Vertical Contracts and Endogenous Product Selections: An Empirical Analysis of Vendor Allowance Contracts*

Sylvia Hristakeva†

November 2, 2017

Abstract

Strategic retailers choose assortments taking consumer preferences, downstream competition, and vertical contracts into account. Thus, vertical contracts cannot be understood in isolation from retailers' endogenous product selections. Producers frequently provide retailers with financial incentives to gain distribution of their products. These payments often take the form of vendor allowances: lump-sum transfers to retailers that do not directly depend on quantity sold. I develop a framework to quantify lump-sum transfers using only data on retail prices, sales, and assortments. Model estimates imply that vendor allowances correspond to 4.21% of retailers' revenues. To understand how vendor allowances affect market outcomes, a counterfactual analysis restricts contracts to include only wholesale prices. Simulations predict a decrease in retailers' profits even though total vertical surplus increases. Moreover, the change in the vertical contract affects both equilibrium wholesale prices and product availability.

*I thank Julie Holland Mortimer and Michael Grubb for their guidance, advice, and continued support. I also thank Alon Eizenberg, Paul Grieco, Wills Hickman, Arthur Lewbel, Peter Rossi, and Mark Rysman for valued comments and suggestions. I am also grateful for feedback from seminar participants at Boston College, University of Rochester, Stanford GSB, Tilburg University, UCLA Anderson, University of Michigan, and Yale SOM. All estimates and analyses in this paper based on SymphonyIRI Group, Inc. data are by the author and not by SymphonyIRI Group, Inc. All remaining mistakes are my own. This paper was previously circulated under the title "How do vertical contracts affect product availability? An empirical study of the grocery industry."

†UCLA Anderson School of Management; email: sylvia.hristakeva@anderson.ucla.edu

1 Introduction

In many industries producers reach consumers only through the retail sector. Yet, due to limited shelf-space, retailers carry only a subset of all available products. Therefore, retailers' product selections have large consequences for firm profits and consumer welfare. In addition to consumer preferences and retail competition, vertical contracts with producers are important determinants of retailers' assortments. This paper seeks to further our understanding of vertical relations by studying vertical contracts in a setting with endogenous retailers' product selections.

Contracts between producers and retailers commonly consist of wholesale prices and vendor allowances. I define vendor allowances as lump-sum transfers to retailers that do not directly depend on volume. They can take the form of slotting fees, warehousing allowances, vendor cash discounts, allowances for damaged goods, or operating support (e.g. stocking personnel).[1] Such financial incentives are extensively used by manufacturers to gain product distribution; hence, vendor allowances likely have a direct impact on the product assortments selected by retailers.

The retail sector accounts for a large fraction of the U.S. economy, totaling \$5.0 trillion in 2013. Considering the size of the market and the potential impact of vendor allowance contracts on product availability and total welfare, it is not surprising that lump-sum transfers have been the subject of policy discussion.[2] Nevertheless, there is little consensus about the equilibrium effects of vendor allowances on market outcomes. Theorists have presented models in which vendor allowances are either anti-competitive or efficiency-enhancing.[3] In

[1]Initially, the term slotting fees was used to refer to one-time payments from producers to retailers to place a product in stores. The term is now broadly used to refer to a variety of vertical arrangements in which producers make lump-sum payments to retailers (Federal Trade Commission (2014)). The IRS broadly defines "vendor allowances" as payments "intended to offset retailer's costs of selling the vendor's products in its stores." In practice, this could also include payments such as promotional allowances, which are calculated on a per-unit basis rather than a fixed lump-sum.

[2]Slotting fees were at the heart of Senate hearings and Federal Trade Commission workshops in the 1990's and the early 2000's with repeated attempts from small business organizations to implement bans on slotting allowances (Bloom et al. (2000), Federal Trade Commission (2001), Federal Trade Commission (2003)).

[3]On the one hand, the use of vendor allowances may lead to anti-competitive practices. For example, vendor allowances increase market prices (Shaffer (1991), Piccolo and Miklós-Thal (2012)), or may be used to foreclose a competitor (Shaffer (2005), Marx and Shaffer (2007), Asker and Bar-Isaac (2014)). Marx and Shaffer (2010) show that powerful retailers may find it optimal to limit shelf space to extract higher rents from producers. On the other hand, vendor allowances may arise as a mechanism for the efficient allocation of scarce shelf space (Sullivan (1997)). Other welfare-enhancing mechanisms include the use of vendor allowances to signal product quality (Lariviere and Padmanabhan (1997)), to increase product variety (Kuksov and Pazgal (2007), Innes and Hamilton (2013)), to ensure that the assortment which maximizes vertical profits is supplied (Aydin and Hausman (2009)), and to coordinate non-contractible manufacturer sales effort (Foros et al. (2009))

fact, the Federal Trade Commission (FTC) abstains from providing clear guidelines on the use of slotting fees, citing conflicting theoretical predictions and scarce empirical evidence as a rationale. Unfortunately, the proprietary nature of vertical contracts and firm costs has been an impediment to empirical analysis that could resolve these conflicting narratives.

Taking these challenges into consideration, this paper analyzes the equilibrium consequences of the use of vendor allowances when product assortments are endogenous. I address two main questions. First, how large are unobserved vendor allowances? To answer this question, I develop a framework to identify lump-sum transfers from producers to retailers when only limited data are available: retail prices, sales, and assortments. The analysis does not require data on vertical contracts or firm costs, which are typically unobserved. Instead, by exploiting the information from the observed retailers' product selections, vendor allowances are estimated as the payments needed to rationalize observed assortments. I apply the framework to the U.S. yogurt grocery market and find that vendor allowances amount to 4.21% of retailers' revenues. The second question asks: how do contracts including vendor allowances affect market outcomes? I use model estimates to simulate a counterfactual scenario that restricts the vertical contract to consist of only linear wholesale prices. Simulations suggest that both equilibrium wholesale prices and product assortments change, illustrating that the type of vertical contract may influence product availability.

The framework describes interactions between producers, retailers, and consumers as a five-stage game. In practice, grocery chains select the yogurt assortments supplied and the model implements this industry practice. First, retailers announce the set of products they would like to supply and initiate negotiations over these selected products. Negotiations are modeled as simultaneous producers' take-it-or-leave-it offers of product-specific wholesale price and vendor allowance. Importantly, retailers have an outside option: if a product offer is rejected, then the retailer may supply an alternative product in its place. In the grocery sector, such replacement products are available to retailers from a wholesaler or another intermediary at non-negotiated prices. These potential replacement options serve as credible threats and allow retailers to demand favorable contracts from producers. Conditional on assortments and contracts, the fourth stage of the game models retailer price competition as a differentiated-product Bertrand-Nash game. Last, consumers observe market assortments and prices, and choose utility maximizing product-retailer pairs.

I apply the framework to the U.S. grocery yogurt market for the 2001-2010 period using the IRI academic dataset. Vendor allowances are known to play an important role for most segments of the grocery industry and especially for refrigerated categories. In addition, the yogurt category is characterized by a proliferation of differentiated product options, limited shelf space, and high costs of holding inventories due to refrigeration. Thus, retailers' strategic assortment choices may substantially impact vertical contracts, consumer choices, and total welfare.

Estimation proceeds in two steps. First, standard techniques, as in Berry et al. (1995), are applied to consumer demand and retailer pricing analyses: demand is estimated using the random-coefficients logit model, while retailers' markups are recovered from the optimality conditions imposed by the Bertrand-Nash game. Next, vendor allowances are inferred using incentive compatibility conditions for retailers: in equilibrium, no retailer may increase its expected profits by unilaterally altering its product assortment. To my knowledge, this is the first paper to exploit the identities of supplied and excluded products to infer information about vertical contracts.

A simple example illustrates how vendor allowances may be inferred from observed product selections. Suppose retailer 1 carries *Yoplait Trix* but it could switch to *Breyers Light*, leaving the rest of its assortment unchanged. Retailer 1's variable profit for the observed product offering is \$20,500 per store and its variable profits for the alternative assortment would have been \$20,600. This suggests that the vendor allowance received for *Yoplait Trix* must be at least \$100 per store. Vendor allowance transfers reflect retailer's shadow price of shelf space, which is approximated as the additional retailer's profits generated by switching a product with its most profitable replacement. The assumption of producers' take-it-or-leave-it offers implies that contract offers place retailers on their participation constraints.

The separation of product assortment decisions and retail price competition allows for the separate identification of wholesale prices and vendor allowances. Conditional on assortments, retail pricing and demand analyses identify downstream variable profits. Then, using the observed assortment choices, I identify vendor allowances as the transfers needed to satisfy retailers' incentive compatibility conditions. To ensure consistency of first-step parameter estimates, I assume that product selection is based on observables: retailers choose assortments before the realization of structural shocks to demand. The assumption is credible because grocery chains alter assortments at only a few predetermined occasions. In contrast, retail prices can be easily adjusted as market conditions change; thus, structural shocks are allowed to affect pricing decisions made by retailers. I use cost-based instrumental variables to address price endogeneity.

Model estimates suggest a median consumer price elasticity of -4.3 and median retailer variable profit margins of 27.5%. These estimates align closely with the 27% median variable profit margins reported by public grocery chains during the analyzed period. Vendor allowance estimates suggest that, for the median retailer, these payments constitute 4.21% of retailer's revenues and 13.41% of retailer's variable profits. Reported vendor allowances for the median chain correspond to 7% of revenues.[4] Constructed vendor allowances suggest that these economic transfers are likely important for firm profitability. The framework allows me to recover this additional component of retailers' profits by exploiting the information from retailers' endogenous product choices.

Next, I investigate how vendor allowances affect market outcomes and, in particular, whether the use of economic transfers from producers to retailers affects product availability. The counterfactual restricts contracts to include only wholesale prices. When contracts are thus restricted, both wholesale prices and product assortments may change. Keeping retailers' shelf space fixed, the simulations find new equilibrium assortments, contracts, and downstream prices.

Counterfactual results for Toledo, OH show that, absent vendor allowances, total vertical profits increase by, on average, 2.18%, and consumer surplus is 0.36% higher. These increases are driven by changes in retailers' product assortments. On average, counterfactual assortments are constructed by changing 6.75 products. In the counterfactual, retailers are predicted to include "popular" products that were previously excluded. In particular, retailers add the products that serve as their most profitable replacement deviations in the observed assortments. The counterfactually dropped products have inferred positive vendor allowances. These adjustments lead to a 4.45% decrease in average retailers' profits, while average producers' profits increase by 13.12%.

The vendor allowance analysis suggested that retailers extract payments from producers by exploiting the profitability of excluded products. Thus, a retailer may strategically exclude a product in order to obtain vendor allowances or wholesale prices discounts. In contrast, counterfactual simulations reveal that the restricted contract cannot support assortments that exclude popular products and imply large retailers' outside options. For example, the observed assortments may not be supported by a contract that consists of only wholesale prices. This occurs because the wholesale price decreases, necessary to satisfy retailers' participation constraints, violate at least one producer's individual rationality conditions. As a result, the counterfactual assortments include the products that implied high retailers' outside options for the observed assortment. These findings suggest that retailers' ability to strategically exclude a product and extract rents from producers might be weakened in the absence of vendor allowances.

