Addressing Endogenous Product Choice in an Empirical Analysis of Merger Effects

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Abstract:

Industrial organization economists have made significant progress on consumer demand estimation in product differentiated markets. Crucially, price is endogenized in these models. As a result researchers can predict a merger's consequences by estimating *ex ante* demand parameters, changing the "identity" of the various players (i.e., combining the behavior of merging parties), allowing prices to adjust endogenously, and calculating changes in consumer welfare. Because the price effects of mergers are critical to consumer welfare, models that endogenize price play an important role in antitrust analysis.

In many applications, however, this approach to evaluating mergers does not go far enough. While prices are explicitly included as choice variables of the industry participants, their product characteristics are treated as exogenous. As such, product characteristics are constrained to be fixed after the merger. This abstraction has consequences for the accuracy of a simulation; to the extent that merged firms may cull duplicate products or competitors may introduce new varieties post-merger, evaluating consumer surplus becomes more complex. If the resulting product variety in the industry exhibits more overall differentiation, price competition may be softened beyond the effect of removing one competitor. However, industry participants may choose to expand their product offerings given the new market structure. Consumer welfare can increase if products with more highly valued characteristics are available more after a merger.

This paper focuses on three aspects of endogenous product choice related to merger simulation. First, we elaborate on the role of abstracting from potential post-merger product repositioning in the economics literature and selected antitrust cases. Second, we demonstrate the potential impact of the fixed product characteristics assumption on consumer welfare citing empirical, theoretical and simulation examples. Finally, we introduce an empirical framework that incorporates endogenous product choice into differentiated-product demand estimation and discuss how this and similar methods can potentially be incorporated into antitrust analysis.

I. Introduction

Over the past several decades, advances in industrial organization economics has had an increasing impact on the analysis of horizontal mergers. In particular, much progress has been made in developing new econometric techniques for estimating demand functions. Applying these methods, along with data from the industry of the proposed merger, can allow an analyst to assess the relationship between market concentration and price changes, providing critical information about market definition. In addition, economists can make a prediction regarding how prices would adjust following the merger of two industry participants. The process of empirical demand elasticity estimation followed by merger simulation (i.e., simulated with the proposed ownership change and the estimated parameters) has been increasingly used as suggestive evidence of the effects of a merger on prices charged to consumers.[1]

Crucially, the prices charged by industry participants are endogenized in these demand models. Valid econometric instruments are needed to ensure that quantity differences that accompany price differences are caused by fundamental consumer preference parameters rather than supply-side factors. Indeed, appropriately endogenizing prices is among the most difficult challenges involved with applying these methods to actual merger scenarios. Such instruments are difficult to find in practice, particularly in a complex market where competing firms offer differentiated products. Without them estimated price elasticities can potentially contain serious bias. In the context of merger simulation, furthermore, the industry participants' optimal response to the proposed change in market structure resulting from the merger can be captured if prices are endogenized in the demand model. Once the "identity" of the various players are modified in the simulation, (i.e. the proposed merging firms are treated as a single profit maximizing firm for the purpose of price-setting) prices will adjust, generating a more realistic prediction regarding post-merger consumer surplus.

This paper focuses on an important potential shortcoming inherent in this approach to estimating demand and simulating the effects of mergers. While prices are explicitly included as choice variables of the industry participants, their product

[1] Budzinski and Ruhmer (2008) provide a recent survey of the use of merger simulation in competition policy.

characteristics are treated as exogenous – they cannot adjust after the merger. This abstraction has consequences for the accuracy of some merger simulations; to the extent that merged firms may cull duplicate products or competitors may introduce new varieties post-merger. Simulating mergers using the method sketched above constrains the set of differential products offered by market participants to be identical pre- and post-merger. Actual firm behavior and its effect on consumer surplus may well be more complex. If the resulting product variety in the industry exhibits more overall differentiation, price competition may be softened beyond the effect of removing one competitor. However, industry participants may choose to expand their product offerings given the new market structure. Consumer welfare can increase if more highly valued product characteristics are available more after a merger.

The analysis and discussion presented here paper proceeds in three parts. First, WE will present some background from the economics literature on horizontal combinations that indicates the potential importance of accounting for endogenous product choice among industry participants. In addition, we will provide some context on the issue by referencing a series of merger cases in which the issue of post-merger product repositioning was at least considered by the court or regulatory body evaluating the proposed merger. Second, we will review the nascent literature on endogenous product choice and differentiated product demand. A series of recent papers have begun to address this modeling challenge, with a variety of different empirical approaches. Third, we will outline an empirical modeling approach, developed in prior joint work (Draganska, Seim and Mazzeo, 2008), that estimates both product differentiated demand parameters and the fixed costs of offering individual product varieties. As such, the approach endogenizes both price and product varieties, allowing both to update as a result of changed industry structure in the context of a merger simulation. Based on this model and the others in the literature, the paper concludes with a discussion of the prospects and challenges associated with extending the empirical analysis of mergers to account for changes in product characteristics and varieties into applied settings.

II. Background

This section will proceed in two parts. First, we will review some of the relevant literature from economics on the relationship between market concentration and product variety. A small number of papers have focused directly on the effects of mergers on firm choice and market heterogeneity – these papers are highlighted. Then, we provide a brief survey of merger cases in which positioning of products after a proposed merger figured into the court's decision. Both the academic literature and the court records suggest a potentially important role for an analytical framework that endogenizes product choice.

A. Economics Literature

In the economics literature, a reasonably small number of empirical studies have addressed the related questions of (1) what is the relationship between product characteristics offered by competing firms and the market structure of firms operating in their industry and (2) what effect do mergers (i.e., changes in market structure) have on the set of products that competing firms offer. Evidence of a relationship between product offerings and market structure suggests that empirical analyses of mergers that do not allow firms to optimally adjust their product portfolios may be incomplete. This issue may be particularly serious in differentiated product industries, where consumers have heterogeneous preferences over the range of product characteristics that firms could potentially offer. In such environments, price changes can either be mitigated or exacerbated by differences in product offerings when calculating consumer welfare. While not an exhaustive collection, the papers described below provide a flavor of the sort of empirical evidence researchers have compiled that relates to this problem.

