via the costs of brand re-building. In the long-run one might argue that the brand will not stay in an unbranded state; it will re-brand itself and begin to deliver the same benefits that it did in its original branded state. But this transformation will not happen costlessly, nor immediately. The fixed costs of rebuilding the brand over time must be accounted for (otherwise we are once again led to nonsensical positions: the product in its unbranded state is delivering the same benefits as in its branded state, with no additional cost, hence brand value must be zero). The econometrician has better tools for estimating short-term counterfactual demand than long-term counterfactual fixed costs. So as a practical matter, it is better to focus on the demand side.

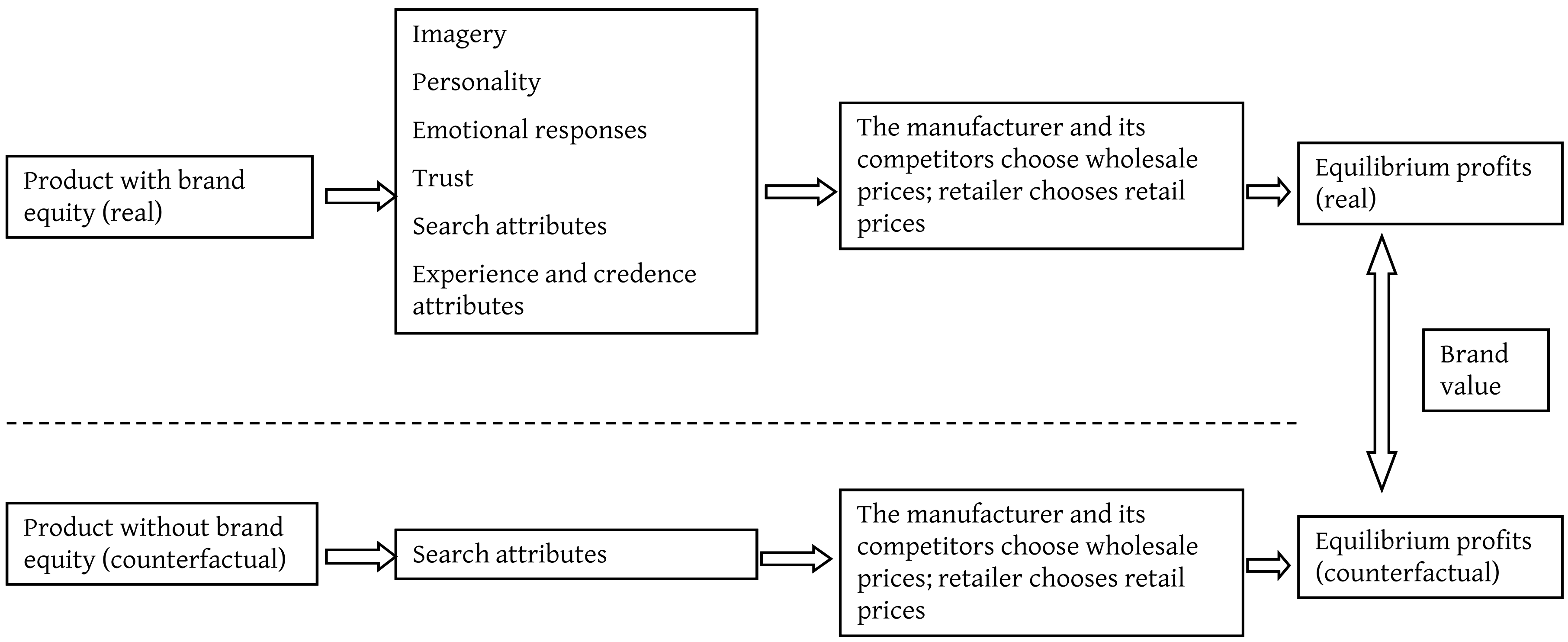

Figure 1: A framework for measuring brand value

these real-world situations.

A basic question arises right away. With manufacturers distributing their products through retailers, whose perspective should we take when estimating brand value, the manufacturer's or the retailer's? Brands are valuable to both. We could define brand value based on the manufacturer's profit, retailer's profit, or even channel profit—the sum of manufacturer's and retailer's profits. With retailer profit, since retailers carry multiple brands in each category, category profit becomes the profit criterion. What does a particular brand's value mean for such a retailer? We define a brand's value to a retailer as the contribution of the brand to the retailer's equilibrium *category* profit. In our factual-counterfactual framework, this means subtracting equilibrium category profit in the counterfactual from the equilibrium category profit in the factual, recognizing that not only will the wholesale and retail prices of the brand in question change between the two equilibria, but also the wholesale and retail prices of other brands in the category.

The supply-side effects of brand equity extend horizontally and vertically when manufacturers have competitors and distribute through intermediaries. For example, if a manufacturer raises its wholesale price to take account of its superior brand equity, then its competitors may follow suit—or they may lower their prices, recognizing their weaker brand equities. Vertically, manufacturers' actions affect retailers who buy from them and resell to consumers. For example, an increase in a manufacturer's wholesale price may trigger a retail price increase by a retailer on that brand, as well as on other brands in the category (Moorthy 2005). The equilibrium concept we use to account for these interactions has the manufacturers behaving as Stackelberg leaders with respect to the retailer, and as Nash players among themselves.[7] As is common in the literature, we assume no store competition and no side payments (allowances) from the manufacturer to the retailer. For each brand, two equilibria need to be computed: one the real-world equilibrium with the brand as it is, and the other a counterfactual equilibrium with the brand having "lost" its equity.

Consider a product category with B brands offered by B different manufacturers. The B manufacturers distribute their products through a common retailer (cf. Sudhir 2001, Villas-Boas and Zhao 2005). The manufacturers set their wholesale prices first; the retailer takes the wholesale prices as given and sets retail prices. Each brand b is available in J_b varieties (e.g., the Kellogg's brand available as Rice Krispies and Corn Pops), with each variety characterized by a search attributes vector, $x_{b_{J_b}}$. Let $D_{b_j}(\beta; x; p)$ denote brand-variety b_j's demand as a function of the entire array of brand equities $\beta_b = (\beta_{b_1}, ..., \beta_{b_B})$, search attribute vectors $x = (x_{1_1}, ..., x_{B_{J_B}})$, and retail prices $p = (p_{1_1}, ...p_{B_{J_B}})$.[8]

[7] There is a separate literature devoted to uncovering market structure in an oligopoly (Nevo 2001; Villas Boas 2007), and our intention is not to contribute to that literature. Still, brand value estimates are obviously sensitive to market structure assumptions, so any brand value estimation intended for application must carefully evaluate the robustness of the estimates to alternative market structure assumptions. We have estimated our model under the following alternative market structure assumptions: (1) colluding manufacturers behaving as Stackelberg leaders with respect to a common retailer, and (2) individual sub-brands behaving as Stackelberg leaders with respect to a common retailer. The first gave estimated average gross margin for manufacturers to be 56%, whereas the second gave 38%. The estimated average gross margin under our maintained assumption was 42%. According to Cotterill (1996, Table A4), manufacturer margins in the cereal industry are 44%. Therefore, we focus on the market structure assumption in the text.

[8] To avoid clutter we are omitting advertising from the demand function even though it is considered in the actual estimation that follows.