[4]The accounting term differs from the opportunity cost estimates in two important ways. First, the IRS definition also includes promotional allowances, which are paid on a per-unit basis. And second, estimated transfers also capture vendor distribution support.

Given these changes in retailers' assortments and participation constraints, producers choose new optimal wholesale prices. Average wholesale prices decrease by 2.78% because the wholesale prices of the counterfactually added products are 45.74% lower than those of the replaced products. However, wholesale prices of products supplied in both assortments increase by 5.94%. The model imposes that producers choose contract offers to maximize their profits subject to retailers' participation constraints. The increases in wholesale prices reflect the lower values of retailers' outside options in the counterfactual. For the counterfactual assortment, I find that equilibrium wholesale prices are 0.23% lower than unconstrained producers' take-it-or-leave-it offers. As a comparison, for the observed assortment, retailers' participation constraints lead to wholesale prices that are 7.12% lower than unconstrained offers. These comparisons reveal that retailers' outside options may impose downward pressure on wholesale prices.

The counterfactual analysis shows that the restricted vertical contract limits retailers' ability to distort assortment in order to obtain better terms of trade from producers. On the one hand, if wholesale prices are kept fixed, then such strategic distortions lead to lower vertical profits and consumer surplus. On the other hand, retailers' credible threats of profitably replacing a product may lead to both vendor allowances and lower wholesale prices. Such decreases in wholesale prices may benefit consumers and generate higher vertical profits. Counterfactual results indicate that, for the studied market, the assortment distortion effects are larger than the benefits from lower wholesale prices.

The vendor allowance and counterfactual analyses highlight that vertical contracts, retailers' markups, and product assortments cannot be viewed independently. While vertical contracts and product availability have been examined in the empirical industrial organization literature, the two questions have largely been considered separately. A contribution of this paper is that it integrates endogenous product selection with vertical negotiations. This proves essential for quantifying vendor allowances and studying how these contracts affect market outcomes.

The rest of the paper proceeds as follows. Section 2 describes the related literature. Section 3 describes the data. I outline the model in Section 4, and Section 5 discusses details of the empirical strategy. Section 6 reports results from the demand and vendor allowances estimation. Counterfactual experiments and implications are described in Section 7. Section 8 concludes.

2 Related Literature

Two empirical studies investigate the effects of slotting fees in the context of new product introductions. Sudhir and Rao (2006) use proprietary data on whether slotting fees were offered to a single grocery chain and find that slotting fees arise due to retailers' opportunity costs. Bloom et al. (2000) use data from a survey of retailers and manufacturers and find that both upstream and downstream firms agree that slotting fees influence assortments and that these payments are associated with the exercise of market power by retailers. However, the authors find that producers and retailers disagree on the effect of lump-sum payments on producers' profitability. Payments in the form of warehousing allowances, vendor cash discounts, allowances for damaged goods, or operating support persist after a successful introduction of a product. This paper furthers our understanding of lump-sum payments by investigating the effect of continued vendor support on product availability and by quantifying the welfare effects for market participants.

To that end, I connect two largely disparate empirical literatures, those on endogenous product choice and vertical relations. The first stream of papers on endogenous product choice incorporates both product assortment decisions and price competition in the analysis of differentiated product markets. Misra (2008) investigates assortment decisions across grocery stores within a chain. Draganska et al. (2009b) focus on producers' market distribution of ice-cream flavors and show that welfare implications can differ significantly once strategic product assortment choices are taken into account. Eizenberg (2014) studies the personal computer market and investigates how innovation affects producers' choices of product assortments. Berry and Waldfogel (1999) and Berry et al. (2016) analyze optimal variety in the radio industry, while Fan and Yang (2017) look at the effects of competition on the number and the composition of smartphone offerings. These works show that counterfactual changes in the underlying demand, firm costs, or market conditions may affect both equilibrium offerings and prices. In many industries, however, producers reach consumers only through a downstream sector. Consequently, vertical contracts between producers and retailers are important determinants of retailers' product selections. I contribute to the endogenous product choice literature by studying how vertical contracts may influence assortment choices by retailers.

The second stream of papers on vertical relations investigates the effects of market structure on equilibrium terms of trade, while treating product availability as exogenous to the model. Papers examining vertical contracts in the grocery sector include Sudhir (2001), Villas-Boas (2007), Bonnet and Dubois (2010), and Bonnet and Dubois (2015). Additionally, bargaining models, based on Horn and Wolinsky (1988), have been applied to study vertical markets in Draganska et al. (2009a), Crawford and Yurukoglu (2012), Grennan (2013), and Gowrisankaran et al. (2015). A feature of the Nash-bargaining solution is that non-offered products may not influence the negotiated terms of trade. This assumption, however, is unreasonable for the retail sector as retailers can credibly replace an offered product with an alternative option. Two recent papers, Ho and Lee (2017) and Ghili (2017), highlight this issue when modeling network formation in insurer-hospital negotiations. The model developed in this paper explicitly accounts for retailers' ability to select different products. To model the negotiations between producers and retailers as a Nash-in-Nash bargaining game, one has to incorporate retailers' credible threat of terminating a negotiation and supplying an alternative product. Binmore et al. (1989) show that the strategic use of an outside option in a Nash-bargaining framework acts as a constraint on the minimum payoffs obtained by the agent. This imposes a lower bound on vendor allowances. If retailers' outside options are large, then retailers' incentive compatibility conditions determine the equilibrium payoffs of the bargaining game. Lump-sum transfers cannot be separately identified from the bargaining power parameter. As a result, this paper focuses on analyzing the effects of vendor allowances because of their wide use, importance for firm profitability, and scarce empirical evidence.

A few papers investigate both endogenous product choice and vertical relations. Ho (2009) analyzes how hospital characteristics and bargaining ability may affect insurer-hospital networks using the moment inequalities of Pakes et al. (2015). Conlon and Mortimer (2017) analyze product assortment decisions in the context of a vertical rebate. Viswanathan (2012) analyzes the competitive effects of another vertical arrangement: category captaincy. The author investigates how category captains affect assortments when retailers act as local monopolists. Israilevich (2004) studies how slotting fees may affect the number of products supplied by a monopoly retailer. Conditional on observed retail prices, promotions, and wholesale prices the author finds that some products may be profitably removed. The retailer's choice to supply these unprofitable products is rationalized with slotting fees. My model allows that retailers strategically choose assortments considering the effects of these product selections on consumer choices, retail competition, and vertical contracts. Furthermore, I extend the vertical relations literature by studying how a change in the structure of the vertical contract affects equilibrium product availability, wholesale prices, and welfare. The counterfactual highlights that vertical contracts cannot be fully understood without recognizing their effect on product availability.

Table 1: Market Summary Statistics

	mean	median	sd	min	max
market population (millions)	3.9	2.9	3.5	0.5	19.5
observed # of chains (in a market)	4.2	4	1.7	1	11
chain market sales ($ millions)	187	155	161	5	1,147

3 Industry and Data

The extensive use of vendor allowances in the grocery sector makes it a good context to study the effects of these payments on welfare and product availability. The median vendor allowance receipts, reported by public grocery chains, correspond to 7% of retailer's revenues.[5] In addition, brick-and-mortar stores are faced with constrained shelf space, which highlights the importance of assortment decisions for firm profits and consumer surplus. Within the grocery industry, the framework is applied to yogurt products. This category offers several advantages as a context to study product assortment decisions and vertical contracts. First, it is characterized by a proliferation of products, while retailers carry only a small number of the product options available. For the analyzed sample the average retailer offers 29 yogurt product lines selected from, on average, 85 non-private label options. Second, two producers, Groupe Danone and General Mills, control the majority of market sales. These producers capture, on average, 70% of yogurt sales during the sample period. At the same time, the industry is populated with a number of small and regional producers who compete to place their products on grocers' shelves. Last, yogurts' perishability alleviates consumer-stockpiling considerations, which allows me to employ static demand techniques for the estimation of consumer demand.

The model is applied to the academic Information Resources Inc. (IRI) dataset, which includes data on grocery chains' quarterly sales and units sold in 44 geographical markets in the U.S. for the sample period 2001-2010.[6] Table 1 summarizes information about the markets and chains covered in the data. The observed markets vary in size, with an average population of 3.9 million. On average, I observe 4.2 chains in a market, and each chain

[5] I collect data on reported vendor allowances from public U.S. grocery companies' annual reports. Vendor incentives reported in accounting statements include promotional allowances, product placement allowances, cash discounts, warehouse allowances, slotting allowances, swell allowances for damaged goods, vendor rebates and credits, wage reimbursements, and long-term contract incentives.

[6] For more information on the IRI dataset see Bronnenberg et al. (2008) who provide a detailed description of the data.

Table 2: Prices and Market Shares: by Characteristic

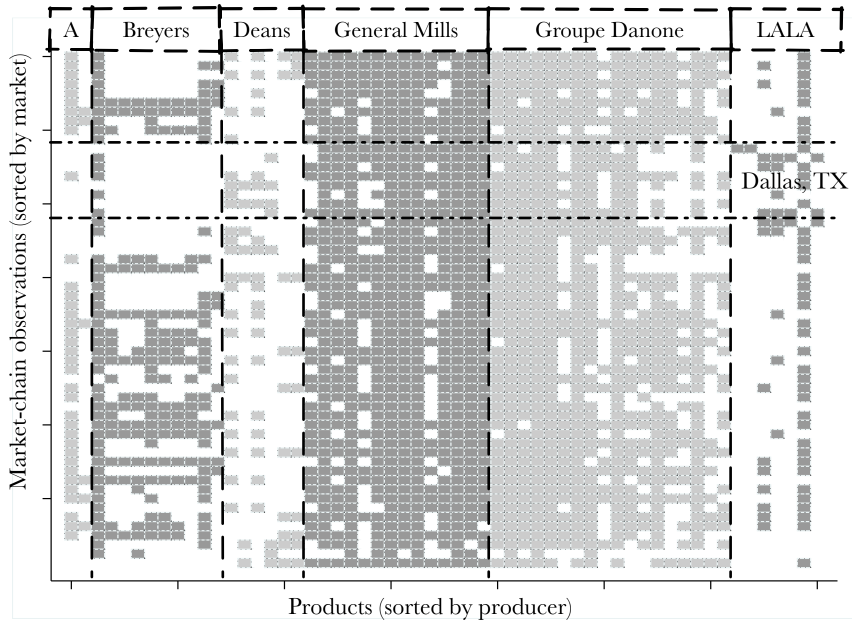
	mean price	sd price	mean market share (%)	sd market share (%)
natural=1	0.94	0.42	0.12	0.07
natural=0	0.79	0.26	0.88	0.07
child=1	0.95	0.27	0.11	0.03
child=0	0.79	0.32	0.89	0.03
soy=1	1.09	0.27	0.00	0.00
soy=0	0.82	0.31	1.00	0.00
light=1	0.80	0.27	0.34	0.07
light=0	0.84	0.33	0.66	0.07
creamy=1	0.85	0.25	0.43	0.10
creamy=0	0.82	0.35	0.57	0.10

appears in the data in an average of 3 markets. Most of the chains in the IRI dataset are among the main competitors in their respective markets with mean estimated market yearly sales of $187 million.