To begin, a series of papers has investigated the relationship between observed market structure in a particular industry and the product offerings of competing firms.[2] For example, Alexander (1997) presents data from the music recording industry that

[2] This literature is not nearly as extensive as the one examining correlations between prices and market structure. Weiss (1990) provides an extensive review of this literature and Whinston (2006) discusses the role of such studies in the literature as evidence in a regulatory/antitrust context. See Manuszak and Moul (2008) for a recent contribution, that revisits the price-concentration relationship in the office supply retail industry using structural methods (e.g., Mazzeo, 2002a) to address market structure endogeneity.

suggests a nonmonotonic relationship between competition indices/concentration ratios in the market for music distribution and overall variety (on various technical dimensions) of the hit songs produced by the studios. In his study, high and low levels of concentration were associated with lower levels of product variety, while products were less differentiated overall in the industry under intermediate levels of concentration. A similar paper by George (2006) examines the effect of market structure on product positioning and product variety in the market for US daily newspapers. Again, the data analyzed include detailed measures (e.g., papers' assignment of reporters to particular topical areas) of product offerings of competing firms. In terms of both the variety of topics and the number of topics covered, more concentrated markets tend to have more variety. Interestingly, the difference in product offerings is not associated with any changes in newspaper readership. This suggests that merging firms would have more strategic instruments available to them – beyond just price – when maximizing profits after an increase in market concentration.

These papers examine the relationship between market structure and the overall level of differentiation and product availability in an industry; the product characteristic choices of individual firms underlie any market-level measures. A series of recent papers (e.g., Mazzeo (2002b), Seim (2006)) have developed new methods for endogenizing the product choice decisions of firms in equilibrium; this literature has expanded to treat more detailed product characteristics in the firms' choice set. Watson (2008) is an excellent example – his paper focuses on the product variety decision, in terms of the number of product offerings sold by retailers (in his case, eyewear retailers).[3] As in the case of recorded music when measured industry-wide, Watson finds that per-firm product variety has a nonmonotonic relationship with competition. When facing a closer rival in geographic space, firms tend to offer more options but the number of product varieties does eventually decline with more competition. This finding again suggests that the

[3] In retail environments, the number of product offerings (or product variety) is often used as a summary measure or proxy of the firm's quality. "Quality" can also be a firm characteristic that competitors optimally adjust depending on market structure. See Mazzeo (2004) for an example of an analysis of competition and product quality, and also a discussion of the challenges associated with empirical work in this area.

optimal response following a merger could be either to increase or decrease product variety, each of which would have an effect on consumer surplus calculations.

A small number of papers have directly addressed the issue of product variety and optimal differentiation in response to merger activity. The most influential study is by Berry and Waldfogel (2001) who document the effect of mergers on station format choice in the radio broadcasting industry. The 1996 Telecommunications Act prompted a merger wave in the broadcasting industry; this provided an instrumental variables identification strategy for measuring the effect of concentration on variety (as measured by the number of different radio "formats" represented in the market).[4] The results of the paper indicate that industry consolidation – that is, the decrease in the number of stations that followed from the Telecom Act – increased both variety per station and overall variety in the market. Mergers appear to have motivated competitors to span larger portions of product space with their offerings, as pairs of jointly-owned local stations are more likely to be in different formats. While suggestive, their analysis does not constitute a formal model of product choice, as the authors state "our approach in this paper is to obtain qualitative empirical results that may guide more detailed subsequent modeling." In a similar vein, Sweeting's (2008) paper uses micro-level data on the programming of individual radio stations to look directly at how the stations vary their playlists following mergers. The results from these initial papers do seem to indicate that firms make distinct changes to their product characteristics, with potentially important competitive consequences.[5]

[4]In a similar vein, Chu (2007) uses the entry of satellite broadcasting as a "natural experiment" and documents the changes in products offered (channel line-ups) by cable firms in response. The analysis is hampered a bit by the fact that all geographic markets experience satellite entry at the same time, which makes it difficult to separate the effect of competition on product choice from other exogenous factors. However, Chu's study does demonstrate substantial changes in the cable firms' offerings over time, which again provides evidence that modeling optimal product choice in the context of mergers would give a more complete picture of the relevant competitive effects.

[5] Interestingly, the qualitative results in another paper (Gotz and Gugler, 2006) in a different industry (the Austrian retail gasoline market) generate the opposite inference – mergers that result in more concentrated markets tend to display *less* product variety. Based on the theoretical results in the literature, it is not surprising that the effect of concentration on product variety could go either way. These authors also note that their results highlight the gap left by structural demand analyses that "neglect a key feature of market power in differentiated markets, namely that a merger between formerly competing firms may change product variety."

A final relevant paper places product characteristic choice more directly in the context of a merger simulation. Richard (2003) notes that "studies of airline mergers have focused almost exclusively on ticket price when determining consumer welfare," despite the fact that other product characteristics – in particular, flight frequency – may matter a great deal to consumers. His empirical model explicitly endogenizes the flight frequency decision of airlines, which allows for a prediction of flight frequency changes in a merger simulation.[6] After demonstrating that flight frequency is positively correlated with consumer demand, the analysis goes on to simulate a merger between American and United Airlines at O'Hare airport. When jointly maximizing profits the firms would reduce flight frequency on most (but not all) of its routes, according to Richard's empirical results. These reductions is flight frequency generate a net reduction in consumer surplus over the sample of markets studied.

In concluding this subsection, it is worth noting that authors who have proposed the use of product differentiated demand models for merger simulation were well aware of the abstraction from post-merger product selection inherent in their approach. For example, Nevo (2000) states, "this approach is not consistent with firms changing their strategies in other (than price) dimensions that may influence demand….this implies that characteristics, observed and unobserved, and the value of the outside good are assumed to stay the same pre- and postmerger." Peters (2006) suggests that real-world violation of this assumption might be the source of differences between economically-based merger simulation results and price effects of actual mergers. His paper is among the first to compare actual postmerger prices with the predictions made by models based on *ex ante* structural demand estimates.[7] His analysis uncovers substantial differences between the simulated and actual price changes associated with several airline industry mergers in the 1980s, and goes on to decompose these differences based on other post-merger data from the industry. In particular, Peters attributes a substantial portion of the post-merger price

[6] Note that the model estimated here is only a partial equilibrium model – the first-order conditions of optimal flight frequency do not include the decisions made by competitors. The model presented later in this paper, does account for market-level competition directly through a game-theoretic structural model of competition.