The retailer chooses retail prices of each product j to maximize category profit, taking as given the wholesale prices $w = (w_{1_1}, ...w_{B_{J_B}})$ set by the manufacturers.[9] In other words, the retailer's problem is

$$\max_p \Pi_r = \sum_j^{B_{J_B}} [(p_{b_j} - w_{b_j}) D_{b_j}(p)] \tag{3}$$

where $D_{b_j}(p)$ represents the longer $D_{b_j}(\beta_b; x; p)$. We have omitted fixed costs because in a comparison between factual and counterfactual they don't change. Assuming the requisite concavity and differentiability of the profit functions, and the existence of interior solutions, this maximization exercise leads to the following first-order conditions:

$$D_{b_j}(p) + \sum_{b_r}^{B_{J_B}} (p_{b_r} - w_{b_j}) \frac{\partial D_{b_r}(p)}{\partial p_{b_j}} = 0, \qquad j = 1, ..., J_b,\ b = 1, ..., B \tag{4}$$

Note that the retailer takes into account how product j's price affects both the profit from product j and the profits from all other products. Solving (4) yields the Bertrand-Nash equilibrium in prices. In matrix form, this can be written as

$$p^* - w = [\Omega^{p*}]^{-1} D(p^*) \tag{5}$$

where $\Omega^{p*}_{jr} = I \times D^{p*}_{jr}$, in which, I is the identity matrix, and $D^{p*}_{jr} = -(\partial D_{b_r}(p^*)/\partial p_{b_j})$.

Given cross-sectional/time-series data on demand, observable attributes x, and retail prices p (and data on suitable instruments to control for the endogeneity of p) we can estimate the demand function $D_{b_j}(p)$. This in turn gives us D^{p*}_{jr}. Substituting in (5) we can then impute the unobserved wholesale prices w.

Manufacturers take their endowments of brand equities and observable attribute vectors as a given in the short-term, and choose prices for each of their varieties so as to maximize their profits. In other words, each manufacturer solves

$$\max_w \Pi_b = \sum_{j \in J_b} [(w_{b_j} - mc_{b_j}) D_{b_j}(p)] \tag{6}$$

where mc_{b_j} is marginal cost of production which varies at the product level j. Once again we omit fixed costs on the assumption that they don't change between factual and counterfactual. The first-order conditions are:

$$D_{b_j}(p) + \sum_{r \in J_b} (w_{b_r} - mc_{b_r}) \sum_m^{B_{J_B}} \frac{\partial D_{b_r}(p)}{\partial p_m} \frac{\partial p_m}{\partial w_{b_r}} = 0, \qquad j = 1, ..., J_b,\ b = 1, ..., B \tag{7}$$

Solving (7), we can get the following in matrix form:

$$w^* - mc = [\Omega^{w*}]^{-1} D(p^*). \tag{8}$$

[9] This model can be extended to apply to short-term promotional activities such as in-store displays.

where

$$\begin{aligned}
\Omega_{jr}^{w*} &= \Omega_{jr}^{I} \times D_{jr}^{w*}, \\
\Omega_{jr}^{I} &= \{ \begin{matrix} 1 & \exists b : r, j \in J_b \\ 0 & \text{otherwise} \end{matrix}, \text{and} \\
D_{jr}^{w*} &= -\sum_{m}^{B_{J_B}} \frac{\partial D_{b_r}(p)}{\partial p_m} \frac{\partial p_m}{\partial w_{b_j}}
\end{aligned}$$

From the retailer's first-order conditions of profit maximization, (5), we can derive $\partial p_m / \partial w_{b_r}$, which when substituted in the above expression for D_{jr}^{w*} yields:

$$D_{jr}^{w*} = -[\frac{\partial D_{b_r}}{\partial p_1} .... \frac{\partial D_{b_r}}{\partial p_{B_{J_B}}}] \Xi^{-1} \begin{bmatrix} \frac{\partial D_{b_j}}{\partial p_1} \\ ... \\ \frac{\partial D_{b_j}}{\partial p_{B_{J_B}}} \end{bmatrix} \tag{9}$$

where Ξ is B_{J_B} by B_{J_B} matrix with kn'th element:

$$\Xi_{kn} = \frac{\partial D_k}{\partial p_n} + \frac{\partial D_n}{\partial p_k} + [p^* - w] \begin{bmatrix} \frac{\partial^2 D_1}{\partial p_k \partial p_n} \\ ... \\ \frac{\partial^2 D_{B_{J_B}}}{\partial p_k \partial p_n} \end{bmatrix} \tag{10}$$

Now (5) and (8) yield mc, the vector of marginal costs of the different manufacturers. Manufacturer b's profits are then

$$\Pi_b^* = \sum_{j \in J_b} [(w_{b_j}^* - mc_{b_j}) D_{b_j}(p^*)],$$

where the superscript * indicates equilibrium values.

To calculate brand value we need the profit that the brand would have if it were unbranded but retained its search attributes. For that we need to simulate the counterfactual equilibrium. Suppose brand b is the one in the counterfactual—all other brands retain their brand equities. We start with a new set of demand functions $D_{b_j}^{b0}(\beta_{b_1}, ..0.., \beta_{b_B}; x; p)$ which are the same as the ones above except that $\beta_{b_j} = 0$; the superscript $b0$ indicates that it is brand b that has "lost" its brand equity in this counterfactual experiment. As discussed above, the search attributes of the product do not change in the move from the factual to the counterfactual. Nor, we assume, do the marginal costs: even without the brand, the product still has the same ingredients, the same design, and the same manufacturing process. Other brands remain the same in terms of their brand equities and search characteristics, but their demand functions are affected by the change in firm b's brand equity. All manufacturers may adjust their wholesale prices, and the retailer may follow with a new set of retail prices for each of the brands in the category. The first-order conditions governing these adjustments are the same as (4) and (7) except $D_{b_j}(p)$ is replaced by $D_{b_j}^{b0}(p)$. The new equilibrium is:

$$p^{b0*} - w^{b0*} = [\Omega^{p^{b0*}}]^{-1} D^{b0}(p^{b0*}). \tag{11}$$

$$w^{b0*} - mc = [\Omega^{w^{b0*}}]^{-1} D^{b0}(p^{b0*}). \tag{12}$$

Solving (11 and 12), and substituting in the manufacturer's profit function yields the counterfactual equilibrium profit of manufacturer b:

$$\Pi_b^{b0*} = \sum_{j \in J_b} [(w_{b_j}^{b0*} - mc_{b_j}) D_{b_j}^{b0}(p^{b0*})].$$

Brand value for the manufacturer is then

$$\Pi_b^* - \Pi_b^{b0^*} \tag{13}$$

For the retailer, the counterfactual profit includes the lost profits from brand b plus the potential increase in sales of other brands. Therefore the value of brand b to the retailer is:

$$\sum_{\widetilde{B}=1}^{B} \sum_{j=1}^{\widetilde{B}J_{\widetilde{B}}} [(p_{b_j} - w_{b_j}) D_{b_j}(p^*)] - \sum_{\widetilde{B}=1}^{B} \sum_{j=1}^{\widetilde{B}J_{\widetilde{B}}} [(p_{b_j}^{b0*} - w_{b_j}^{b0*}) D_{b_j}^{b0}(p^{b0*})]. \tag{14}$$

2.3 Identification

The most fundamental identification issue in using observational data to estimate brand value is how to identify the outcomes that will result in the counterfactual equilibrium given that the counterfactual is never observed. There are two aspects to this question. One, how to estimate a demand function for a brand in its unbranded state.[10] Two, how to estimate what the firm would do in the counterfactual state, i.e., the counterfactual equilibrium.