The unit of analysis is 'product line'-retailer-market-quarter. A product line (e.g. *Stonyfield Smooth & Creamy, 6 ounce*) includes a variety of flavors (e.g. *Stonyfield Smooth & Creamy, 6 ounce, french vanilla*). The aggregation to a product line matches the level of contracting in the grocery sector.[7] I define five product characteristics: natural, marketed for children, soy, creamy, or light. Table 2 reports price and market share variation across products described by each characteristic. The average price for natural products is $0.94, while non-natural products are, on average, priced at $0.79. Similarly, children's and soy products are more expensive than non-children's and non-soy options, respectively. Natural and children's products account for, on average, 11% of market sales each. Light products are responsible for, on average, 32% of market sales, while average market share for soy products is 0.005%. Consumers are offered a variety of natural, children's, creamy, and light options: typically, more than 25 product-retailer offerings with each of these characteristics are available in a market. The exception is soy products with, on average, 4 product-retailer soy options available in a market. For the sample period, soy yogurts may be characterized as "niche" offerings: they are offered by only three producers, supplied by only some of the retailers, and are low-velocity items generating low sales as compared to other products. Information on producers' distribution and market shares is available in Appendix A.

[7] Throughout this paper I refer to 'product line' and 'product' interchangeably.

Figure 1: Assortment Snapshot: South Census Region 2010q1



Assortment snapshot of markets in the South census region for 2010q1. Vertical axis goes over observed chains in each market (sorted by market - e.g. Dallas, TX). Horizontal axis identifies products. Products are shown for each producer separately in the following order: Agro Farma, Breyers, Dean Foods, General Mills, Groupe Danone, and LALA Foods. White blocks correspond to instances in which the product is not offered in the retailer.

To identify vendor allowances, I exploit variation in observed assortments across grocery chains and markets. In particular, if all retailers carried the same products, then these assortments would provide no information about vendor allowances. To investigate the variation in product offerings, Figure 1 shows a snapshot of market assortments for the top 6 brands supplied in the first quarter of 2010 in the South census region. The vertical axis tracks retailers in the 12 markets (e.g. Dallas, Texas), while the horizontal axis shows the product offerings ordered by producer (Agro Farma, Breyers, Dean Foods, General Mills, Groupe Danone, and LALA Foods). Each filled box implies that the product-retailer pair is observed in the data, while white blocks correspond to instances in which the product is not offered by the retailer. Figure 1 highlights that there is substantial variation in the assortments selected by grocery chains both across markets and within markets. Notice that some products are supplied by most retailers (Draganska et al. (2009b) refer to these as staple products), while the availability of other products varies markedly across retailers and markets (Draganska et al. (2009b) define these as optional products).

The estimation methodology addresses retail price endogeneity by employing cost shifters as instrumental variables. I create a "distance" measure to capture transportation costs from each producer's manufacturing facility to each market. First, I locate yogurt plants in the

Table 3: Geographic Distances between Plants and Markets

producer	mean	sd
Agro Farma	828	636
Anderson-Erickson	679	343
Auburn Dairy	1496	563
Belfonte	683	345
Breyers	890	640
Cabot Creamery	953	645
Cascade Fresh	1504	559
Crowley Foods	804	633
Dean Foods	739	424
General Mills: Yoplait	379	200
General Mills: Colombo	965	670
Groupe Danone: Dannon	354	160
Groupe Danone: Stonyfield Farm	960	668
Groupe Danone: Brown Cow	1485	635
Fage USA Corp.	863	643
Johanna Foods	826	652
Kalona Organics	656	369
LALA Foods	1010	452
Northwest Dairy	1443	555
Old Home Foods	738	331
Prairie Farms	725	344
Purist Foods	929	365
Springfield Creamery	1507	596
Sun Valley Dairy.	1416	604
Tillamook County Creamery	1539	591
Wallaby Yogurt Company.	1502	638
Whole Soy	1459	627

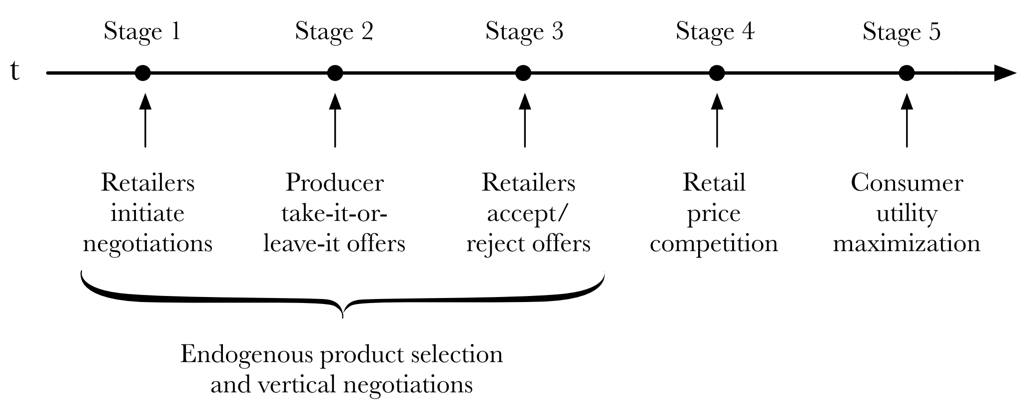
Geographic distances are reported in nautical miles. If a brand has its own manufacturing facility, the distance measure is calculated at the brand rather than producer level. This is the case for Colombo (General Mills), Stonyfield Farm (Groupe Danone), and Brown Cow (Groupe Danone). If a producer has multiple plants manufacturing a brand, I assign the closest plant to each market.

U.S. that were used during the sample period. Table 3 summarizes the geographic distance information between each brand and the 44 markets used for the analysis. General Mills and Groupe Danone produce multiple brands, however, some of these brands were manufactured in separate facilities. During the sample period Colombo (General Mills), Stonyfield Farm (Groupe Danone), and Brown Cow (Groupe Danone) were produced in their own plants. In such cases, distance measures are constructed at the brand level. If a producer had multiple plants manufacturing a brand, I assign the closest plant to each market. Finally, to calculate a proxy for transportation costs between plants and each market, I combine these geographic distances with gas prices obtained from the U.S. Energy Information Administration.

4 Model

The model draws from key institutional features and describes the determination of product assortments, vertical contracts, and retail prices. Figure 2 presents the timeline for the game. First, retailers select the set of products they would like to supply and initiate negotiations over these products. Contract negotiations are modeled as producers' simultaneous take-it-or-leave-it offers. The last two stages describe retail price competition and consumer choice of the product-retailer pair that gives them the highest utility level. The setup is static taking the identities and characteristics of products, retailers, and markets as given. I describe each stage in reverse order.

Figure 2: Timeline of the Game



4.1 Consumer Demand

Consumer demand is modeled using a random utility framework that describes products as bundles of characteristics. In each market-quarter, $\{mt\}$, consumers observe the full set of product offerings (A_{mt}) and select the product-retailer pair that maximizes their utility. I define consumer i's utility from choosing product j at retailer r as

$$u_{ijr} = X_{jr}\beta_i - \alpha_i p_{jr} + \xi_{jr} + \epsilon_{ijr} \tag{1}$$

where market and time subscripts are omitted for ease of readability. The utility function depends on prices (p_{jr}), observed product, retailer, and market characteristics (X_{jr}), and a component not observed by the researcher but considered by consumers when making their purchase decisions (ξ_{jr}). The model allows for two types of consumer heterogeneity: $\theta_D = (\alpha_i, \beta_i)$ are individual-specific taste parameters, while ϵ_{ijr} are idiosyncratic shocks modeled as i.i.d. extreme value type I error terms. The unobservable shocks to demand (ξ_{jr}) create both a potential source of price endogeneity (Berry (1994), Berry et al. (1995)) and a classic selection problem. The estimation section discusses the methods and assumptions used to overcome these concerns.

To complete the demand model, an outside option is defined as the choice not to purchase yogurt from any of the observed grocery chains in the market. The mean utility of the outside option is normalized to 0 as it cannot be separately identified. The utility maximization assumption, along with the logit stochastic shock, implies that predicted shares for each product-retailer pair in a market are given by

$$s_{jr}(A, \theta_D, \xi, X, p) = \int \frac{\exp(X_{jr}\beta_i - \alpha_i p_{jr} + \xi_{jr})}{1 + \sum_{\{lk\}\in A} \exp(X_{lk}\beta_i - \alpha_i p_{lk} + \xi_{lk})} dF(\theta_D) \tag{2}$$

where A is the collection of products offered by all retailers in the market.

The indirect utility function defined in equation (1) can be derived from a quasilinear utility function that is free of income effects. This is a reasonable assumption in the yogurt market as the product represents a small fraction of consumers' income. The static setup is justified by the perishability of the product, which alleviates stockpiling considerations. The model imposes that individuals select one yogurt in a quarter, while in reality consumers may buy multiple yogurts. I do not observe individual consumer purchases and therefore I cannot allow for multi-unit shopping behavior as modeled by Hendel (1999) and Kim et al. (2002). The model assumption implies that multi-unit purchases are either for different members of a household or for independent consumption occasions.

4.2 Retail Price Competition

Vendor allowances are defined as lump-sum transfers that do not affect retailers' sales. Conditional on assortments, these payments do not affect retailers' variable profits; thus, vendor allowances are irrelevant for retail pricing analysis. Given market assortments (A), parameters that govern consumer utility ($\theta_D = (\alpha, \beta)$), shocks to demand ($\xi$), and retailers' marginal costs (w), retailer r's variable profits $\pi_r(A, \theta_D, \xi, w)$ are calculated as

$$\pi_r(A, \theta_D, \xi, w) = \sum_{j \in A_r} (p_{jr} - w_{jr}) M s_{jr}(A, \theta_D, \xi, p) \tag{3}$$

where the summation goes over the products supplied by retailer r (A_r) and M stands for market size.[8] Notice that retailer r's sales of product j ($Ms_{jr}(A, \theta_D, \xi, p)$) depend on its own assortment and its competitors' offerings. The main component of grocery chains' marginal costs is wholesale prices. I refer to retailers' marginal costs and wholesale prices interchangeably as the two cannot be separately identified given the available data. The distinction does not affect the analysis of vendor allowances.