[7] Current working papers by Weinberg (2008) and Ashenfelter and Hosken (2008) perform similar analyses on a cross-section of industries in which recent mergers have been approved by regulators and have actually occurred.

effect to observed changes such as entry/exit, flight frequency and airport presence, as well as unobserved post-merger changes in demand and costs. Again, the takeaway is "while merger simulation can be useful in understanding the effect of a merger on unilateral pricing incentives, such methods are likely to yield unsatisfactory predictions of a merger's overall effect…unless richer models of firm conduct are incorporated into the methodology."[8]

B. Merger Cases

Courts and regulatory agencies have taken some consideration of changes in the product offerings of differentiated competitors in the process of merger evaluation. However (perhaps because of the lack of an appropriate framework to simulate product changes), specific findings are not often cited as part of the merger case rulings. The discussion that follows is not meant to represent an exhaustive summary of the legal landscape on this issue, but instead includes a survey of the cases and decisions where postmerger product repositioning is explicitly referenced.

One recent relevant case involves the merger between Whole Foods Market and Wild Oats Market – two supermarkets that specialize in organic foods (FTC v. Whole Foods Market, Inc. 533 F.3d 869 (C.A.D.C.,2008.)). The government's expert testimony in this case argued that the merged firm would close a number of currently existing stores, resulting in a reduction of competition on non-price dimensions (over and above the anticipated price effects), with a loss of consumer surplus as a consequence. However, the identity and number of stores to be closed was not projected by a formal economic model or econometric analysis; instead, plans for the status of particular establishments in the merged company was obtained through discovery. Along with the price effects of the merger, assertions were made regarding consumer harm due to

[8] Similar concerns continue to be associated with mergers in the airline industry. For example, more than 40 percent of travel managers surveyed anticipated that the 2008 merger between Delta and Northwest would negatively impact access to smaller US markets and flight schedules/frequencies (Avery, 2008). Policy makers in Montana elicited an *ex ante* response – executives from the merging airlines wrote a letter to the Montana Senate delegation promising not to cut the total number of flights servicing the state after the merger. Senator Baucus of Montana promised to "keep an eye of this merger if it goes through" and "hold the NWA-Delta CEOs feet to the fire to make sure they follow through on their promises." (Bond, 2008).

changes in "quality, service, and importantly, the breadth of product offerings available to consumers."[9]

The district court, however, focused on the potential repositioning of competitors in response to the merger as mitigating these price and non-price effects in its decision, observing that several supermarkets "have already repositioned themselves to compete vigorously with Whole Foods and Wild Oats for the consumers' premium natural and organic food business." *Whole Foods*, 502 F.Supp.2d at 48. In particular, the court decided that Whole Foods and Wild Oats competed among supermarkets generally and that the cost of other supermarkets expanding their product lines to include organic foods would not be prohibitive. While this conclusion was based on observations of the product lines of existing supermarkets, there was not an underlying empirical analysis on which it was based or an assessment of which markets would be more or less likely to experience supermarkets changing their product lines to become more direct competitors.[10]

Indeed, in several cases, the court seems more inclined to focus on the endogenous repositioning response of competitors following a merger. For example, in approving the merger between Oracle and PeopleSoft (U.S. v. Oracle Corp., 331 F.Supp.2d 1098 (N.D.Cal. 2004.)), the court found that "plaintiffs have not proved that SAP, Microsoft and Lawson would not be able to reposition themselves in the market so as to constrain an anticompetitive price increase or reduction in output by a post-merger Oracle." This suggests opposing considerations associated with exploring issues of product choice endogeneity and post-merger product repositioning in the context of antitrust. While only formally considering pricing and constraining merging parties to offer the same products after a merger necessarily understates producer surplus gains, (and potentially underestimates consumer surplus declines if product variety is reduced post-merger) anticipating the consequences of product portfolio changes for merging parties invites consideration of the ability of other market participants to mitigate the merger's effects through their own repositioning following a merger in their industry. In addition, optimal post-merger repositioning could conceivably result in more product

[9] Cited from the expert report of Kevin M. Murphy, PhD, downloaded from the FTC website.

[10] In early 2009, a settlement was ultimately reached in this case – Whole Foods is required to sell a prescribed list of stores as a result of the settlement.

heterogeneity, generating a positive effect on consumer surplus that nets away some of the harm done to consumers by higher prices.

From that perspective, an important issue becomes the relative ability of various industry participants – due to scale economies, sunk costs, or perhaps based on their market power – to introduce new products. For example, in the market for facial tissues (U.S. v. Kimberly-Clark Corp**.,** No. CIV. A. 3:95-CV-3055-P., 1996 WL 351145 (N.D.Tex. April 04, 1996)), the court's decision stated that "because entry into the facial tissue market is difficult, requiring a significant investment in plant equipment and brand building, successful new entry or repositioning after the merger is unlikely to restore the competition lost through Kimberly-Clark's removal of Scott from the marketplace." However, the court appears to have been swayed that the merger of the second and third largest manufacturers of jarred baby food would permit additional product innovation in the industry (FTC v. H.J. Heinz Co. 116 F.Supp.2d 190 (D.D.C.,2000)). The court cites the fact that fixed marketing and distribution costs are required to launch new products and "the conditions for increased competition in the form of product innovation and product differentiation will be enhanced by the merger, because the distribution of the combined entities will add Heinz's all commodity volume to Beech-Nut's all commodity volume." The court cites testimony from the defendants' expert that posited a particular volume threshold at which new product introductions would be pursued in the industry (though it is not clear how such a threshold was derived, or what the specific consequences of the product innovation ability would be).

This brief summary suggests that the effect of mergers on the extent of product differentiation in an industry is potentially quite important for courts in judging their competitive impact and ruling on whether they should be permitted. Evidence regarding post-merger product repositioning has been used in a variety of ways – to argue that merging firms will cause competitive harm over and above price effects, to justify a merger based on enhanced ability to introduce products against a more formidable competitor, or to dismiss concerns regarding anticompetitive behavior of merged parties based on the product differentiation of other industry participants. However, testimony regarding these potentially important effects has been limited (typically to circumstances in which explicit product differentiation strategies can be obtained through discovery) or

speculative. A more formal economic framework through which analysts can simulate how a merger might affect optimal product choice, industry heterogeneity, and ultimately consumer surplus may well assist courts in addressing this question in a systematic and more comprehensive manner.