We estimate a demand function for a brand in the counterfactual situation by borrowing from the sales performance of a real brand. (This is the sense in which we need to assume that the brand in its counterfactual state continues to be considered.) Of course, real brands do have brand equities, so the simulation can never reveal absolute brand values, only relative brand values.[11] The choice of comparison brand determines how close we come to estimating absolute brand values. If there is a generic brand in the category which can be used as the baseline brand, then we come close, but even generic brands have equity. To illustrate how the simulation estimates counterfactual demand, consider a product category with three brands, B_1, B_2, and S, the first two being the brands whose values are being estimated, and S the baseline brand. In the demand function we will have two dummy variables for B_1 and B_2 with (0, 0) on these dummy variables representing S. Note that $B_1$and B_2 would continue to retain the search attributes that characterize their product varieties—only the brand is changing in the simulation. Thus, if B_1 has two product varieties with search attribute vectors x_{11} and x_{12} , B_2 has x_{21} and x_{22} , and S has x_{S1} and

[10] This is not a problem with survey-based techniques like conjoint analysis because the counterfactual can actually be created in the laboratory: the survey respondent is simply presented with a product profile without a brand name and asked to rate it.

[11] Arguably, this is no great loss. After all, absolute brand values are of limited value. A manager is interested in comparing her brand's value against a competing brand's value, not in the number itself.

x_{S2} (x_1 and x_2 need not be the same as x_S), then the counterfactual with respect to B_1 creates the industry (S, x_{11} , x_{12}), (B_2, x_{21} , x_{22}), and (S, x_{S1} , x_{S2}).

Having estimated a demand function for the brand in its counterfactual state, there still remains a question of how to estimate the counterfactual equilibrium, i.e., the prices that will be chosen in the counterfactual situation. A key assumption becomes necessary: that the product in its unbranded state retains its *marginal* production costs. To illustrate with the monopoly model above, if we knew the monopolist's marginal cost c in the real situation and we assumed that it would be the same in the unbranded state, then we can go to the first-order condition, (2), plug in $D(0; x; p)$, c and $\partial D(0; x; p)/\partial p$ (having estimated the counterfactual demand function as above), and solve for p^0, the counterfactual equilibrium price. Knowing demand, price and marginal cost in both the factual and the counterfactual states, brand value can then be estimated from (1).

Generally, however, marginal costs are not known to the econometrician. But this turns out not to be a problem. In the New Empirical Industrial Organization (NEIO) framework, marginal costs can be estimated from data on demand and prices using the firms' first-order conditions (Nevo 2000). To see this, consider equation (2), the first-order condition in the monopoly model. From cross-sectional and/or time-series data on D, p, and x (as in the cereal data) we can estimate $D(\xi_B; x; p)$, the demand function, and its partial derivative, $\partial D(\xi_B; x; p)/\partial p$. Substituting in (2), we can solve for c, the marginal cost in the real situation.

To summarize the discussion so far, the empirical strategy for estimating brand value will be as follows:

1. Using data on prices, search attributes, advertising, and sales, estimate the demand functions, D. This yields the demand-derivatives matrix Ω^p.

2. Using these estimates, and the equilibrium conditions, back out the wholesale prices first, and then the marginal costs of production.

3. For each brand $b = 1, ..., B$, simulate the counterfactual demand by setting β_{b_j} equal to zero in D. This yields the demand function D^{b0}, and the demand-derivatives matrix Ω^{pb0}.

4. For each brand $b = 1, ..., B$, using Ω^{pb0}, and the marginal costs previously estimated in step (2), solve for the counterfactual equilibrium prices, wholesale and retail.

5. Calculate brand value as the difference between the real and simulated counterfactual profits using (13) and (14).

3 Data and empirical procedures

3.1 Data

We illustrate our methodology using aggregate data on ready-to-eat breakfast cereals from the IRI Infoscan Database.[12] These data have been previously used by Nevo (2001), to which we refer for more details. Essentially, the data set contains quarterly market shares and prices for various cereal brands in up to 65 major U.S cities from the first quarter of 1988 until the last quarter of 1992. No data on promotional activities are available. Our estimates are based on the top 25 cereals nationally in the last quarter of 1992, listed in Table 4 below. Each of these top-selling cereals is associated with a brand name (General Mills, Kellogg's, Post, Quaker, and Nabisco) and a sub-brand name (Honey Nut Cheerios, Life, Special K, etc.). A brand may have several sub-brands. For example, Kellogg's has, besides Special K, Crispix, Rice Krispies, and several other sub-brands. Nabisco, however, has just one, Shredded Wheat. While both generic and store brands are present in the category, the data pertaining to them are not usable. This is because while the national brands have uniform characteristics in all cities, the generic and store brands do not; they are not present in all city-markets, and when present, vary from city to city because of local sourcing.

We supplement the IRI Infoscan data with data from a variety of other sources. Quarterly national advertising expenditures by each cereal brand are obtained from Leading National Advertisers. Data on the search attributes of cereals were collected online and in local supermarkets from cereal boxes; these include data on sugar content, fiber content, calories from fat, total calories, and whether the cereal is primarily intended for children, adults, or the whole family. We also have information on an experience attribute of cereals: "mushiness" in milk, as measured by Nevo (2001). We will include this in one of our regressions to show the consequences of controlling for experience attributes when theory suggests that one shouldn't. Finally, city-level demographic data on income, age, household size, and population under 16 years of age ("child") were drawn from the March Current Population Survey from each year.

Market shares are measured as a function of potential market size, defined to be one serving per capita per day. Prices are defined as dollar sales divided by number of servings sold; these were deflated using regional urban consumer price indices from the Bureau of Labor Statistics. Table 1 provides descriptive statistics for the cereal data set.

We now describe how we implement our estimation strategy with our data.[13]

3.2 Estimation procedure

We follow the basic procedures for estimating oligopoly models from aggregate data described in a series of papers: Berry (1994), Berry, Levinsohn, and Pakes (1995), Nevo

[12] We thank Ronald Cotterill, Director of the Food Marketing Policy Center at the University of Connecticut, for making this data and data on advertising expenditures (see below) available to us.

[13] Our method can apply to many different types of data and many industries. For instance, in a previous version of this paper we showed how it can be implemented on household-level data from the ketchup category.

Table 1: Descriptive statistics for the market-level cereal data

Brands	**Market share**	**Price**§
General Mills	0.36	0.21
Kellogg's	0.45	0.20
Post	0.07	0.23
Quaker	0.10	0.19
Nabisco	0.02	0.25
§ In dollars/serving		

(2000), and especially Nevo (2001). A key difference from these papers is that we consider two layers of firm decision-making, manufacturers and retailer (as in Sudhir 2001), not just manufacturers. This makes a difference when estimating marginal costs and price-cost margins in the counterfactual: the retailer's first-order conditions (5) must be considered in addition to the manufacturers' first-order conditions (8). At the demand-estimation stage, however, our estimation procedure is essentially the same as in Nevo (2000, 2001), with a few notable deviations that we highlight below.

We start by writing consumer i's indirect utility for cereal j ($j = 1, ..., 25$) in city-quarter t as:

$$u_{ijt} = \psi_i x_j - \alpha_i p_{jt} + \gamma a_{jt} + \xi_j + \Delta\xi_{jt} + \varepsilon_{ijt}, \tag{15}$$

where x_j is a K-vector of cereal-specific search attributes, p_{jt} is price (city and quarter-specific), a_{jt} is national advertising spending (quarter-specific, but not city-specific), α_i and ψ_i are consumer-specific coefficients, ξ_j is a mean valuation of unobserved cereal characteristics, $\Delta\xi_{jt}$ is a city–quarter specific deviation from this mean (to account for any cereal-specific unobserved characteristics that vary by city-quarter, such as local promotions), and ε_{ijt} is a mean-zero stochastic term. When not consuming any of the cereals, the consumer is assumed to be consuming an "outside good" (other breakfast options such as eggs). Operationally, we define the outside good in "cereal units" as one cereal serving per person-day minus the per-day prorated amount of cereal actually purchased.