Bertrand-Nash competition requires that equilibrium prices satisfy the following first-order conditions

$$s_{jr}(A, \theta_D, \xi, p) + \sum_{k \in A_r} (p_{kr} - w_{kr}) \frac{\partial s_{kr}(A, \theta_D, \xi, p)}{\partial p_{jr}} = 0.$$

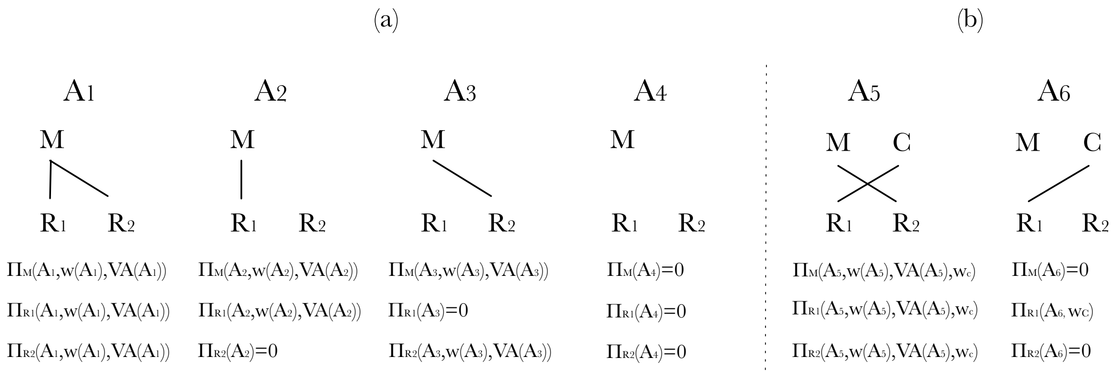
As in Nevo (2001), I assume that, conditional on assortments, prices are uniquely determined in a pure-strategy interior Bertrand-Nash equilibrium.

4.3 Vertical Negotiations and Retailers' Product Selection

Interviews with industry representatives confirmed that grocery chains select the yogurt assortments supplied and the model implements this industry practice. The determination of product offerings and vertical contracts is modeled in three steps: (i) retailers initiate negotiations over the products they would like to supply; (ii) producers make simultaneous take-it-or-leave-it offers; (iii) retailers decide whether to accept a product offer. If a retailer rejects a product offer, it may supply an alternative product in its place. A contract is defined as product-specific wholesale price and vendor allowance. The contract structure does not allow for bundling because the practice is not common for the yogurt category. In line with industry practices, I assume that the parties may not contract over retail prices.

[8] Market and quarter subscripts are again omitted for readability.

Figure 3: Stylized Example: Possible Assortments and Payoffs



Next, I present a stylized example to illustrate the relationship between endogenous product selections, retailers' outside options, and equilibrium vertical contracts. Then I describe the general conditions prescribed by the model.

Stylized example: Consider a market with one producer and two symmetric, horizontally differentiated retailers. Each retailer may supply only one product. The vertical contract consists of a wholesale price and a vendor allowance cash payment from the producer to retailers.[9] The game proceeds following the stages described in Figure 2: retailers decide whether to initiate negotiations with the monopolist; negotiations are modeled as producers' take-it-or-leave-it offers. If a retailer rejects an offer, it supplies no products and generates zero profits. Once contracts and assortments are determined, retailers select prices in a Bertrand-Nash game and the last stage describes consumer demand.

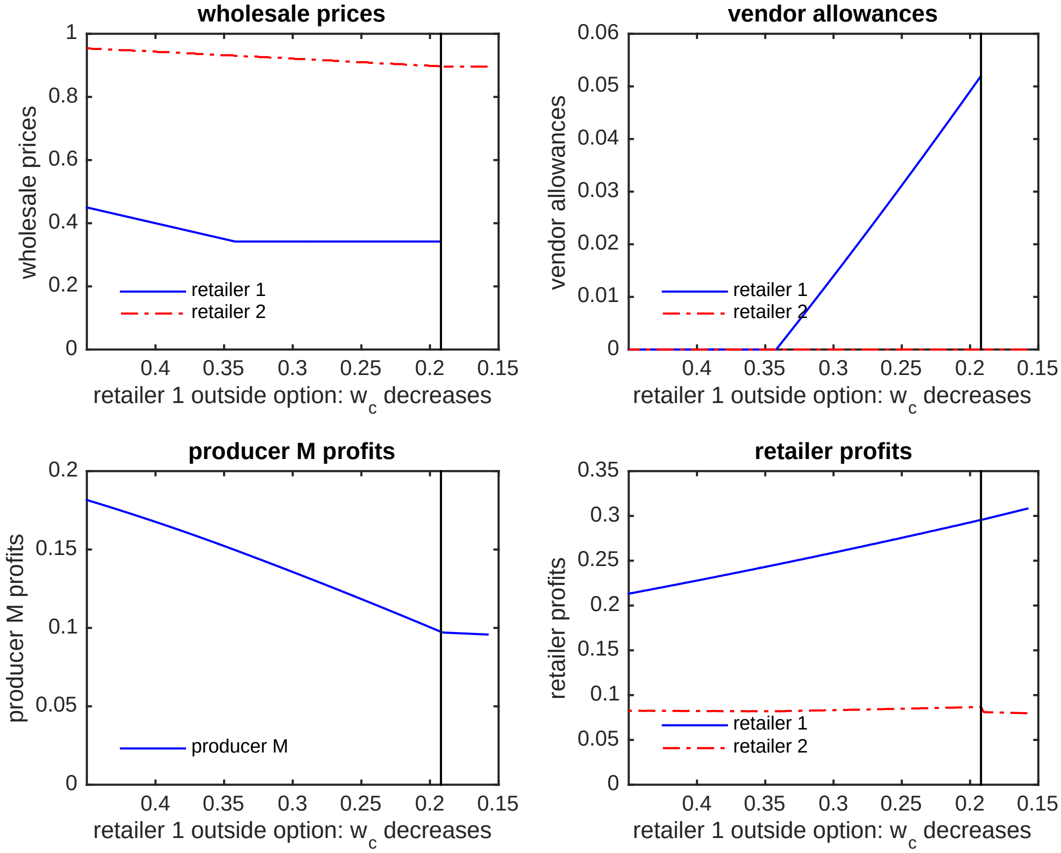
Panel (a) of Figure 3 shows the four potential market assortments and payoffs. For example, the second assortment (A_2) describes the case in which only retailer 1 supplies product M. Underneath each assortment, I describe the payoffs for each firm in order to highlight that contracts and payoffs depend on market assortments. Given A_2, retailer 1's profits are given by $\Pi_{R1}(A_2, w(A_2), VA(A_2))$, where VA$(A_2)$ is the vendor allowance received by retailer 1; retailer 2's profits are zero $\Pi_{R2}(A_2) = 0$.

With this setup, in equilibrium both retailers initiate negotiations with the monopolist. Wholesale price offers maximize producer's profits subject to non-negative retailers' profits. As retailers' outside options are zero, vendor allowances are zero in equilibrium.

To extend this base case, suppose that retailer 1 has access to products from a competitive fringe (C). These products may be procured at a pre-determined wholesale price of w_C. The

[9]The implications of restricting the contract to linear wholesale prices are discussed in Section 7.

Figure 4: Stylized Example: Equilibrium Contracts and Payoffs



additional market assortments and payoffs are shown in panel (b) of Figure 3. If retailer 1 initiates negotiations with M, its outside option is to *reject M's offer and supply product C at w_C*. Now, contract offers by M (w, VA) may depend on w_C as well.

The equilibrium of the game changes with w_C. To show this, suppose producer M's marginal cost is 0.2. Let consumer i's utility from purchasing product j at retailer r be: $u_{ijr} = 0.8 - 2p_{jr} + \varepsilon_{ijr}$, where ε_{ijr} is an i.i.d extreme value type I error term; individuals may also choose an outside option and obtain $u_{i0} = \varepsilon_{i0}$.

Figure 4 illustrates the changes in equilibrium contracts, market assortments, and firm payoffs as the value of retailer 1's outside option increases, that is, as w_C decreases from 0.5 to 0.15. The two top panels show the change in equilibrium wholesale prices and vendor allowances. The solid lines track the contract for retailer 1 and the dashed lines for retailer 2. For example, if w_C=0.4, then, in equilibrium, both retailers supply M's product (assortment A_1 in Figure 3). The contract for retailer 1 is $(w_1, \mathrm{VA}_1) = (0.4, 0)$; and the contract for retailer 2 is $(w_2, \text{VA}_2) = (0.94, 0)$. If $w_C = 0.3$, then the equilibrium assortment is again A_1; however, contracts change to $(w_1, \text{VA}_1) = (0.34, 0.014)$ and $(w_2, \text{VA}_2) = (0.92, 0)$. Producer M's contract offer to retailer 1 is constrained by the value of retailer 1's outside option. These constraints affect both wholesale prices and vendor allowances. In this example, vendor allowance payments emerge as w_C decreases. Due to retail competition, producer M finds it optimal to maintain higher wholesale prices and match retailer 1's participation constraint with a lump-sum transfer. In general, vendor allowance contracts may emerge in markets where competing retailers have credible outside options.

As w_C decreases, the equilibrium assortment changes from A_1 to A_5 (in A_5 retailer 1 supplies product C and retailer 2 offers product M). The plots mark this change in assortments with a solid vertical line: the assortment is A_1 if $w_C \geq 0.19$; and A_5 if $w_C < 0.19$. The bottom panels in Figure 4 show the change in firm payoffs as assortments and contracts change.