III. Literature Review on Endogenous Product Choice

A few recent papers have proposed various empirical strategies in an effort to fill the gap in the literature described in the previous section. WE will provide a brief description of each below, to tee up the model presented in the following section.

A. Background Theory Work

The empirical papers cited in the previous section are partially motivated by the theoretical literature which (not surprisingly) can make almost any prediction about the optimal product differentiation behavior of competing firms depending on the assumptions in the model. The recent theoretical contribution by Gandhi et al. (2008), however, is notable for its direct focus on post-merger product repositioning and in its use of novel computational methods for solving out market equilibria in both price and product space location. The paper employs a traditional Hotelling (1929) set-up, with four stores in a unit-length product space and a standard specification for consumer utility. Initially, the stores are independently owned and play a simultaneous-move game in prices and product space locations. The analysis then compares the outcome with a potential "merger" scenario in which two of the establishments become jointly owned.

In particular – and in direct response to the gaps in extant merger simulation methodology – the paper compares outcomes in simulations in which industry participants reoptimize on price but are not allowed to change their product-space locations and with new equilibria computed for both price and location choice. While, again, the results are sensitive to the parameterization of the model (the authors go into detail regarding the effects of altering each of the parameters), the analysis highlights the impact of including product space location as a choice variable of the firms. Merging parties that previously offered similar products tend to move further away from each other in product space, as it is more profitable to avoid cannibalization. In addition, the

remaining industry participants also alter their product space locations. The authors conclude that "the merged firm's product repositioning both mitigates the reduction in consumer welfare the merger otherwise would produce and allows the merged firm to capture a much larger portion of the profits the merger generates." While the results cannot be extrapolated directly to any particular industry, the analysis does frame the important issues that an empirical model of this sort should address.

B. Endogenous Product Choice: Examples of Modeling Approaches

The challenge of adding product differentiated demand to an empirical product choice model has been taken up in a few recent working papers.[11] Each deals with the complexity involved by taking a different econometric approach, which WE will describe below in turn:

Crawford and Sum (2006) – this paper makes progress by largely abstracting from competition. Instead, the authors consider a monopolist who has the choice among various price and quality combinations for its product (including the option to offer more than one price/quality combination). In effect, they address the identification challenge associated with having an additional endogenous variable by imposing a very detailed structural model -- the one-dimensional screening model of Rochet and Stole (2003). This structural model is well-suited to their empirical example, which is the price and quantity (number of channels offered) choice for basic cable television services. While using this approach to estimate this particular product characteristic endogenously along with price is quite reasonable in this context, a substantially more complicated screening model would need to be employed to incorporate competition (unless the merger in question was a merger to monopoly).

Sweeting (2008) – the author incorporates dynamics into his product choice model, specifically focusing on the industry-wide effects of changes in product characteristics. Interestingly, his application mirrors the Berry and Waldfogel (2001) example, as he analyzes format changes in radio markets. The econometric model estimated follows the literature on dynamic competition in competitive markets (e.g., Bajari, Benkard and Levin (2007)) – by focusing on format changes, the model generates

[11] Recent contributions by Einzenberg (2008) and Fan (2008) develop similar econometric models to study endogenous product choice in the PC and newspaper industries, respectively.

an estimate of the costs to changing formats as an additional output. This is potentially quite useful, in the sense that a merger simulation would need to address the fixed costs of offering particular product characteristics. Identifying these costs, along with the usual demand parameters, is essential in appropriately adapting an endogenous product choice model to a merger application. Again, it is not clear that other empirical contexts would fit this model as well as the radio format choice model does. In addition, it might be difficult to assemble appropriate data to estimate from a panel of geographic markets. However, Sweeting's approach appears like a very promising one, which other authors should attempt to follow up on and extend.

Zhou (2008) – this paper combines some of the ideas in the two papers above, focusing on quality as the key endogenous product characteristic and using a panel of data to back out fixed costs. The application is to the banking industry, where a bank can choose whether to enter particular geographic markets and how many branches (more branches representing higher quality) to open. To aid with identification of the model, Zhou exploits the relatively large number of bank mergers during the period of her data (1994 to 2005), and is able to observe how market participants change their price and product quality behavior as a result. While mergers are not endogenized within the model, the endogeneity is accounted for using the geographic heterogeneity of competition within the banking industry. With the cost estimates from the model, Zhou is able to simulate both the price and the product quality effects of potential subsequent mergers. In addition, she finds that failing to endogenize product quality in this application results in a substantial underestimate of the relevant price elasticities.

IV. DSM (2008) Model and Merger Simulation

In this section, WE present an alternative approach to incorporating endogenous product choice within a differentiated product demand model. The model was developed along with Michaela Draganska and Katja Seim; the presentation below follows our joint paper (Draganska, Mazzeo and Seim, 2008), which also estimates the model and present several counterfactual analyses. Here, WE will do two things – (1) describe the model that we used in this paper and (2) report the results from a very simple merger simulation.

Because product choice is endogenized in the model, the merger simulations allow for the possibility that merging firms will choose to offer different products after the merger. The impact of this assumption relaxation will be highlighted in the discussion.

A. Model

Suppose the industry has a total of $b = 1, \ldots, B$ firms that decide which products to offer in a given market and how to price them given their expectation of their competitors' offerings, demand, and a fixed cost of offering each subset of products. The model begins by assuming a first stage, in which the firms decide which products to offer. Each firm starts with a predetermined set of potential products to offer and selects the optimal subset of products among this potential set. In the second stage, firms observe each others' product choices.[12] Conditional on the firm's choice of products and its competitors' choice of offerings, firms optimally choose prices.

For any firm that offers multiple products, it is likely that there are certain products it always offers (and would continue to offer after a merger). These are referred to as staples. The decision modeled here concerns only what remain – the optional products. The product choice model can be thus thought of applying to optional products of a firm that are not offered in all of the geographic markets where the firm operates, as opposed to its staples. While abstracting from the product offering decision for staples, the model takes into account the demand for staples in determining the price for all products in the market.