The consumer-specific coefficients are assumed to be drawn from a multivariate normal distribution conditional on observed demographics as follows:

$$\begin{pmatrix} \alpha_i \\ \psi_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \psi \end{pmatrix} + \Delta D_i + \Sigma v_i$$

where $v_i \sim N(0, I_{K+1})$, D_i is a d-vector of individual-specific demographic variables, Δ is a $(K+1) \times d$ matrix of coefficients that captures how tastes for search attributes and prices vary by demographics, and Σ is a scaling matrix to be estimated from the data.

We include a dummy variable for each of the 25 cereals (when all these dummy variables are at zero then the outside good is being consumed) to control for mean differences between cereals that do not vary by city or quarter.[14] This leaves only $\Delta\xi_{jt}$ as a source of endogeneity

[14] We also estimated a model with individual-specific fixed effects but it did not improve model fit while

in prices, which we then control for by using average prices in "other cities" as an instrument (see Nevo 2001 for a discussion).[15]

The estimation itself is done in two stages. In the first, Generalized Method of Moments (GMM) stage, we estimate the cereal fixed effects and the parameters for variables that vary by city-quarter, i.e., prices, advertising, and the demographic variables. In the second, Generalized Least Squares (GLS) stage, we regress the estimated cereal fixed effects on the cereal-specific variables that do not vary by city-quarter. Here we deviate from Nevo (2001) in two ways. Whereas Nevo thinks of the js as brands, we call them cereals. Each cereal in our terminology has a brand (e.g., General Mills) and a sub-brand (e.g., Wheaties). So while Nevo's work is done once he has split the estimated fixed effects from the first stage into ψx_j and ξ_j, we still have the task of splitting ξ_j into β_{b_j}, the brand's equity, and $\beta_{_j}$, the sub-brand's equity. We do this via the following GLS specification:

$$F_j = \psi x_j + \beta_{b_j} I_{b_j} + \beta_{_j}.$$

Here F_j is the estimated fixed-effect for cereal j from the first stage and I_{b_j} is a vector of four dummy variables to capture the brand identity of cereal j (one each for Kellogg's, General Mills, Post, and Quaker, with Nabisco as the baseline brand). Assuming that $E(\beta_{_j} | x_j, I_{b_j}) = 0$, we can estimate ψ and β_{b_j} consistently by GLS. Sub-brand equities then fall out as residuals from this regression.[16] The second way we deviate from Nevo (2001) is that we do not include experience attributes (e.g., mushiness) in the vector of observed attributes x_j. As discussed earlier, part of a brand's function is to signal the experience attributes of the product. To the extent brands are differentiated on experience attributes, including them in x_j will affect the brand value estimates. Brands strong in experience attributes will be undervalued; brands weak in experience attributes will be overvalued.

With the demand estimates in place, steps 2–5 of the empirical strategy are executed in sequence. In step 3, using Nabisco as the baseline brand, we set in turn $\beta_{b_j} = 0$ for each of the brands Kellogg's, General Mills, Post and Quaker, and track the effect of this change on equilibrium prices and sales. Sub-brand values are estimated similarly.

Confidence intervals on brand equities are calculated using a bootstrap method (Horowitz 2001). The simulation is repeated 1000 times, drawing the coefficients for use in the simulation from the estimated joint distribution of the coefficients. The 95% confidence interval is then the 25th and 975nd largest simulated values.

---

lowering the precision of estimates. We believe the reason is, given heterogeneity in attribute tastes and price sensitivities, another layer of heterogeneity in brand intercepts is redundant.

[15] We compared the price elasticities obtained with our instrument to the price elasticities obtained with three additional instruments: percentage of children in each city, average wages in each city, and population density in each city. The own- and cross-price elasticities do not change significantly.

[16] Brand and sub-brand equities can be expressed in dollar terms by dividing by α, as in Park and Srinivasan (1994) and Chintagunta, Dube and Singh (2003). These dollar values may then be interpreted as brand values from the consumer's perspective.

4 Results

4.1 Brand value estimates

Table 2 shows the demand parameter estimates from the random-coefficients model. As expected, price has a negative impact on sales and advertising has a positive impact. Some of the brand coefficients in these regressions are negative because average per capita daily consumption of cereal is substantially less than one serving in the data.[17]

Brand value estimates are summarized in Table 3. Besides our profit-based estimates, we include estimates from two previously used reduced-form methods: price premiums based on hedonic regression (Holbrook 1992) and revenue premiums based on Ailawadi, Lehmann, and Neslin's (2003) method (each brand's average revenue minus Nabisco's average revenue). Kellogg's, for instance, has a 15 cent price premium per serving and \$1277.9 million dollars/year revenue premium over Nabisco.[18] The next four columns present brand value estimates from our methodology, i.e., these are the equilibrium profits to the manufacturer and the retailer from the brand after accounting for search attributes.[19] To show the impact of controlling for experience attributes, we present two sets of estimates, one with an experience attribute ("mushiness") in the demand function and one without (the one we recommend). The main estimates show for instance that Kellogg's brand has a value of \$726.9 million dollars/year relative to Nabisco from Kellogg's perspective. From the retailer's perspective, Kellogg's brand brings a value of \$294.1 million dollars/year although the brand is owned by the manufacturer.

Since the different methods compute brand value in different units, the brand value numbers themselves are not comparable, but we can compare rank orders of brand values and brand value differences. The purpose of these comparisons is not to say which is "closer

[17] We compared the out-of-sample predictive ability of our demand model with the following VAR model:

$$\begin{bmatrix} s_t \\ p_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \sum_{j=1}^{T} \beta_{1sj} s_{t-j} \\ \sum_{j=1}^{T} \beta_{2sj} s_{t-j} \end{bmatrix} + \begin{bmatrix} \sum_{j=1}^{T} \beta_{1pj} p_{t-j} \\ \sum_{j=1}^{T} \beta_{2pj} p_{t-j} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

where s are the market shares and p are the prices. This is estimated using a seemingly unrelated regression. Our model fit slightly better. In particular, we used the first 15 quarters of data to estimate the model using both methods. The random coefficients model predicts the market shares of the five firms in the remaining quarters more accurately than the VAR model, although both perform well. For the 25 out of sample firm-quarters, the average predicted market share divided by the real market share was 1.0012 in the random coefficients model and 1.0716 in the VAR model (standard deviations were 0.0018 and 0.5676 respectively).

[18] Price and revenue premiums calculated from our structural model differ from these reduced-form estimates. The price premiums per serving for General Mills, Kellogg's, Post and Quaker over Nabisco from our model are: 1.37, 1.95, 0.21 and 0.27 cents. Note that these numbers are smaller than those calculated with the reduced-form approach, and the ordering of Quaker versus Post is reversed. Structural estimates of revenue premiums (millions of dollars per year) are: General Mills \$1352.8 million, Kellogg \$1527.0 million, Post \$245.3 million, and Quaker \$254.4 million. These are higher than their reduced-form counterparts.

[19] We also estimated a number of alternative models. If we assume no retailer, not surprisingly, the brand value estimates for the manufacturer turn out substantially lower (\$318.9 million for Kellogg): The wholesale prices paid by the retailer are now attributed to the manufacturer as its marginal costs. If we assume collusion between manufacturers, brand values are higher (\$946.9 million for Kellogg's, for instance). If we assume sub–brand level competition, brand values are lower (\$640.6 million for Kellogg's). The relative brand values change little. As mentioned earlier, the estimated mark-ups suggest that manufacturer-level Bertrand competition is a reasonable market structure to use. In situations where the researcher has no independent means of assessing market structure, we suggest estimating brand values under several different market structures to get upper and lower bounds on brand value.