The example highlights that market outcomes may change once the model accounts for retailers' endogenous product selections. In this case, retailer 1's potential replacement product influences the equilibrium assortments, contracts, and firm payoffs. This example also illustrates that price discrimination may be driven by differences in retailers' outside options.[10]

General setup: The yogurt market is characterized by multi-product producers and retailers and the discussion below extends the stylized example to reflect this. Let A be the set of products with initiated negotiations, and (w_{jr}, VA_{jr}) be the contract offer that retailer r receives for supplying product j for all product-retailer pairs $(\{jr\} \in A)$. Retailer r's expected profit from supplying assortment A_r is

$$\begin{aligned} E_\xi[\Pi_r(A, w, \text{VA})] &= E_\xi[\pi_r(A, w) + \sum_{j \in A_r} \text{VA}_{jr} - C_r] \\ &= E_\xi[\pi_r(A, w)] + \sum_{j \in A_r} \text{VA}_{jr} - C_r \end{aligned} \tag{4}$$

where C_r captures the cost of supplying A_r if the retailer incurs all expenses. I assume that C_r may vary with assortment size but is invariant to the identities of the products supplied. As a result, vendor distribution support, which decreases fixed costs borne by the retailer, is captured by the vendor allowance transfer. Product selections and contract

[10]The Robinson-Patman Act prohibits producers from selling the same product at different prices to different retailers where such discrimination lessens competition. The price discrimination observed in the example would, however, satisfy the "meeting-competition defense" described in Section 2(b) of the Robinson-Patman Act. The essential principle is that firms are allowed to price discriminate, in order to match the prices of a potential competitor (Calvani and Breidenbach (1991)).

negotiations are completed prior to the realization of structural shocks and the expectations operator in equation (4) reflects that firms form expectations over these shocks. Notice that vendor allowances affect retailers' total profits; however, given assortments, they do not affect retailers' variable profits.[11]

Similarly, producer p's expected profits from supplying A_p are described as

$$E_\xi[\Pi_p(A, w, \text{VA})] = E_\xi[\pi_p(A, w)] + \sum_{\{jr\} \in A_p} VA_{jr}. \tag{5}$$

The negotiations stage implies that, conditional on the set of products with initiated negotiations (A), producers choose contracts to maximize profits subject to retailers' participation constraints. These participation constraints reflect retailers' outside options of rejecting a product offer and supplying an alternative product in its place. Thus, with risk neutral retailers, equilibrium conditions require that no retailer may increase its total profits by unilaterally altering its assortment. That is,

$$E_\xi[\Pi_r(A, w, \text{VA})] \geq E_\xi[\Pi_r(A', w', \text{VA}')] \tag{6}$$

where A' is any counterfactual assortment in which retailer r unilaterally deviates from the set of products with initiated negotiations; and (w', VA') reflects retailer r's costs of supplying the counterfactually added products in A'. These deviations assume that retailers may procure such replacement products from a wholesaler or another intermediary at a cost of w' and zero vendor allowances. These incentive compatibility conditions are exploited for the estimation of vendor allowances.

Vendor allowances capture economic transfers from producers to retailers. These transfers reflect both cash payments from producers and incentives in the form of cost savings for the retailers such as distribution support. Thus, the cost of vendor allowances to producers might be lower than the benefits captured by retailers. This would occur if producers provide operations support at lower costs than those incurred by retailers. One such example is described in Section 6: due to economies of scope in distribution, Dean Foods may be able to provide distribution support for yogurt products at little or no additional costs. Vendor allowances are estimated as retailers' opportunity costs of shelf space; therefore, they reflect the value of these transfers to the retailer.

The credible threat of rejecting an offer and supplying alternative assortments A' allows re-

[11] Vendor incentives, such as promotional allowances, which are paid per unit sold, are not captured by the vendor allowances' estimate.

tailers to extract a higher fraction of the vertical surplus. The producer may adjust wholesale prices as well as vendor allowances to satisfy retailers' participation constraints. The stylized example showed that in markets with downstream competition, producers may find it optimal to maintain higher wholesale prices and match retailers' outside options with positive lump-sum transfers.

5 Empirical Analysis

The model is estimated in two steps. First, standard techniques, as in Berry et al. (1995), are applied to consumer demand and retail pricing analyses. Then, vendor allowances are inferred as the payments needed to rationalize observed assortments. The separation of retailers' assortment and pricing decisions allows me to separately identify wholesale prices and vendor allowances. The assumption is reasonable because grocery chains alter assortments only at a few predetermined occasions. In contrast, retail prices can be easily adjusted as market conditions change.

5.1 Step 1. Demand and Retail Price Competition

The analysis of retailers' assortment decisions requires a rich demand model, which allows for flexible variation in consumer preferences. To that end, a flexible fixed-effects parameterization is used to characterize consumer utility. I include product-year intercepts, which capture how mean product valuations change over time. Retailer-market-specific constants and quarter fixed effects account for differences in consumer valuations across grocery chains and seasonal changes in yogurt preferences, respectively. The demand specification includes interactions between product characteristics and retailer fixed effects. The characteristics used are dummy variables indicating whether a product is natural, marketed for children, soy, creamy, or light. These interactions capture the possibility that a product characteristic may be perceived differently across retailers; that is, consumers may regard natural products to be of higher quality when bought at Whole Foods than at a discount grocery chain. Product shelf location and number of facings may affect consumer demand. Unfortunately, I do not observe either variable. However, I include the log of number of flavors supplied by the retailer as a proxy for the shelf space occupied by each product line. The estimation includes random coefficients on price, product characteristics, flavors, and the constant term. Market size is constructed as market population multiplied by quarterly per capita yogurt consumption, which is obtained from the USDA per capita consumption data.

As most demand analyses, I encounter a classic selection problem: firms supply products with anticipated high profits. This implies that the observed sample is not a random sample from the underlying distribution of product characteristics. To address this concern, the estimation strategy assumes that product assortments and non-price characteristics are determined prior to the realization of structural shocks to demand. If assortment decisions are based on observables only, then demand parameters are consistently estimated. The assumption is credible for two reasons. First, the estimation controls for time-varying product-specific unobservables, retailer-specific intercepts, as well as chain interactions with product characteristics. Thus, the unobservable shocks do not capture systematic components that are likely known prior to the assortment choices and contract negotiations. Second, assortment decisions are "sticky." Changing an assortment requires coordination across stores. In consequence, grocery chains typically adjust product selections at only a few predetermined occasions during the year.

Unlike assortment decisions, prices are easily adjusted as market conditions change. Thus, I allow retailers to select optimal prices once they observe demand shocks. To the extent that retailers observe these shocks and condition on them when setting prices, retail prices are endogenous. To address endogeneity concerns, I employ cost-based instruments. The instruments capture direct components of retailers' market costs, such as transportation costs, interacted with retailer fixed effects. The intuition is that prices depend on retailer costs of operation, but these costs are not correlated with unobservables.[12]

Demand parameters are estimated using a Mathematical Program with Equilibrium Constraints (MPEC) algorithm. The MPEC computational algorithm is preferred to the nested fixed-point (NFP) method as it avoids the numerical issues associated with nested inner loops (Dubé et al. (2012)). At the same time, the MPEC and NFP algorithms generate the same estimator (shown by Su and Judd (2012)), hence, the statistical properties of the Berry et al. (1995) estimator apply to both NFP and MPEC.

5.2 Step 2. Vendor Allowances

Vendor allowances are inferred as retailers' opportunity costs of shelf space. The strategy assumes that observed assortments yield weakly higher expected retailers' profits than

[12]Eizenberg (2014) presents an informal argument about the assumptions needed for point identification of demand parameters. The method requires that shocks are mean-independent for the set of all potential products that may be offered in the market.

switching each of its products with any feasible alternative.[13] If retailer r switches a product j that it supplies ($j \in A_r$) with a product l that it does not supply ($l \notin A_r$), then its incentive compatibility requires that

$$E_\xi[\Pi_r(A, w, \text{VA})] \geq E_\xi[\Pi_r(A'_{-jlr}, w'_{-jlr}, \text{VA}'_{-jlr})] \quad \text{for } \forall j \in A_r, \, \forall l \notin A_r. \tag{7}$$

For the observed market assortment (A), wholesale prices and vendor allowances are $w = [w_{-jr}, w_{jr}]$ and $VA = [VA_{-jr}, VA_{jr}]$, respectively. For the counterfactual assortment (A'_{-jlr}), the new contract ($w'_{-jlr}, \text{VA}'_{-jlr}$) reflects the difference in retailer r's costs from supplying product l instead of j: $w'_{-jlr} = [w_{-jr}, w_l]$ and $VA'_{-jlr} = [VA_{-jr}, VA_l]$. The deviations assume that retailer r may procure such non-offered products ($l \notin A_r$) from a wholesaler or another intermediary. The contract for product l is not negotiated and $\text{VA}_l = 0$. To construct w_l, I use the highest inferred wholesale price for product l in that census region.[14]

Substituting retailer profits from equation (4) in equation (7) yields that, for all products j offered at retailer r and all potential replacement products l, the following condition holds

$$E_\xi[\pi_r(A, w)] + \sum_{k \in A_r} \text{VA}_{kr} - C_r \geq E_\xi[\pi_r(A'_{-jlr}, w'_{-jlr})] + \sum_{k \in A'_{-jlr}} \text{VA}_{kr} - C_r \tag{8}$$

where C_r is the fixed cost associated with supplying an assortment if the retailer bears all expenses. These costs can vary with assortment size but are assumed to be invariant to the identities of the products offered. The counterfactual product assortment holds fixed the number of products supplied by the retailer; hence, these fixed costs are the same across the two considered assortments. Vendor incentives may take the form of both cash transfers and retailer cost savings. As a result, if a producer offers operations support (e.g. the producer uses a direct-store-delivery system), then the resulting cost savings for the retailer are associated with a vendor allowance transfer.

Retailers' outside options imply that

$$E_\xi[\pi_r(A, w)] + \sum_{k \in A_{-jr}} \text{VA}_{kr} + \text{VA}_{jr} \geq E_\xi[\pi_r(A'_{-jlr}, w'_{-jlr})] + \sum_{k \in A_{-jr}} \text{VA}_{kr} \tag{9}$$

[13] Naturally, retailers have multiple unilateral deviations. For example, a retailer may switch multiple products at a time or it may add a new product by decreasing the shelf space of a different product category (e.g. cream cheese). I employ one-product deviations as these allow me to identify product-specific vendor allowances, while keeping yogurt shelf space constant.

[14] I assume that w_l does not depend on A and w_{jr}. For example, w_l are determined by producer negotiations with wholesalers (Costco) and mass merchandisers (Walmart), which are not included in the data.

which leads to

$$\text{VA}_{jr} \geq E_\xi[\pi_r(A'_{-jlr}, w'_{-jlr})] - E_\xi[\pi_r(A, w)] \quad \text{for } \forall j \in A_r \text{ and } \forall l \notin A_r. \tag{10}$$

In the grocery industry, lump-sum payments flow from producers to retailers, so industry practices provide a natural lower bound on vendor allowances, that is, $\text{VA}_{jr} \geq 0$.[15] Additionally, producers' profit maximization requires that, if $\text{VA}_{jr} > 0$, then contract offers are such that retailers' incentive compatibility conditions are exactly satisfied. Vendor allowances reflect the shadow price of shelf space, which is approximated as the additional retailers' profits generated by switching each product with its most profitable replacement. In particular, given a profitable retailer deviation, equation (10) holds with equality for the most profitable replacement option of product j at retailer r. That is,

$$\text{VA}_{jr} = \max\{0, \max_{l \notin A_r}\{E_\xi[\pi_r(A'_{-jlr}, w'_{-jlr})] - E_\xi[\pi_r(A, w)]\}\} \quad \text{for } \forall j \in A_r. \tag{11}$$

These deviations are used to infer vendor allowances for all products observed in the market.