More formally, firm b has products $f = 1, 2, \ldots, O_b, O_{b+1}, O_{b+2}, \ldots, F_b$ at its disposal. The optional products are $1, \ldots, O_b$ and products $O_{b+1}, \ldots, F_b$ are the staples that the firm always offers. Note that the optional and staple products may differ from firm to firm. Define the vector $d_{bt} = (d_{b1t}, \ldots, d_{bObt}) \varepsilon \{0, 1\}^{Ob}$, where d_{bft} indicates whether optional product f is offered by competitor b in market t.

Stage 2: In the second stage, the model solves for equilibrium prices for every possible combination of product choices. These prices then flow back into the first stage to determine profits for each of the products that a firm is considering.

[12] Therefore, the current model does not permit market participants to occupy "new" product space locations after a merger. As such, it is best to interpret the repositioning effects as short-run effects only.

Consumer demand To begin, the model asserts a discrete choice model of demand. Let U_{bfkt} denote consumer k's utility for brand b's product f in market/period t. and specify:

$$U_{bfkt} = X_{bft}\beta - \alpha p_{bt} + \epsilon_{bfkt} = \bar{U}_{bfkt} + \epsilon_{bfkt} \qquad (1)$$

where U_{bft} is the mean utility across consumers. In the above specification of utility, X_{bft} denotes observed characteristics of the product, such as firm and/or product fixed effects, whether the product is featured in the store ads or on display in the store in a given market. p_{bt} denotes the price charged by firm b in market t. Note that prices for all products within a brand are the same as is typical in product categories such as ice cream (e.g., Draganska and Jain, 2006). The random component of utility, ε_{bfkt}, is assumed to be distributed according to an extreme value distribution. It is known to the consumer, but observed by the firms or the researcher only in expectation.

Normalizing utility from the outside good to zero results in logit market shares for the products that the brands offer:

$$s_{bft}(p_{1t}, \ldots, p_{Bt}; d_{1t}, \ldots, d_{Bt}) = \frac{\exp\left(\bar{U}_{bft}\right)}{1 + \sum_{b'} \sum_{f'=1}^{O_{b'}} \exp\left(\bar{U}_{b'f't}\right) d_{b'f't} + \sum_{b'} \sum_{f'=O_{b'}+1}^{F_{b'}} \exp\left(\bar{U}_{b'f't}\right)} \qquad (2)$$

Market shares depend on prices $p_{1t}, \ldots, p_{Bt}$ as well as product offerings $d_{1t}, \ldots, d_{Bt}$.

Firm profits For a given choice of products determined in the first stage, firm b chooses prices to maximize expected profit. Firms are assumed to compete in Bertrand-Nash fashion, given their cost structures. Firm b incurs a marginal cost of c_{bt} for each unit offered in market t. The marginal costs of offering a product may include costs of raw materials, packaging, and distributing the product. These are specified as $c_{bt} = \sum_k w_{bkt}\gamma + \eta_{bt}$, where w_{bt} are brand-specific cost shifters k and η_{bt} is a brand-specific component of marginal cost. By assumption, firms observe each other's marginal costs when they choose prices, i.e., marginal costs are public information.

As in the literature (e.g. Berry et al. 2004), the model allows part of the marginal costs to be unobservable to the researcher. Similar to the demand-side problem of accounting for unobserved product characteristics for absent products, the value of the unobservable marginal cost components for a brand-product combination that is not

offered is not observed. This problem is solved by assuming that the unobservable component of marginal cost varies by time and brand but not by product. Assuming that firms set their prices optimally (conditional on the chosen assortment), this allows for recovery of the value of the unobservable from the pricing first-order conditions, which can be used to estimate the firm's marginal costs of offering a product that it ultimately does not include in its assortment.

In addition, firm *b* has a fixed cost to offer product *f* in each market *t*, v_{bft}, distributed according to probability distribution function G_{bf} that differs across brands and products. The fixed costs of offering a product may potentially include the operating costs of producing the product (foregone economies of scale due to smaller batches, cost of maintaining equipment, cleaning machines, labeling, etc.), or advertising costs associated with promoting the product (which may vary on a product-by-product basis depending on the offerings of the local competition). The model assumes that this fixed cost varies by product and is only observed by the firm itself, but not by its competitors, i.e., it is private information. In contrast to marginal costs, which are primarily driven by observable costs for homogeneous inputs, fixed costs may depend on the efficiency of each firm's processes or a proprietary strategic decision they have made.

If a firm decides to offer more than one optional product, its total fixed costs are the sum of the individual fixed costs. This additive formulation allows handling of multi-product firms without adding too much complexity. The drawback is that economies of scope are ruled out in this specification, i.e., the fixed cost of adding a particular product does not change with the products that are already being offered. This is one factor that may need to be relaxed in analyzing competition in an actual merger context.

Firm *b*'s objective is to maximize the profit from the staples and the optional products that it offers (as indicated by $d_{bt} = (d_{b1t}, \ldots, d_{bO_bt})$):

$$\max_{p_{bt}} (p_{bt} - c_{bt}) M \left(\sum_{f=1}^{O_b} s_{bft}(\cdot)\, d_{bft} + \sum_{f=O_b+1}^{F_b} s_{bft}(\cdot) \right) - \sum_{f=1}^{O_b} v_{bft}\, d_{bft} \qquad (3)$$

where *M* is the size of the market. To simplify the notation, $(p_{1t}, \ldots, p_{Bt}; d_{1t}, \ldots, d_{bt})$ are supressed as arguments of s_{bft}.