Table 2: Demand for cereal

	Parameter	**Estimate**
	Constant	-5.72 (0.10)**
	Price	-30.27 (4.43)**
	Advertising	0.01 (0.004)**
Nutritional content	Sugar	-0.23 (0.01)**
	Fat	0.03 (0.001)**
	Fiber	-0.06 (0.002)
	Calories	0.08 (0.84)
Cereal types+	All-family	-0.03 (0.001)
	Kids	-3.06 (0.28)**
	Adults	-1.32 (0.21)**
Brand coefficients++	General Mills	1.19 (0.04)**
	Kellogg's	0.49 (0.04)**
	Post	-0.78 (0.04)**
	Quaker	0.91 (0.04)**
Standard deviations (σ)	Price	1.89 (6.21)
	Sugar	-0.04 (0.11)
	Fat	0.03 (0.42)
	Fiber	0.21 (0.60)
	All-family	-0.22 (1.91)
	Kids	0.12 (2.48)
	Adults	0.97 (1.25)
Interaction	Price*Child	0.10 (6.40)

Standard errors in parentheses; state dummy variables not shown.
+Base is taste-enhanced cereal (as defined in Nevo 2001)
++Brand coefficients relative to Nabisco.
*significant at 0.05 level; **significant at 0.01 level.

to the truth"—we don't know what the truth is—but to assess to what extent our estimates agree with those produced by the other methods, and, to the extent they differ, why that might be so.[20] The rank order of brand values produced by the different methods are fairly similar, but there are some differences, namely the ordering of Post vis-a-vis Quaker; our method ranks Quaker higher whereas the reduced-form methods rank Post higher. Brand value differences also vary by method. For instance, in our method Kellogg's brand value is over 25% higher than General Mills', but by Ailawadi, Lehmann and Neslin's (2003) revenue premiums method, its advantage is just 7%. This could be, of course, because wholesale price differences among brands figure in our computation, but also we model the counterfactual explicitly taking into account (a) the contribution of search attributes, and (b) the responses of other manufacturers and of the retailer.

Brand value from the perspective of the manufacturer versus the retailer. A cereal brand is apparently more valuable to its manufacturer than to a retailer who carries it. This may be because the cereal category provides a lot of variety to a retailer: two relatively strong brands that offset each other, and several weaker brands. The retailer's fortunes are not dependent on one brand. If a brand loses equity, the retailer has the opportunity to make adjustments in prices and promotions to drive sales from the affected brand to other brands in the category. This shows up in the numbers. For example, when General Mills loses equity, the simulations estimate that General Mills itself loses \$569.1 million in profits. While retailers lose \$349.4 million in foregone sales of General Mills products, they gain \$55.3 million from the increased sale of other cereals. The overall value of the General Mills brand to the retailer is then \$294.1 million. Similar results are seen for the other brands.

Role of experience attributes. We also present results for brand value controlling for a brand's "mushiness in milk" in the demand function (a binary variable, "mushy"/"not mushy"). Consistent with Nevo (2001), our estimates suggest that mushiness is generally a negative attribute of cereals—people prefer their cereal not to get soggy in milk—but there is some heterogeneity in this. The cereal makers, catering to this preference structure, generally make their cereals not mushy, although a few varieties are mushy. Putting the mushiness variable in the demand function amounts to assuming that brand has no signaling value for this attribute, that consumers will know the mushiness of the cereal even without the aid of a brand. Clearly, such an assumption will change brand values, and that is what we find in Table 3.[21] Because Post and Quaker perform relatively well on mushiness, it is these brands that lose (relative) value when controlling for mushiness. The value of Post

[20] Interestingly, our brand value calculations are consistent with the actual profits for Kellogg's during this time period. According to their annual report, Kellogg's US division had operating profits of \$602.8 million in 1992 (the company profit was \$1062.8 million). While Kellogg's does have other products besides cereal, cereal is by far the most dominant category. It was not possible to proxy cereal-related profits for the other brands from annual reports. While the closeness of our brand value estimate to Kellogg's 1992 profits provides some support for the external validity of our measure, we do not want overemphasize this point.

[21] Kartano and Rao (2005) estimate brand values in the car market controlling for experience attributes in the demand function. However, since they do not report brand values without such controls we cannot tell by how much their brand value estimates are affected by the inclusion of experience attributes. The fact that their demand function shows significant effects for some experience attributes—Perceived Quality (transmission and ignition) and Satisfaction (interior features)—suggests that these attributes may be soaking up some brand equity.

Table 3: Brand values

	Previous methods		Our methods			
			Without experience attributes		With experience attribute "mushiness"	
	Price premium#	Revenue premium^	Brand Value to Manufacturer^	Brand Value to Retailer^	Brand Value to Manufacturer^	Brand Value to Retailer^
General Mills	0.10	1192.6^	569.1 (567.8,571.2)	238.4 (234.6,239.8)	558.3 (553.9,561.2)	233.5 (228.9,234.4)
Kellogg's	0.15	1277.9	726.9 (723.9,730.6)	294.1 (291.1,296.3)	698.0 (685.5,706.0)	281.4 (276.4,285.2)
Post	0.09	111.3	27.0 (23.4,35.9)	17.2 (11.5,19.8)	2.6 (-7.1,10.8)	7.3 (0.02,10.2)
Quaker	0.04	66.6	72.6 (71.1,76.1)	36.3 (29.7,38.5)	60.2 (52.5,68.3)	31.3 (24.1,33.1)

#Dollars/serving relative to Nabisco
^Millions of dollars/year relative to Nabisco,assuming U.S. population of 300 million
95% Confidence intervals in parentheses where applicable

Table 4: Sub-brand values

	Brand Value to Manufacturer^	Brand Value to Retailer^		Brand Value to Manufacturer^	Brand Value to Retailer^
General Mills			**Kellogg's**		
Cinnamon Toast Crunch	15.2 (15.0,15.4)	7.4 (7.3,7.5)	Crispix	29.9 (29.7,30.0)	14.2 (14.1,14.2)
Cheerios	113.3 (113.1,113.5)	57.3 (57.1,57.4)	Froot Loops	60.1 (60.0,60.1)	28.7 (28.7,28.8)
Kix	14.6 (14.4,14.8)	7.1 (7.0,7.2)	Frosted Flakes	146.0 (145.4,146.4)	71.0 (70.8,71.2)
Raisin Nut	12.3 (12.2,12.4)	6.0 (6.0,6.1)	Mini Wheats	42.3 (41.7,42.7)	20.1 (19.9,20.2)
Trix	30.0 (29.9,30.0)	14.8 (14.8,14.8)	Frosted Corn Flakes	141.6 (139.4,143.0)	68.7 (67.9,69.3)
Honey Nut Cheerios	73.9 (74.1,73.8)	37.0 (36.9,37.1)	Corn Pops	33.9 (33.7,33.9)	16.1 (16.1,16.1)
Lucky Charms	41.1 (41.0,41.1)	20.4 (20.4,20.4)	Raisin Bran	61.1 (61.0,61.1)	29.3 (29.2,29.3)
Total	37.1 (36.6,37.5)	18.3 (18.1,18.5)	Rice Krispies	89.4 (89.0,89.6)	43.0 (42.8,43.1)
Wheaties	32.6 (32.4,32.7)	16.1 (16.0,16.2)	Special K	13.8 (11.7,14.9)	6.2 (5.6,6.6)
Quaker			**Post**		
CapN Crunch	64.2 (64.0,64.4)	35.5 (35.3,35.5)	Grape Nuts	68.9 (13.4,117.5)	28.4 (63.1,2.8)
Life	9.4 (9.0,9.6)	5.2 (5.0,5.3)	Bunches of Oats	21.4 (11.1,33.1)	14.0 (6.8,19.3)
100% Natural	-83.9 (-95.6,-77.2)	-45.7 (-52.1,-42.0)	Honey Raisin Bran	32.9 (32.8,32.9)	18.1 (18.1,18.1)

95% confidence intervals in the brackets.
^Millions of dollars/year relative to Nabisco,assuming U.S. population of 300 million.