Papers studying vertical relations have often modeled the interactions between firms using a Nash-in-Nash bargaining problem. The standard Nash-in-Nash model requires that only observed product-retailer pairs may affect negotiation outcomes. In particular, the disagreement payoffs for each negotiating pair ($\{jr\}$) are derived by dropping $\{jr\}$ and keeping the rest of the assortment fixed. As a result, these payoffs do not account for retailer r's outside option to terminate the negotiations and supply a different product instead of product j. Binmore et al. (1989) relax these conditions and show that the strategic use of an outside option in a Nash-bargaining framework acts as a constraint on the minimum payoffs obtained by the agent. These constraints are identical to the retailers' incentive compatibility conditions defined in equation (10). As a result, these inequalities prescribe a lower bound on the vendor allowances received by retailers. Moreover, if retailers' outside options are large, then these retailers' participation constraints determine the equilibrium payoffs of the bargaining game. In such cases, the vendor allowance conditions in equation (10) are identical to those specified by a Nash-in-Nash bargaining problem. Unfortunately, lump-sum transfers may not be separately identified from bargaining power parameters. This paper focuses on analyzing how lump-sum payments from producers to retailers affect market outcomes when product selections are endogenous. These effects are important to study because these contracts are wide-spread in the retail industry, whereas their impact on equilibrium product availability

[15] Other forms of retailers' efforts, which might differ across products and might be construed to be part of vendor allowances, are assumed to be not material enough to violate the non-negativity assumption.

is unclear.

Construction of deviations explained by example: The set of potential product offerings for each retailer in a market is defined as the collection of products that are observed in the market combined with all products the retailer carries in other markets during the quarter. These restrictions guarantee that producers distribute the potential products during the time period and that the retailer can supply the counterfactual product without incurring disproportionately larger supply costs. In addition, I avoid deviations in which regional brands are counterfactually supplied in other census regions, e.g. a deviation in which Tillamook (a regional West coast producer) is offered in an East coast market. The resulting set of potential products includes, on average, 14 replacement options for each retailer.

The deviations are constructed by ***dropping*** *each product from the observed assortment with replacement*. These unilateral deviations keep the shelf space occupied by the yogurt category fixed, both in terms of the number of products and the number of flavors offered. To estimate retailer opportunity cost of shelf space, I replace the dropped product with the counterfactual option that renders the highest variable retailer profits.

To present the method used to construct these deviations, consider the Boston market for the 2010q1 period and suppose that retailer 1 in Boston, $\{r1\}$, supplies *Yoplait Trix*, $\{trix\}$. First, I construct retailer 1's expected variable profits for the observed assortment, $E_\xi[\pi_r(A)] = 20,500$. The next step is to construct retailer 1's expected variable profits after removing *Yoplait Trix* and replacing it with each product from its set of potential product deviations. For simplicity, suppose that there are three products in retailer 1's set of potential offerings: $\{$*Breyers Light*, *Stonyfield Farm Yobaby*, *Weight Watchers*$\}$. The expected variable profits per store for each deviation are given by

$$E_\xi[\pi_r(A'_{-trix,bl,r1})] = 20,600$$

$$E_\xi[\pi_r(A'_{-trix,sfy,r1})] = 20,540$$

$$E_\xi[\pi_r(A'_{-trix,ww,r1})] = 20,300$$

The most profitable replacement for *Yoplait Trix* for retailer 1 is *Breyers Light* with profits of $20,600$. I use the *drop Yoplait Trix, replace with Breyers Light* deviation. Given that producers make take-it-or-leave-it offers, the deviation yields that

$$E_\xi[\pi_r(A)] + \mathrm{VA}_{trix,r1} \geq E_\xi[\pi_r(A'_{-trix,bl,r1})] \implies \mathrm{VA}_{trix,r1} = \min\{0, 100\} = 100.$$

Expected retailers' variable profits are simulated using the empirical distribution of structural shocks. For all simulations and counterfactual assortment changes, retail prices are re-optimized according to the Bertrand-Nash competition assumption. As it is unreasonable to assume that private label products pay vendor allowances, the deviations are constructed for non-private-label products only.

6 Results

The demand estimation allows for consumer heterogeneity in price sensitivity and preferences for product characteristics. The individual-specific taste parameter for price is drawn from the empirical income distribution, while the random coefficients for product characteristics (marketed for children, natural, soy, number of flavors) and the constant term are estimated using draws from a standard normal distribution.

Results from the demand parameterization are reported in Table 4. The reported estimates of product characteristics are calculated as projections on the estimated product-year intercepts.[16] The estimates align with expectations: demand is downward sloping, while the random coefficient on price implies that consumer price sensitivity decreases with income. In addition, consumers prefer children's and creamy products, while they value soy and light products less. Consumers value products with more flavor options offered by retailers. However, there is substantial heterogeneity in individual preferences for flavors.

These demand estimates imply a median consumer own-price elasticity of -4.3. Table 5 reports that none of the calculated own-price elasticities are positive and only 0.006% of the estimates suggest that there are individuals on the inelastic parts of their demands for yogurt. The assumption of retail price competition leads to an estimated median retail markup of 21 cents and a median variable profit margin of 27.5%. To analyze how well the model matches the observed margins in the grocery industry, I collect information on variable profit margins reported by public grocery retailers in their accounting statements. I find that the median reported variable profit margin is 27% for the sample period.

Vendor allowances: To gain perspective on the importance of vendor allowances for retailers' profitability, I compare the value of estimated lump-sum transfers to retailer sales and variable profits. Constructed vendor allowances suggest that, for the median grocery chain, received vendor allowances represent 4.21% of revenues and 13.41% of variable profits. These payments are likely important for retailers' profitability, given that public grocery chains in

[16] The procedure is described in Nevo (2001).

Table 4: Demand Estimates

	estimate	standard error
constant (mean)	-7.366	0.200
constant (st. dev.)	0.249	0.567
price (mean)	-6.947	0.425
price (st. dev.)	1.960	0.227
natural (mean)	0.048	0.041
natural (st. dev.)	0.119	1.227
child (mean)	7.087	0.179
child (st. dev.)	1.897	1.043
soy (mean)	-15.363	0.823
soy (st. dev.)	0.682	4.038
flavors (mean)	0.773	0.084
flavors (st. dev.)	0.662	0.074
creamy	0.146	0.003
light	-0.279	0.021
q2	0.043	0.004
q3	-0.045	0.006
q4	-0.222	0.009
2002	-0.058	-0.058
2003	-0.110	-0.110
2004	-0.149	-0.149
2005	-0.187	-0.187
2006	-0.154	-0.154
2007	-0.233	-0.233
2008	-0.150	-0.150
2009	-0.188	-0.188
2010	-0.283	-0.283

The random coefficient on price is drawn from the empirical income distribution, while the standard normal distribution is used to estimate the random coefficients on product characteristics and the outside option. Product characteristics and year fixed effects are projected on product-year dummies. Other variables include retailer-market intercepts, characteristics interacted with retailer fixed effects, and quarter dummies. Price instruments are based on cost shifters: producers' transportation costs interacted with retailer fixed effects. Sample size is 230,679. Results are obtained using the MPEC algorithm.

Table 5: Implications from Demand and Retail Price Competition Analysez

median own-price elasticity	-4.317
% own-price elasticity > 0	0.000
% own-price elasticity > -1	0.006
median markup (in \$)	0.211
median margin	0.275

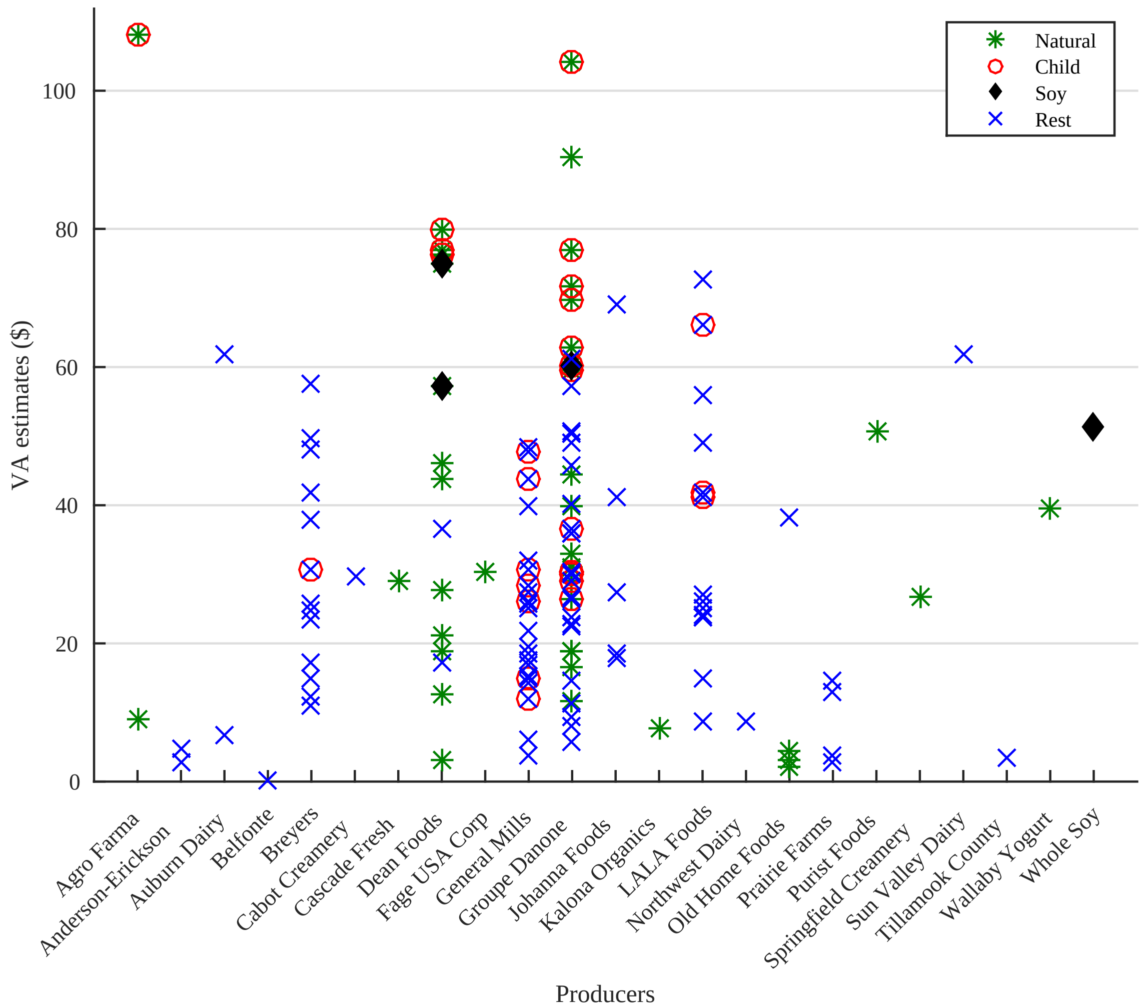
Markups are derived under the assumption of retail price competition. Variable profit margins are calculated as variable profits divided by total sales.

the U.S. report profit margins on the order of 2-4% of revenues.