Differentiating yields the competitors' first-order conditions with respect to prices:

$$p_{bt}(d_{1t},\dots,d_{Bt}) = c_{bt} - \frac{\sum_{f=1}^{O_b} s_{bft}(\cdot)\, d_{bft} + \sum_{f=O_b+1}^{F_b} s_{bft}(\cdot)}{\sum_{f=1}^{O_b} \frac{\partial s_{bft}(\cdot)}{\partial p_{bt}} d_{bft} + \sum_{f=O_b+1}^{F_b} \frac{\partial s_{bft}(\cdot)}{\partial p_{bt}}} \qquad (4)$$

Solving the system of equations (4) yields equilibrium prices for the specific flavor offerings considered. The dependency of prices on product offerings is emphasized by writing $p_{bt}(d_{1t},\dots,d_{Bt})$ for equilibrium prices. Equilibrium prices for the remaining possible product sets are determined analogously. This yields gives us a vector of $2^{\sum_b O_b}$ different prices for firm *b*, one for each possible bundle of products that could be offered. Let $s_{bft}(d_{1t},\dots,d_{Bt})$ denote the corresponding market share of product *f* offered by brand *b* in market *t* and s_{bt} denote brand *b*'s aggregate market share as a function of its and its competitors' product offerings, $s_{bt} = \begin{pmatrix} \sum_{f=1}^{O_b} s_{bft}(d_{bt}, d_{-bt}) d_{bft} + \\ \sum_{f=O_h+1}^{F_b} s_{bft}(d_{bt}, d_{-bt}) \end{pmatrix}$, where $d_{-bt} = (d_{1t},\dots,d_{b-1t}, d_{b+1t},\dots,d_{Bt})$ are the product offerings of all brands but *b*. There is no asymmetric information in the price-setting stage. Conditional on having made a product choice, prices are determined in a symmetric Nash equilibrium.

Stage 1: Each firm chooses the optimal set of products given its expectation of the other firms' choices and prices under each configuration. Firm *b* chooses $d_{bt} = (d_{b1t},\dots,d_{bO_ht})$ to maximize expected profits given by:

$$\begin{aligned} \mathrm{E}[\Pi_{bt}(d_{bt}, d_{-bt})] &= \mathrm{E}\left[(p_{bt}(d_{bt}, d_{-bt}) - c_{bt}) M s_{bt}(d_{bt}, d_{-bt}) - \sum_{f=1}^{O_b} v_{bft} d_{bft}\right] \\ &= \sum_{d_{-bt}} \left((p_{bt}(d_{bt}, d_{-bt}) - c_{bt}) M s_{bt}(d_{bt}, d_{-bt})\right) \Pr(d_{-bt}) - \sum_{f=1}^{O_b} v_{bft} d_{bft} \\ &= \overline{\Pi}_{bt}(d_{bt}) - \sum_{f=1}^{O_b} v_{bft} d_{bft} \qquad (5) \end{aligned}$$

The first part of the expression is the expected variable profit and the second represents the fixed costs. Since firm *b* does not know the fixed costs of its rivals, it cannot predict their product offerings with certainty. Hence, firm *b* forms expectations

over its rivals' product offerings. In particular, Pr(d_{-bt}) is the joint probability that its rivals offer the particular subset of products in d_{-bt}.

The marginal probability that firm b offers bundle d_{bt} is:

$$Pr(d_{bt}) = Pr(\mathrm{E}[\Pi_{bt}(d_{bt}, d_{-bt})] \geq \mathrm{E}[\Pi_{bt}(d'_{bt}, d_{-bt})] \forall d'_{bt} \in \{(0,1)\}^{O_b})$$
$$= \int_{A(d_{bt})} \prod_{f=1}^{O_b} dG_{bf}(v_{bft}) \qquad (6)$$

where $A(d_{bt})$ denotes the set of values for $v_{bt} = (v_{b1t}, \ldots, v_{bO_bt})$ that induce the choice of product bundle d_{bt}:

$$A(d_{bt}) = \left\{ v_{bt} \left| \overline{\Pi}_{bt}(d_{bt}) - \overline{\Pi}_{bt}(d'_{bt}) \geq \sum_{f=1}^{O_b} v_{bft}(d_{bft} - d'_{bft}) \, \forall d'_{bt} \in \{0,1\}^{O_b} \right. \right\} \qquad (7)$$

Assuming independence across firm cost shocks, v_{bft}, entails that the joint probability of observing a particular set of product offerings in the market $(d_{1t}, \ldots, d_{Bt})$ is the product of the marginal probabilities for d_{bt} defined in equation (6). Substituting the product choice probabilities defined above into each firm's expected profit yields a measure of the attractiveness of each choice as a function of the competitors' probabilistic choice. The probability that firm b chooses product offering d_{bt} is then the probability that the expected profit of offering d_{bt} exceeds expected profits of any other product offering d'_{bt}, given its conjecture of its competitors' behavior.

The expressions defined in equations (5) and (6) characterize a system of $\sum_{b=1}^{B} 2^{O_b}$ equations in $\sum_{b=1}^{B} 2^{O_b}$ unknown product choice conjectures. Each firm's probability of offering a given product assortment is determined by numerically integrating over its unobserved fixed cost v_{bt}, as a function of its competitors' assortment choice probabilities. The equilibrium probabilities of offering each product combination are found by searching for the fixed point of the system of equations for all competitors, the solution to which are the $\sum_{b=1}^{B} 2^{O_b}$ product offering probabilities. A nonlinear equation solver is used to solve the system of equations defined in equation (6). The resulting fixed point in product offering probabilities is the Bayesian Nash equilibrium for the system of best response functions.[13]

[13] It is worth noting here that there may be other variants of demand and/or product choice modules, with different assumptions, that could reasonably be combined to address the issue at hand. Depending on the context provided by a particular merger case, an alternative approach might be better.

B. Constructed Merger Simulation

One compelling reason to model endogenous product choice together with demand is to generate more accurate merger simulations. As discussed previously, simulations based on demand models that do not allow for the possibility that a merged firm might change the composition or characteristics of its post-merger product portfolio do not necessarily reflect the firm's optimal behavior. The parameters of the model permit a more accurate simulation, as both price and the set of offered products can be optimally adjusted. To illustrate the impact of this change, a series of simple merger counterfactuals using data from 256 simulated markets. In each market, there are initially two firms, each of which offers two products. Subsequently, a merger between the two firms commences. The results of this counterfactual simulation demonstrate the potential pitfalls that can occur by ignoring endogenous product choice.

To obtain the effects of a merger and to demonstrate the impact of allowing for product choice in the model, optimal behavior is simulated in three different scenarios. First is the base duopoly case in which the two firms in question are competitors, choosing products to offer and then competing on price. The firms are then allowed to merge, acting like a monopolist and potentially offering as many as four products. The results distinguish between two alternatives, constraining the merged firm to either offer the same products that the duopolist did (the current standard in the literature) or allowing it to reoptimize in the product-choice stage. As a consequence, the monopolist potentially chooses a different set of products to offer than in the competitive environment. Market outcomes are simulated under a low and high regime for the fixed costs of offering the individual products as presented in the left and right panels of Table 1.