Table 5: Own and cross-price elasticity changes with changes in brand equity (%)

	ΔElasticity (%) for brand in the first column with respect to retail price changes in				
	General Mills	Kellogg's	Post	Quaker	Nabisco
General Mills	-6.31 (-8.85,-4.98)	14.1 (11.9,14.8)	18.70 (17.1,19.4)	17.60 (15.8,18.3)	19.41 (18.02, 20.26)
Kellogg's	18.33 (16.72,20.27)	-9.1 (-12.9,-6.9)	23.0 (21.3,24.6)	21.4 (19.6,23.3)	23.63 (22.46,25.62)
Post	3.62 (0.80,4.06)	3.2 (0.7,3.8)	-0.9 (-0.9,-0.2)	3.8 (0.9,4.2)	4.22 (1.04,4.73)
Quaker	4.52 (1.80,5.05)	4.4 (1.6,4.8)	5.2 (2.2,5.7)	-1.4 (-1.5,-0.6)	4.20 (1.65,4.90)
95% Confidence intervals in parentheses; brands in the first column are changing their equities					

falls from $27 million to near zero; the value of Quaker falls by one-sixth. Although the results for Post are striking, mushiness generally does not account for much of the brand value. There are other experience and credence attributes that brand continues to signal, and, of course, brand continues to play a purely marketing role, adding imagery, personality, and emotional values to the cereal.

Brand value at the sub-brand level. Table 4 shows sub–brand values, calculated from the residuals of the second-stage GLS regression. The results show that sub-brands play an important role in driving overall brand value. For example, the sub-brand Cheerios by itself contributes as much as 19.9% of General Mills' brand value. Quaker and Post provide an interesting contrast. Quaker's overall brand value seems to be driven primarily by the "Quaker" brand, not by its sub-brands. In fact, the combined value of its sub-brands (CapN Crunch, Life, and 100% Natural) is *less* than the value of the base brand, Nabisco; however, "Quaker" itself is a strong brand worth $72.6 million in profits. In contrast, Post's overall brand value seems to be primarily driven by its sub-brands, especially Grape Nuts; the umbrella brand, Post, is quite close to Nabisco in brand value, which may provide some explanation for Post's decision (as a unit of Kraft) to buy Nabisco in 1992 (the merger was approved in February 1995).

4.2 Effects of brand equity on manufacturers and retailers

One of the main advantages of our structural approach is that it enables us to simulate what would happen if one of the brands were to "lose its equity." This allows us to better understand the drivers of brand value. Tables 5 through 8 describe what happens to price elasticities,[22] prices and market shares when a brand's equity becomes like Nabisco's.

Price elasticity. Table 5 reports the changes in own and cross-price elasticities from the real to the counterfactual (a positive number indicating an increase in elasticity in absolute terms). For example, General Mills' own-price elasticity falls 6.31% when its

[22] Even though the brand coefficients are intercepts in the utility function, changes in any of them will affect the (own) price elasticities of *all* brands. This is because both shares and equilibrium prices are functions of the brand coefficients. As Nevo (2000) shows, own-price elasticity is given by $(-p_{jt}/s_{jt})\int \alpha_i s_{ijt}(1-s_{ijt})dP_n$ where s_{ijt} is the share of cereal j in individual i's cereal purchases in market t.

Table 6: Market share changes with brand equity changes (%)

Effect on →	General Mills	Kellogg's	Post	Quaker	Nabisco
General Mills	-6.33 (-6.36,-6.29)	1.40 (1.13,1.46)	0.28 (0.25,0.29)	0.40 (0.35,0.41)	0.07 (0.06,0.07)
Kellogg's	1.41 (1.25,1.53)	-7.75 (-7.84, -7.69)	0.34 (0.32,0.36)	0.49 (0.45,0.51)	0.08 (0.08,0.09)
Post	0.30 (0.05,0.34)	0.37 (0.06,0.43)	-0.32 (-0.41,-0.25)	0.09 (0.02,0.11)	0.02 (0.00,0.02)
Quaker	0.37 (0.13,0.42)	0.46 (0.15,0.51)	0.08 (0.03,0.09)	-0.88 (-0.94,-0.78)	0.02 (0.01,0.02)
95% Confidence intervals in parentheses; brands in the first column are changing their equities The total market includes the outside good, whose share changes are not reported					

equity falls to the level of Nabisco's. The remainder of the first row shows the changes in cross-price elasticities for General Mills with respect to other brands. Each of these cross-price elasticities increase when General Mills loses equity, signifying that price changes in the other brands influence General Mills' market share more after it loses its equity. The cross-elasticity between General Mills and Nabisco increases the most, by 19.41%, as might be expected considering that when General Mills becomes like Nabisco, they become closer competitors (not identical competitors because their search attributes are still different). Overall, rival brands become closer substitutes to General Mills and Kellogg's when these two powerful brands lose equity. For the weaker brands, Post and Quaker, the elasticities do not change much: they are closer to Nabisco to begin with, so the counterfactual doesn't represent a big change.[23]

Market shares. Table 6 shows differences between actual and counterfactual market shares. The manufacturer who loses equity loses a great deal of share, while rivals gain. Interestingly, when major brands like General Mills or Kellogg's lose brand equity, they lose 2.9 and 3.3 times (respectively) the sales that the other firms gain. Category sales suffer as a result. This shows branding has value not only with respect to rivals in the category, but also in making the category as a whole more attractive.

Wholesale and retail prices. Tables 7 and 8 show differences between actual and counterfactual wholesale and retail prices respectively. Both are matrices: when a brand's equity changes, it has a ripple effect on the entire industry; all brands adjust their prices. What happens to wholesale prices when a brand's equity falls to the level of Nabisco's? The results (Table 7), although noisy due to the compounding of many simulated values, show that own wholesale prices drop and the players with the most equity drop their wholesale prices the most and generally have competitors that react most strongly. By contrast, weak brands evoke weak reactions. The one notable exception is that Kellogg's and General Mills do not drop wholesale prices much (or at all) in response to the other losing brand equity. This

[23] To avoid cluttering up the paper, we only present elasticity changes, not the elasticities. The elasticity numbers range from -5.61 for Kellogg's to -7.73 for Nabisco. These are at the high end of the estimates listed in Bijmolt, van Heerde, and Peiters (2005).

Table 7: Wholesale price changes with brand equity changes (%)

Effect on →	General Mills	Kellogg's	Post	Quaker	Nabisco
General Mills	-6.71 (-9.68,-5.16)	0.07 (-0.07,0.10)	-1.02 (-1.47,-0.80)	-1.28 (-1.91,-0.99)	-0.96 (-1.36,-0.75)
Kellogg's	-0.28 (-0.47,-0.17)	-10.10 (-15.20,-7.64)	-1.26 (-1.81,-0.97)	-1.59 (-2.34,-1.19)	-1.19 (-1.68,-0.93)
Post	0.10 (-0.02,0.10)	0.17 (0.00,0.18)	-0.26 (-0.39,-0.20)	-0.03 (-0.07,-0.02)	-0.05 (-0.07,-0.04)
Quaker	0.07 (-0.04,0.07)	0.16 (-0.01,0.17)	-0.12 (-0.19,-0.10)	-0.70 (-1.04,-0.52)	-0.13 (-0.18,-0.10)
95% Confidence intervals in parentheses; brands in the first column are changing their equities					

Table 8: Retail price changes with brand equity changes (%)