Vendor allowance payments reported in retailers' 10-K filings are the closest accounting statement metric to the estimated transfers. I collect data on vendor allowances reported by public grocery chains that are observed in my data. During the sample period, the median of these reported vendor allowance payments corresponds to 7% of retailers' revenues. The closeness between estimated and reported vendor allowances is reassuring, but should be interpreted with caution, recognizing the differences between the two measures. The estimated vendor allowances are designed to reflect retailers' opportunity costs. As a result, the estimates capture vendor support in the form of savings in distribution costs, a transfer that is not recorded in accounting statements. Additionally, reported vendor allowances from accounting statements include payments, such as promotional allowances, which are paid on a per-unit basis rather than as a fixed lump sum. These vendor incentives would not be included in my vendor allowance estimates; rather they would be captured in the wholesale price analysis.

To illustrate the differences in constructed vendor allowances across products, I project the payments prescribed by the model on product fixed effects. Figure 5 shows these estimates across producers for the 130 non-private label products supplied during the analyzed period. To facilitate comparison across products, product-specific vendor allowances are reported as the lump-sum transfer per store, quarter, and flavor. The *x-axis* sorts the products by producer, while different symbols identify product characteristics: natural products are marked with an asterisk, a circle identifies products marketed for children, and soy yogurts are shown with a diamond shape. Constructed vendor allowances are characterized by substantial heterogeneity across products within a producer. For example, the two extreme projections for Groupe Danone indicate that the producer pays, on average, \$100 more per store-quarter-flavor for *Stonyfield Farm YoMommy* than for *Dannon Light N Fit*. This result aligns with industry narratives that producers may refuse to pay slotting fees for staple products, but

Figure 5: Comparison of Vendor Allowances across Products



The *x-axis* sorts the products by producer, the *y-axis* measures vendor allowances per store-quarter-flavor. Results are based on 500 simulations.

they are likely to pay high lump-sum transfers for products that may be profitably replaced by retailers. In addition, Figure 5 displays that vendor allowances for niche products, such as soy and natural-children's yogurts, are, on average, higher than financial incentives provided for most other products offered by retailers. Estimates suggest that the vendor allowances for soy products are \$37 (st. error = 0.68) higher than the transfers for non-soy products; and natural-children's products pay \$21 (0.83) more than products that are not characterized as natural-children's yogurts.

Inferred vendor allowances are derived from retailers' incentive compatibility conditions, so they capture the value of these economic transfers to retailers. Therefore, it is possible that the estimates overstate the cost of these transfers to producers. If producers' costs to provide vendor allowances are lower than the benefits to retailers, then producers may have further incentives to offer vendor allowances instead of wholesale price discounts. Producers might experience efficiencies in providing vendor allowances, if, for example, these transfers are in the form of distribution support. Dean Foods presents a case where transfers to retailers might be primarily in the form of distribution support.

In particular, Dean Foods is an international food manufacturer that specializes in dairy products. During the sample period of 2001-2010, the firm produced a wide variety of local and national brands such as *Alta Dena*, *Land O'Lakes*, *Garelick*, *Silk*, etc. Even though the company distributed a number of yogurt products, its most popular dairy products were in the milk category. Over the sample period milk products represented more than 70% of all offerings supplied by the manufacturer. Moreover, Dean Foods completed the sale of all yogurt operations in 2011 in order to focus on core dairy products. Importantly, the manufacturer distributed its products through a wide direct-store-delivery system, which was developed to accommodate its core milk business.[17] Hence, the milk category may have affected the profitability of distributing yogurt products for this producer.

Due to economies of scope in distribution, Dean Foods may be able to provide vendor allowances for its yogurt products at little or no additional costs. Such efficiencies would affect producers' individual rationality conditions and optimal wholesale price offers. Producers' individual rationality conditions impose that the cost to supply a product may not exceed the additional benefits generated by the product. Even if I use producer's revenues to construct the additional benefits from offering a product, I find that the constructed individual rationality constraints for Dean Foods are lower than the estimated vendor allowances for 60% of its products.[18] Dean Foods' operations convey that its efficiencies in providing vendor

[17]Direct-store-delivery is common practice in the milk category. In contrast, I could not find support that such systems are used by other yogurt producers.

[18]For the remaining producers, 10% of the deviations suggest that vendor allowances are higher than the

allowances may rationalize the inferred vendor allowances in these cases. In addition, the counterfactual analysis relies on producers' marginal cost estimates. If I assume that Dean Foods' vendor allowances are cash transfers, then producers' optimality conditions imply negative margins for Dean Foods' products. Instead, I use the insights about Dean Foods' operations and impose that the producer provided these benefits to its retailers at zero cost.

7 Counterfactual Analysis

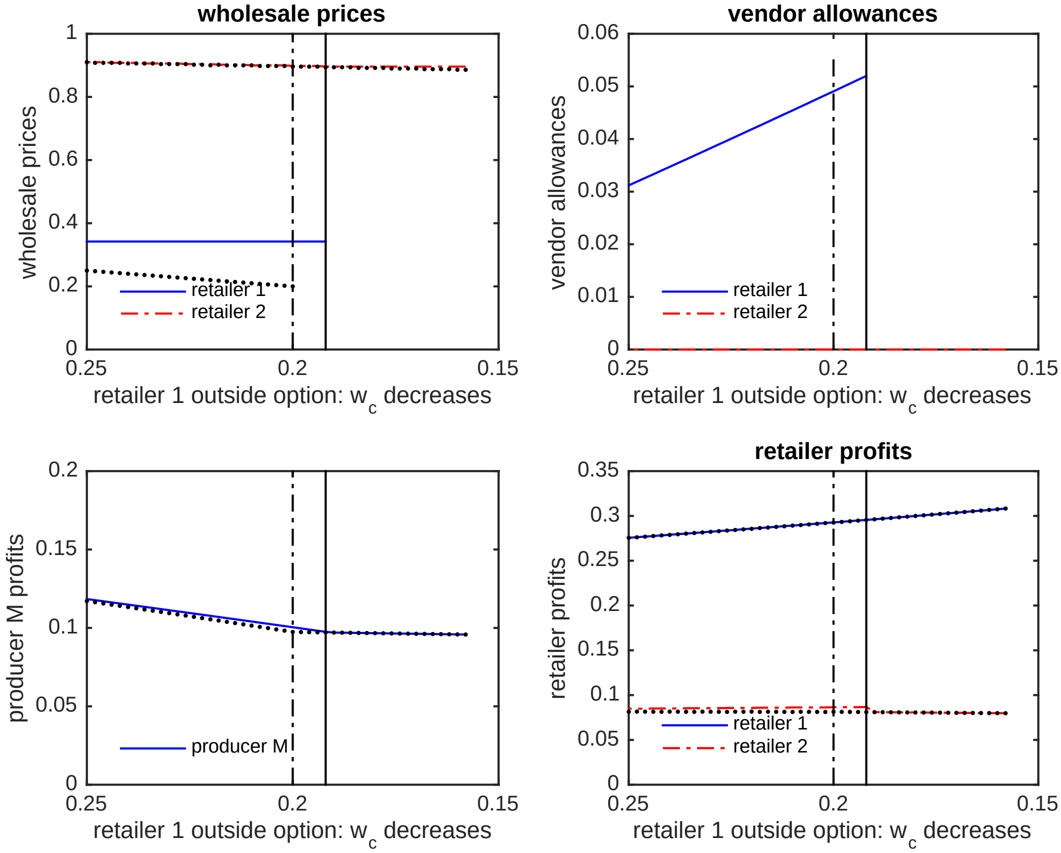
The empirical analysis indicates that vendor allowances represent a substantial component of retailers' variable profits. In addition, theory suggests that economic transfers from producers to retailers may affect both equilibrium wholesale prices and product availability. Thus, it is important to understand the equilibrium consequences of the vendor allowance contract in a setting with endogenous product selections. A counterfactual analysis studies how market outcomes change if the vertical contract is restricted to consist of only wholesale prices.

First, to show how the restriction of the vertical contract may affect market outcomes, consider the stylized example from Section 4. The example showed that a producer will rely on both wholesale price discounts and vendor allowances to match the outside option of a retailer. Figure 6 compares the contracts and firm payoffs from the stylized example to those from a setup that restricts the vertical contracts to include only wholesale prices. The additional dotted lines in Figure 6 show how the restricted contracts and payoffs change as the value of retailer 1's outside option increases (w_C decreases). As expected, if vendor allowances are restricted to be zero, then producer M matches retailer 1's participation constraint by offering a lower wholesale price. In addition, if the wholesale price of the competitive fringe product (w_C) is sufficiently low, then the equilibrium market assortment changes from A_1 (both retailers supply product M) to A_5 (retailer 1 supplies product C and retailer 2 supplies product M). The dashed vertical lines in all plots mark the new value of w_C at which the equilibrium market assortment changes. When the contract is restricted, the equilibrium assortment is A_1 if $w_C \geq 0.20$, and A_5 if $w_C < 0.20$. This implies that, if $w_C \in [0.19, 0.2)$, then the elimination of vendor allowances affects product availability, along with terms of trade and firm payoffs.

In practice, the restriction of the vertical contract may affect equilibrium product assortments, retail and wholesale prices, the number of products offered, and the types of products developed by producers. The counterfactual accounts for adjustments in retailers' assort-

additional revenues generated from supplying the product.

Figure 6: Stylized Example: Equilibrium Assortments and Payoffs



ments, retail prices, and wholesale prices, and holds retail shelf space and product characteristics fixed. The shelf-space assumption imposes that each retailer offers the same number of yogurts as in its observed assortment, which keeps retailers' fixed costs unchanged. If vendor allowances were eliminated for yogurts, retailers could reallocate space across other product categories. However, in order to allow for such adjustments, I would need data on retailers' category-specific fixed costs, along with estimates of consumer preferences, wholesale prices, and vendor allowances for other refrigerated categories.

The model imposes that, conditional on the set of products with initiated negotiations (A), wholesale price offers maximize producers' profits subject to retailers' participation constraints. For each producer p these conditions are given by

$$\max_{w} E_{\xi}[\Pi_p(A, w)] \quad \text{subject to}$$

$$E_\xi[\Pi_r(A, w)] \geq E_\xi[\Pi_r(A', w')].$$

In this optimization problem, wholesale prices have three effects. First, wholesale prices affect producers' variable profits through their direct effect on retail prices and quantities sold in the market ($E_\xi[\Pi_p(A, w)]$). Second, conditional on retailers' outside option values, wholesale prices are the only tool available to producers to match these participation constraints by influencing retailers' variable profits ($E_\xi[\Pi_r(A, w)]$). Finally, wholesale prices influence the value of retailers' outside options ($E_\xi[\Pi_r(A', w')]$) and the replacement products that determine these outside options (A'). To account for changes in the profitability of potential replacement products, I re-calculate retailers' outside options at each wholesale price iteration. Retailers' marginal costs of private labels are not adjusted.