To compute the statistics presented in Table 1, simulation techniques are used to integrate over the empirical distribution of product fixed costs. For a given draw from the cost distributions of each of the four products, the monopolist's optimal product choice given the realizations are recorded together with the optimal price, variable profit, and total profit of the chosen assortment. Then, the duopolists' assortment choice problem are solved for by computing each brand's expected profit of offering each assortment. As in

the monopoly case, the realization of brand-product fixed costs, each firm's chosen assortment, and the associated optimal prices and profits are recorded. For the duopolists' chosen assortments, the monopoly prices and profits are recomputed. This procedure is repeated to integrate over the distribution of fixed costs, allowing determination of the expected profit and prices of offering each assortment under the three competitive scenarios and, for the monopolist, the empirical frequency with which each assortment is offered. For each of the 256 markets, weighted average prices, consumer surplus, and variable and total profits are obtained by aggregating across assortments using as weights the empirical (in the case of the monopolist) or equilibrium (in the case of the duopolists) probability with which each assortment is offered.

Table 1 presents a summary of the key market-level outcomes under the scenarios described above, with all the figures representing the average outcomes across all the markets. The “fixed products" merger simulation generates reasonable findings, in line with other studies using similar methodology. Comparing the first two columns of each panel, prices and profits are higher for the merged firm than for competing duopolists, while consumer surplus is lower. By construction, the number of products is the same in each of the first two columns. When no longer constrained, total industry profits are (necessarily) higher, as the newly merged firm chooses to offer a different assortment some of the time. In the case presented in Table 1, the resulting endogenous post-merger product assortment depends critically on the level of the fixed costs of offering additional products. In the low fixed cost regime the merged firm offers fewer products on average, while the merged firm occasionally offers more products in the high fixed cost scenario. Indeed, it appears that the reduction in price competition makes it worth spending the higher fixed cost to offer an additional product some of the time. As a consequence, in the high fixed cost simulation the merger results in both higher total profits and higher consumer surplus as compared with the duopoly case. Such a finding would not be possible without endogenizing the product assortment decision, as our methodology allows.

These simulated merger results also give some idea about magnitudes; in particular, whether ignoring product assortment endogeneity generates substantial changes between the results in the second and third columns (as compared with the

differences between the first and second columns). As such, one could interpret the results in Table 1 as suggesting that ignoring product choice has minimal effect if the fixed costs to offering each product are low. However, it is important to recognize that the example constrains the merged firm to optimize only among the previously offered products. In a case where the merged firm has the entire Hotelling line available to choose from (as in Gandhi et al. (2008)) or a larger product choice set at its disposal, the impact is likely to be more substantial. Additional market participants may also re-optimize portfolios post-merger, generating more changes to surplus and profits. Indeed, the results in any specific case will rely critically on the estimated parameters in the model. Nonetheless, this exercise clearly demonstrates the importance of endogenizing product choice in the context of a policy simulation.

C. Simulations and Counterfactuals Using Estimates

While the simulations discussed above give a good idea of could happen in a hypothetical scenario constructed for that purpose, the use of empirical methodology in actual applied settings is the ultimate goal. Toward that end, we have constructed Table 2, which presents the same type of merger simulations as in Table 1 using the demand and cost parameters estimated in Draganska, Mazzeo and Seim (2008) for the ice cream industry. As it turns out, in this example, the difference in the "Fixed Products" and the "Endogenous Choices" simulations are quite similar – especially as compared to the duopoly results – in terms of prices, profits and consumer surplus. This is not surprising, given the fact that the freedom to change products optimally does not actually change the set of products offered in most cases. The table indicates that the firms change the flavors offered about two percent of the time, given the estimated demand and fixed cost parameters.

A major advantage of estimating the structural parameters of the demand and cost functions using our method is that it allows the possibility to see the implications of changing these parameters on the merger simulations. In particular, Table 3 investigates the effect of changes in the fixed costs associated with offering products. As discussed in section II.B above, parties in antitrust cases have made arguments that merger synergies may decrease such fixed costs, but courts have been forced to speculate about

the effect of this on prices, profits and consumer surplus. Here, we experiment with a hypothetical reduction from the base case presented in Table 2, of 10 percent in the fourth column of Table 3 and 25 percent in the last column. The results indicate that prices, profits and consumer surplus all increase – in conjunction with a substantial increase in the number of products offered with large fixed cost reductions. Again, the direction of the effect is not surprising; the key is that the model allows the computations to be made. Indeed the size of the result will be idiosyncratic, and evaluations will need to be done on a case-by-case basis.[14]

V. Discussion

This application highlights both the opportunities and limitations associated with models that add endogenous product choice to the estimation of product differentiated demand. There is a tradeoff between isolating an empirical context that is promising for estimation and having an application that may be policy relevant. As a prerequisite, there must be multiple markets to build the data set (either a cross-section or a time series will do) with variation in the products offered by competing firms across the observations. The ice-cream industry application used to estimate the model presented above in Draganska, Mazzeo and Seim (2008) met this criterion because (in the premium ice cream category) there are two national manufacturers who distribute at least some of their product line in all of the designated regional submarkets. However, across the regional markets (and within the markets over time), a different subset of the product line is offered to consumers. Without this sort of variation, it would not be possible to investigate the issue of product choice at all.

Provided the setting has some variation in the product availability of competing firms, separately identifying the costs of offering particular products becomes the next empirical challenge. Unless a very specific structural model of industry behavior is reasonable to impose (e.g., Crawford and Shum, 2006), having some additional source of exogenous variation – essentially, another "instrument" beyond the usual instrument for price – is extremely useful. In the ice cream context, the national manufacturers face

[14] In future work, we will investigate the effects of having a third firm in the industry that does not merge but can act optimally in response to the merger of two of its competitors in terms of both price and product offereings.

different local ice cream makers in each of the various regional markets. The market position and product lines of the smaller, local firms depend largely on their history and geography (e.g., there are no strong local firms in Phoenix, a newer city with a minimal local dairy industry). To aid with identification, therefore, we take these local competitors to be exogenous in the product choice stage of the model. Again, this attractive feature of the context we examine may not have an analog in a particular policy-relevant industry. Furthermore, treating the non-national competitors as exogenous with respect to product choice obviates their own potential post-merger repositioning, which is likely to be especially important to courts in antitrust proceedings. Some additional modifications to the model may be required to address such issues.