Effect on →	General Mills	Kellogg's	Post	Quaker	Nabisco
General Mills	-6.52 (-9.14, -5.15)	-1.83 (-2.04,-1.05)	-2.11 (-2.54,-1.48)	-2.60 (-3.11,-1.80)	-1.89 (-2.30,-1.34)
Kellogg's	-2.05 (-2.37,-1.90)	-9.75 (-13.88,-7.47)	-2.47 (-3.03,-2.19)	-3.03 (-3.70, -2.69)	-2.22 (-2.75,-1.96)
Post	-0.81 (-0.85,-0.09)	-0.87 (-0.94,-0.10)	-0.91 (-0.96,-0.24)	-0.99 (-1.04,-0.14)	-0.70 (-0.73,-0.10)
Quaker	-0.90 (-0.94 -0.18)	-0.96 (-1.02 -0.18)	-0.91 (-0.94, -0.23)	-1.43 (-1.49, -0.59)	-0.80 (-0.82 ,-0.21)
95% Confidence intervals in parentheses; brands in the first column are changing their equities					

may be a consequence of the less competitive environment for the brand the maintains its equity. Retail prices also fall when a brand loses equity (Table 8). Interestingly, Quaker has a larger own-price reaction than Post, even though the hedonic regression shows a higher price premium for Post. Reduced-form and structural estimates of price premiums may thus be sufficiently different to change conclusions qualitatively. The lower wholesale price on the brand losing equity coupled with an increase in own-price elasticity at the retail level (due to the brand losing equity) induces the retailer to reduce prices throughout the category even when other brands' wholesale prices are unchanged or rising. This illustrates the different considerations that go behind brand competition at the manufacturer level and category management at the retail level, as discussed in Moorthy (2005). In many cases, the retail price drop exceeds the wholesale price drop, squeezing retail margins. Seen in pass-through terms, retailer pass-through on wholesale price reductions stemming from brand equity loss are often greater than 100%. This contrasts with the usual finding that retailers do not pass on all of the price decreases they get at wholesale (Chevalier and Curhan 1976; Moorthy 2005). Our results suggest that when brand equities are changing, the retailer is more inclined to pass through.

5 Limitations and future research

While our method for estimating brand value is better grounded theoretically, and more rigorously operationalized, than existing methods, it is not without its limitations. Some of these limitations are particular to our data set—which a richer data set might overcome—still, we do not mean to imply that we have exhausted the possibilities for improving/refining the methodology. Some ideas are discussed below.

We have argued forcefully for keeping search attributes out of the brand value calculation, the theory being that these attributes can be seen by the consumer independent of brand. But "searchness" of an attribute is a matter of degree, and arguably, to some extent in the eye of the beholder. What is missing typically is any information on the ability or inclination of consumers to observe so-called search attributes. To the extent that some search attributes are costly to observe and brand serves as a short-cut to infer them (Erdem and Swait 2004), our method, by treating them as observable, will underestimate or overestimate brand value (depending on whether a brand's products are strong or weak in these attributes). By the same token, if relevant search attributes such as promotions are correlated with brand, and observed by the consumer, but missing in the data (as in ours), then, too, brand values will be mismeasured. Our method, by forcing discussion of this issue contributes positively to our understanding of brand value, and provides a way to assess its sensitivity to alternative assumptions (as we demonstrated by comparing brand values with and without experience attributes in the regression).

Advertising plays an important role in reducing search costs and in building and maintaining brand value. We assume current advertising to be exogenous and past advertising to affect current sales only through brand equity. Of these, the first is more difficult to justify. Current advertising is endogenous and likely to respond to changes in brand equity. In addition, endogenizing advertising (and/or promotions) may be a way to relax the assumption that costs do not change when brand equity "falls" in the counterfactual. Again, given the limitations of our data set, we believe we have made reasonable compromises. Nevertheless, understanding the impact of brand values on current advertising/promotion expenditures is an interesting research topic.

Currently, our models are static, and we base our brand value estimates on observed short-term profits. As discussed in footnote 4, if there are reliable means to forecast future profits, then it is a simple matter to capitalize current and future profits into a NPV-based measure of brand value (as is done in commercially by agencies such as Interbrand). The static formulation may also be justified considering the maturity of the cereal category (see, for example, Sriram, Balachander and Kalwani 2007, which finds stability in brand equities in the toothpaste category). However, a multi-period formulation with the dynamics of brand-building and harvesting fully modeled would nevertheless be a useful contribution. Brand assets would be viewed as depletable, but renewable resources in this formulation. Such a model might use, for the demand side, Erdem and Keane's (1996) formulation of the dynamics of quality perceptions. A firm's current actions would be interpreted as a combination of "harvesting" the brand and "investing" in it. In addition, such a model will recognize that a brand can do many more things in a longer time frame than we have given it credit for in this paper. For example, it can be extended and co-branded. The data requirements for estimating such a full-blown model would be correspondingly higher.

If data from competing retailers are available, the model in Section 2.2 can be extended to incorporate retail competition (along the lines of Villas-Boas and Hellerstein 2006). Another particularly promising possibility is to combine the advantages of survey methodology with those of observational data in an integrated model. While consumer surveys have been justly criticized for not providing reliable indications of consumer *behavior*, they may nevertheless be useful in identifying utility components. Survey-based techniques such as conjoint analysis have the advantage of flexibility: freed from the constraints of observational data, brand and sub-brand equity can be more cleanly separated from the effects of product attributes. If these data are collected contemporaneously with observational data on sales, prices and promotions, then survey-based estimates of brand equity can be used as direct inputs into the indirect utility function. The equilibrium framework still applies, tracking the industry-wide supply-side effects of brand equity.

6 Conclusion

Measuring brand value—what a brand brings to a firm—is ultimately an exercise in specifying two things: (1) what the brand does for the consumer—what we have called brand equity, and (2) how brand equity affects a firm's competitive position, its position in the supply chain, and its decisions. As we have emphasized in the paper, a brand should be given credit for some things, but not everything. Specifically, a brand brings to a product imagery, personality, emotional reactions, status, and on the performance side, information on what the product delivers on the things consumers can't see for themselves—its experience and credence attributes. On the other hand, a consumer doesn't need a brand to see the product's search attributes. Besides this conceptual clarification which has been missing in the brand equity measurement literature, the other major contribution of this paper is a methodology to track the implications of brand equity at the firm level taking account of competitors' and retailers' reactions. Using observations on sales, prices, advertising, and product attributes for various brands in the breakfast cereal category we estimate each brand's profit contribution to the manufacturer and to the retailer, and compare these estimates to brand values estimated by previously-used methods.

As we see it, our methodology has several advantages over current procedures for measuring brand value. First, it produces brand value estimates in profit terms, not price premiums, quantity premiums, or revenue premiums, all of which are components of profits, not profits. This emphasis on profit accords well with received theory in accounting and finance, and with FASB rules for evaluating intangible assets and goodwill. Second, our methodology is based on observational data—what consumers and firms actually did in the marketplace, not what they reported in surveys. Third, by taking an equilibrium approach, we account for the impact of brand on the entire market: on the firm manufacturing the product, its competitors, as well as the retailer through whom the product reaches the consumer. Our results show that both manufacturers and retailers get value out of a manufacturer's brands, although their values could be quite different. Finally, our structural methods allow us to simulate the counterfactual situation of a brand changing its equity and measure its impact on price elasticities, market shares, and margins.

In the previous section we discussed the most promising lines for future work. We close by encouraging our colleagues to pursue this agenda.

References

[1] Aaker, Jennifer L. (1997), "Dimensions of Brand Personality," *Journal of Marketing Research*, 34 (August), 347-56.

[2] Agarwal, Manoj K. and Vithala R. Rao (1996), "An Empirical Comparison of Consumer-Based Measures of Brand Equity," *Marketing Letters,* 7 (July), 237 - 247.

[3] Ailawadi, Kusum L., Donald R. Lehmann, and Scott A. Neslin (2003), "Revenue Premium as an Outcome Measure of Brand Equity," *Journal of Marketing* 67 (October), 1-17.

[4] Allison, Ralph I., & Uhl, Kenneth P. (1964). "Influence of beer brand identification on taste perception." *Journal of Marketing Research*, 1, 36-39.

[5] Berry, S. (1994), "Estimating Discrete-Choice Models of Product Differentiation," *Rand Journal of Economics,* 25, 242 – 262.

[6] Berry, Steven, James Levinsohn and Ariel Pakes (1995), "Automobile Prices in Market Equilibrium," *Econometrica* 63(4), 841-890.

[7] Bijmolt, Tammo H.A., Harald J. van Heerde, Rik G.M. Pieters (2005), "New Empirical Generalizations on the Determinants of Price Elasticity", *Journal of Marketing Research*, 42 (2), 141-156.

[8] Chevalier, Michel, Ronald C. Curhan (1976), "Retail Promotions as a Function of Trade Promotions: A Descriptive Analysis," *Sloan Management Review*, 18(3) 19–32.

[9] Chintagunta, Pradeep K. (2001). "Endogeneity and heterogeneity in a probit demand model: Estimation using aggregate data". *Marketing Science*. 20(4) 442–456.

[10] Chintagunta, Pradeep K., Jean-Pierre Dube, and Vishal Singh. 2003. "Balancing Profitability and Customer Welfare in a Supermarket Chain." *Quantitative Marketing and Economics* 1(1), 111-147.

[11] Cotterill, Ronald (1996), "High Cereal Prices and the Prospect of Relief by Expansion of Private Label and Antitrust Enforcement," Food Marketing Policy Issue Paper #11.

[12] Erdem, T. (1998), "An Empirical Analysis of Umbrella Branding," *Journal of Marketing Research*, 35(3), 339–351.

[13] Erdem, T. and M. P. Keane (1996), "Decision-Making under Uncertainty: Capturing Dynamic Brand Choice Processes in Turbulent Consumer Goods Markets," *Marketing Science*, Vol. 15, No. 1., pp. 1-20.

[14] Erdem, T. and J. Swait (1998) "Brand Equity as a Signaling Phenomenon". *Journal of Consumer Psychology*, 7(2):131-157.

[15] Farquhar, Peter H. (1990), "Managing Brand Equity," *Journal of Advertising Research*, 30(4), RC7-RC12.

[16] Ford, G. T., D. B. Smith, and J. L. Swasy (1990), "Consumer skepticism of advertising claims: Testing hypotheses from economics of information," *Journal of Consumer Research*, 16 (March), 433-441.

[17] Holbrook, Morris B. (1992), "Product quality, attributes and brand name as determinants of price: The case of consumer electronics, *Marketing Letters*, 3, 71-83.

[18] Horowitz, Joel (2001), "The Bootstrap", in J.J. Heckman and E.E. Leamer, eds *Handbook of Econometrics Vol. 5*, Elsevier Science B.V., ch. 52, 3159-3228.

[19] Hoyer, W. D., & Brown, S. P. (1990). "Effects of Brand Awareness on Choice for a Common, Repeat-Purchase Product". *Journal of Consumer Research*, 17(2), 141-48.

[20] Kamakura, Wagner A. and Gary J. Russell (1993), "Measuring brand value with scanner data," *International Journal of Research in Marketing,* 10 (March), 9-22.

[21] Kartono, Benjamin and Vithala R. Rao (2005), "Linking Consumer-Based Brand Equity to Market Performance: An Integrated Approach to Brand Equity Management," Working Paper, Cornell University.

[22] Keller, Kevin Lane (2003), *Strategic Brand Management,* second edition, Prentice Hall.

[23] Klein, Benjamin & Leffler, Keith B. (1981). "The Role of Market Forces in Assuring Contractual Performance," *Journal of Political Economy*, 89(4), 615-41.

[24] Milgrom, Paul & Roberts, John (1986). "Price and Advertising Signals of Product Quality," *Journal of Political Economy*, 94(4), 796-821.

[25] Moorthy, Sridhar (2005), "A General Theory of Pass-Through in Channels with Category Management and Retail Competition," *Marketing Science,* 24 (Winter), 110–122.

[26] Nelson, Phillip (1970), "Information and Consumer Behavior," *Journal of Political Economy* 78 (March/April), 311-329.

[27] Nevo, Aviv (2000), "A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand," *Journal of Economics & Management Strategy,* 9(4), 513-548.

[28] Nevo, Aviv (2001), "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica,* 69 (2), 307-342

[29] Park, Chan Su and V. Srinivasan (1994), "A Survey-Based Method for Measuring and Understanding Brand Equity and its Extendability," *Journal of Marketing Research*, 31 (May), 271-288.

[30] Rosen, S. (1974), "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy* 82 (January/February), 34–55.

[31] Shapiro, Carl (1983), "Premiums for High Quality Products as Returns to Reputation," *Quarterly Journal of Economics*, 98 (4), 659-680.

[32] Shugan, Steven M. (2004). Editorial: Endogeneity in marketing decision models. *Marketing Science*. 23(1) 1–3.

[33] Simon, Carol J., and Mary W. Sullivan (1993), "The Measurement and Determinants of Brand Equity: A Financial Approach," *Marketing Science*, 12(1), 28-52.

[34] Smith, Daniel C. and C. Whan Park (1992), "The Effects of Brand Extensions on Market Share and Advertising Efficiency," *Journal of Marketing Research* 29 (August), 296–313.

[35] Srinivasan, V., Chan Su Park, and Dae Ryan Chang (2005). An Approach to the Measurement, Analysis and Prediction of Brand Equity and its Sources. *Management Science* 51(9), 1433-1448.

[36] Sriram, S., Subramanian Balachander, and Manohar U. Kalwani (2007), "Monitoring the Dynamics of Brand Equity Using Store-Level Data," *Journal of Marketing*, 71(2), 61-78.

[37] Sudhir, K. (2001), "Structural Analysis of Competitive Pricing in the Presence of a Strategic Retailer," *Marketing Science*, 20 (3), 244–64.

[38] Sullivan, Mary (1998), "How Brand Names Affect the Demand for Twin Automobiles," *Journal of Marketing Research, 35* (May), p. 154.

[39] Swait, Joffre, Tulin Erdem, Jordan Louviere and Chris Dubelaar (1993), "The Equalization Price: A Measure of Consumer-Perceived Brand Equity," *International Journal of Research in Marketing* 10 (March), 23–45.

[40] Villas-Boas, J. Miguel, and Russell S. Winer (1999). Endogeneity in Brand Choice Models. *Management Science* 45(10), 1324-1338.

[41] Villas-Boas, J. Miguel, and Ying Zhao (2005), "Retailer, Manufacturers, and Individual Consumers: Modeling the Supply Side in the Ketchup Marketplace," *Journal of Marketing Research* 42 (February), 83-95.

[42] Villas-Boas, Sofia Berto. 2007. "Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data," *Review of Economic Studies* 74(2), 625-652.

[43] Villas-Boas, Sofia and Rebecca Hellerstein (2006), "Identification of Supply Models of Retailer and Manufacturer Oligopoly Pricing," *Economics Letters,* 90 (January), 132-140.

[44] Wernerfelt, Birger (1988). "Umbrella Branding as a Signal of New Product Quality: An Example of Signaling by Posting a Bond." *RAND Journal of Economics*. 19(3) 458–466.