In addition, this modeling approach makes the underlying assumption that there are some unobserved fixed costs to offering particular products that – along with local variable cost and demand factors – determine which product space locations firms choose to occupy. From an econometric perspective, this is almost tautological, as adding the entry/product space location stage to the model allows the researcher to "back out" what is subsequently interpreted as the unobserved fixed cost. However, from a more conceptual perspective, it is useful to have in mind what such unobserved fixed costs might actually be, and why these costs would vary by the choice of product space location. This may or may not be a stretch, in any specific empirical setting.

Finally, in order to generate results that are useful in a policy context, the model and merger simulation may need to be enhanced. In particular, it would be beneficial to add additional market participants beyond the merging parties who could potentially also optimally reposition their products after a merger. Some merger cases have argued that a merged competition may have lower fixed costs of introducing products; the implications of such possibilities on welfare calculations could also be accommodated with some extension to the model. The framework proposed here is reasonably flexible and in future work we plan to investigate the implications of some of these additional features.

In conclusion, the models presented and reviewed in this paper represent the early steps in filling an important gap in the empirical industrial organization literature. Researchers should continue to push forward on these methods to improve both demand estimation and merger simulation. At the same time, having estimable models that

incorporate product choice will be extremely useful to courts, which seem to be very interested in incorporating the consequences of mergers in terms of product availability and differentiation but do currently not have the analytical techniques to evaluate these issues in a systematic way. Economists working on this topic should be mindful of the potential applications of this work, therefore, and as much as possible focus on methodological contributions that are feasible to be used in applied settings.

Table 1: Constructed Merger Simulations

	Low Fixed Costs			High Fixed Costs		
		Merged Firm			Merged Firm	
	Duopoly	Fixed Products	Endogenous Products	Duopoly	Fixed Products	Endogenous Products
Price – Brand 1	4.1707	4.8710	4.8317	4.6044	4.7048	4.8011
Price – Brand 2	3.9295	4.7381	4.6685	4.4347	4.4736	4.5245
Total Profits – Brand 1	0.2117	0.4981	0.4833	0.0487	0.0488	0.0646
Total Profits – Brand 2	0.2075	0.3266	0.3822	0.0818	0.0819	0.0790
Industry Total Profits	0.4191	0.8247	0.8656	0.1305	0.1307	0.1436
Number of Products	1.8585	1.8585	1.4361	0.4395	0.4395	0.4709
Consumer Surplus	2.7593	1.2642	1.2261	0.6356	0.6348	0.6766

Notes:

- This merger simulation is presented as Table 12 in Draganska, Mazzeo and Seim (2008). For the ice cream application in the paper, the data include supply and demand shifters (parameters listed below) that represent factors affecting costs and preferences relevant for this industry.
- Both scenarios assume the same demand parameters of β_0 = [6.5;6.0;5.0;5.5], β_{price} = [-2.5], β_{temp} = [0.1], where [β_0^1 … β_0^4] denote the four product-specific intercepts.
- Both scenarios assume the same marginal cost parameters of γ_0 = [0.45;0.30], $\gamma_{distribution}$ = 0.001, and γ_{sugar} = 0.30], where γ_0^1,β_0^2 denote brand-specific intercepts.
- The low-fixed cost scenario assumes the following parameter values for the four product fixed cost distributions: ν = [0.035;0.3; 0.09; 0.12] and σ = [0.16; 0.16; 0.16; 0.16].
- The high-fixed cost scenario assumes the following parameter values for the four product fixed cost distributions: ν = [1.44; 1.20; 1.00; 1.12] and σ = [0.16; 0.16; 0.16; 0.16].

Table 2: Merger Simulations Using Estimated Parameters

		Merged Firm	
	Duopoly	Fixed Products	Endogenous Products
Price – Breyers	4.549	6.329	6.283
Price – Dreyers	4.842	6.027	6.003
Total Profits – Breyers	3.260	3.348	3.394
Total Profits – Dreyers	5.307	6.480	6.461
Industry Total Profits	8.567	9.828	9.855
Number of Products Offered	2.550	2.550	2.483
Share of Time Offered			
Product #1	0.975	0.975	0.951
Product #2	0.869	0.869	0.841
Product #3	0.706	0.706	0.691
Consumer Surplus	14.906	14.074	14.055

Notes:

- This merger simulation is presented as the middle panel in Table 11 in Draganska, Mazzeo and Seim (2008). For the ice cream application in the paper, the data include supply and demand shifters (parameters listed below) that represent factors affecting costs and preferences relevant for this industry.
- The calculations made here involve only the "optional" products for the two firms. The total market is set to 5% of the actual market and the value of the outside option is scaled down by 50%.

Table 3: Merger Simulations Using Estimated Parameters

		Merged Firm			
		Same Fixed Costs		Fixed Cost Reduction	
	Duopoly	Fixed Products	Endogenous Products	10% Lower	25% Lower
Price – Breyers	4.549	6.329	6.283	6.384	6.459
Price – Dreyers	4.842	6.027	6.003	6.085	6.149
Total Profits – Breyers	3.260	3.348	3.394	3.312	3.281
Total Profits – Dreyers	5.307	6.480	6.461	7.029	7.491
Industry Total Profits	8.567	9.828	9.855	10.341	10.772
Number of Products Offered	2.550	2.550	2.483	2.640	2.798
Share of Time Offered					
Product #1	0.975	0.975	0.951	0.968	0.985
Product #2	0.869	0.869	0.841	0.918	0.976
Product #3	0.706	0.706	0.691	0.754	0.837
Consumer Surplus	14.906	14.074	14.055	14.109	14.150

Notes:

- The first three columns come from the merger simulation is presented as the middle panel in Table 11 in Draganska, Mazzeo and Seim (2008). For the ice cream application in the paper, the data include supply and demand shifters (parameters listed below) that represent factors affecting costs and preferences relevant for this industry.
- The calculations made here involve only the "optional" products for the two firms. The total market is set to 5% of the actual market and the value of the outside option is scaled down by 50%.
- The last two columns change the level of the fixed costs estimated by the econometric model, as a consequence of the merger.

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