Another challenge is presented by the combinatorial problem of finding new equilibrium assortments in a market. The analysis is conducted for Toledo, OH, for the period from 2006q1 to 2006q4, where I observe two grocery chains. On average, grocery chains in this market supply 34 products from 40 options, which yields about four million possible assortments.[19] Simulating wholesale prices for a market assortment is computationally taxing because the algorithm iterates over producers' first order conditions, and re-calculates retailers' outside options at each wholesale price iteration. As a result, I use the fact that some products are highly profitable in the market and all retailers supply these products (staple products) in order to decrease the number of potential assortments. In particular, I fix staple products and simulate, on average, six thousand assortments for each retailer in the market.[20] The function iterates over retailers in the market until no retailer would find it profitable to alter its assortment. Even though a unique equilibrium is not guaranteed, the brute-force search over assortments identifies one equilibrium in assortments and prices. Structural shocks are set to zero due to computational complexity.

Table 6 reports counterfactual changes for key variables. The simulations suggest that if contracts are restricted to include only wholesale prices, then, on average, vertical surplus would increase by 2.18%, and consumer surplus would be 0.36% higher. These increases are driven by the change in retailers' assortments discussed below. Even though total vertical profits are predicted to increase, retailers are worse off. Retailers' profits decrease by 4.45%, while total producers' profits increase by 13.12%.

[19] The set of potential product offerings for each grocery chain in a market is defined as the collection of products that are observed in the market combined with all products the retailer carries in other markets during the quarter.

[20] Additional checks reveal that assortments excluding staple products require wholesale price decreases that violate at least one producer's individual rationality. As a result, assortments that imply large retailers' outside options could not be supported with the restricted contract.

Table 6: Counterfactual Analysis: Results (in % changes)

	counterfactual results	role of retailers' outside options count. A	observed A
vertical profits	2.18	0.00	0.09
retailer profits	-4.45	0.02	6.85
producer profits	13.12	-0.01	-9.36
consumer surplus	0.36	0.01	1.13
# products	65.25	65.25	65.25
# switched prods	6.75	0	0
wholesale prices (all)	-2.78	-0.23	-7.12
wholesale prices (unchanged)	5.94	-0.25	-5.85
wholesale prices (switched)	-45.74	0.00	-13.09
retailer prices (all)	-1.99	-0.17	-5.37
retailer prices (unchanged)	4.32	-0.19	-4.29
retailer prices (switched)	-37.65	-0.00	-11.18

Results are reported as percent changes of key variables. The first column shows changes in key variables comparing the observed and counterfactual market outcomes. Columns 2 and 3 show the difference in market variables between the equilibrium vertical contracts and producers' take-it-or-leave-it offers that do not take retailers' participation constraints into account. Column 2 uses the counterfactual assortments; column 3 report these differences for the observed assortment.

Moreover, the change in the vertical contract affects product availability. Counterfactual assortments are constructed by changing, on average, 6.75 products in a quarter. This suggests that retailers' product selections cannot be understood in isolation from contract negotiations. Expected contract offers govern retailers' profitability from supplying a product. Similarly, equilibrium contracts depend on the set of products with initiated negotiations. First, I discuss the counterfactual changes in product selections and the implications for retailers' strategies. Next, I examine how wholesale prices adjust to the counterfactual product selections. Last, I analyze the changes in individual producers' profits and product distributions.

The counterfactual changes in assortments are primarily driven by adjustments from one of the retailers in this market. Retailer 1 changes, on average, 6.25 products, while retailer 2 switches 0.5 products. This difference in the intensity of adjustments is related to the estimated vendor allowances for each retailer. Inferred vendor allowances suggest that retailer 1 receives positive transfers from producers for 55% of its products; whereas, retailer 2 receives payments for 10% of its products. As a result, retailer 2 only mildly adjusts its assortments in the counterfactual. In contrast, retailer 1's assortment strategy changes when the vertical contract is restricted to include only wholesale prices. In particular, the model prescribes that potential replacement products may influence vertical contracts and firm payoffs because these products may be used as credible threats in contract negotiations. For the observed assortment, retailer 1 has profitable deviations for more than half of the products it supplies. Thus, the retailer may be strategically excluding products in order to obtain better terms of trade from its producers. In the counterfactual, however, retailer 1 adds the products that governed its most profitable replacement deviations and excludes products with positive vendor allowances. Consequently, the counterfactual assortment implies lower values of retailer 1' replacement threats in negotiations.

The adjustments in product selections occur because the restricted contract cannot support assortments in which retailers have large outside options. For example, simulations reveal that the observed assortments may not be supported by a contract that consists of only wholesale prices. Absent vendor allowances, producers need to lower wholesale prices to match retailers' outside options. For the observed assortment, these adjustments require that retailer 1's wholesale prices decrease by, on average, 4.8%. However, these decreases in wholesale prices violate at least one producer's individual rationality conditions. Instead, in the counterfactual, retailer 1 supplies all products that are used as profitable replacement threats in the observed assortment. Additional simulations showed that assortments, which exclude "popular" products and imply large retailers' outside options, could not be supported by the restricted contract. These findings suggest that retailers' ability to distort assortments in order to command favorable contracts is weakened under the restricted contract.

Next, counterfactual wholesale prices adjust to account for the change in assortments and retailers' participation constraints. Table 6 reports that average wholesale prices fall by 2.78%. However, this drop is not uniform across products. On the one hand, wholesale prices of counterfactually added products are lower than the wholesale prices of replaced products ("switched" products). On the other hand, average wholesale prices of products supplied in both the observed and the counterfactual assortments ("unchanged" products) increase by 5.94%. If product assortments were kept fixed, then we would expect wholesale prices to decrease when vendor allowances are eliminated. Instead, I find that wholesale prices increase for a third of the products. These increases reflect the lower values of retailers' participation constraints in the counterfactual.

To illustrate this, I analyze how retailers' outside options influence contracts and firm payoffs for the observed and the counterfactual assortments. Specifically, for each assortment I compare the equilibrium contracts with contracts simulated as producers' take-it-or-leave-it wholesale price offers that ignore retailers' participation constraints. Column 2 of Table 6 reports the differences between constrained and unconstrained contracts for the counterfactual assortments; column 3 shows the results for the observed market assortments. For the counterfactual assortment, I find that constrained wholesale price offers are, on average, 0.23% lower. These discounts generate a 0.02% increase in retailers' profits and a 0.005% increase in vertical surplus. In comparison, for the observed assortment, the credible threat of replacing a product allows retailers to capture 6.85% higher profits through vendor allowances and wholesale price discounts. Constrained wholesale price offers are, on average, 7.12% lower, which leads to 0.09% higher vertical profits and 1.13% higher consumer surplus. These comparisons reveal that retailers' outside options impose downward pressure on wholesale prices and, consequently, mitigate double marginalization concerns. The counterfactual changes in assortments imply low values of retailers' outside options so counterfactual wholesale prices resemble unconstrained take-it-or-leave-it offers.

Table 7: Changes in Producers' Profitability and Distribution

	total Π_p ($)	variable Π_p ($)	# products
Cascade Fresh	105.63	12.24	-0.50
Dean Foods	726.33	-36.64	-2.50
General Mills	501.06	202.72	1.50
Groupe Danone	1491.81	384.25	0.50
LALA Foods	985.45	941.24	2.00
Springfield Creamery	43.04	-17.07	-0.50
Whole Soy	313.58	0.13	-1.00

Last, I compare how the change in the vertical contract impacts individual producers. Table 7 reports the change in producers' total profits, variable profits, and the number of products supplied. Results show that, if vendor allowances consist entirely of cash transfers, then all producers are better off in the counterfactual. However, if producers benefit from efficiencies in providing these economic transfers, then the results differ by producer. For example, changes in producers' variable profits show that, if vendor allowances cost zero to producers, then Dean Foods and Springfield Creamery are predicted to be worse off. In the counterfactual, Dean Foods supplies, on average, 2.5 less products per quarter. Springfield Creamery loses distribution for its product in half of the quarters. The producers that benefit from expanded distribution are LALA Foods, General Mills, and Groupe Danone. The increased distribution leads to both higher total and variable profits for these producers.

To gain insight into the assortment changes, Table 8 lists the products supplied in the observed and counterfactual assortments in Toledo, OH for the third quarter of 2006. The third column displays the number of chains that carry the product line in the observed assortment, and the fourth column reports the statistic for the counterfactual assortment.

Table 8: Changes Product Availability for the Toledo-2006q3 market

producer	product line	observed A # chains	count. A # chains
Cascade F.	Cascade Fresh	1	1
Dean Foods	Horizon Organic	1	0
	Horizon Organic Tuberz	1	0
	Horizon Organic Yo-Yos	1	0
General Mills	Yoplait Go Gurt	2	2
	Yoplait Grande	0	1
	Yoplait Kids	2	2
	Yoplait Light	2	2
	Yoplait Light Thick and Cream	2	2
	Yoplait Original	2	2
	Yoplait Ro Gurt	2	2
	Yoplait Thick and Creamy	2	2
	Yoplait Trix	2	2
	Yoplait Whips	2	2
	Yoplait Yumsters	2	2
Groupe Danone	Dannon Activia	2	2
	Dannon Creamy Fruit Blends	1	2
	Dannon Danimals	1	2
	Dannon Fat Free	2	2
	Dannon Fruit on the Bottom	2	2
	Dannon La Crem with Chocolat	1	0
	Dannon La Creme	2	2
	Dannon Light N Fit C&S Control	2	2
	Dannon Light N Fit	2	2
	Dannon Light N Fit Carb Control	2	1
	Dannon Natural	2	2
	Dannon Natural Flavors	2	2
	Dannon Premium	1	2
	Dannon Sprinklins	1	2
	Stonyfield Farm	2	2
	Stonyfield Farm Kids	0	1
	Stonyfield Farm O'Soy	2	1
	Stonyfield Farm Yobaby	2	2
LALA Foods	Blue Bunny Carb Freedom	1	2
	Blue Bunny Lite 85	1	2
	Weight Watchers	2	2
Springfield	Nancys	1	0
Whole Soy	Whole Soy	1	0

Retailer 2 drops *Nancy's* (Springfield Creamery) and replaces it with *Stonyfield Farm Kids* (Groupe Danone). The other changes are adjustments in retailer 1's assortment. In this quarter, the counterfactual predicts that Dean Foods, Springfield Creamery, and Whole Soy would lose distribution if the vertical contract is restricted to include only wholesale prices.

In terms of product characteristics, the excluded producers supply natural products to the market. In the counterfactual, retailer 1 drops 4 of its 9 natural products; and it supplies only 1 natural-children's product as compared to the 3 offerings available in the observed assortment. Consumers may purchase a soy yogurt only from retailer 2, because retailer 1 drops both of its soy products (*Whole Soy* and *Stonyfield Farm O'Soy*). In addition, the product variety in the market decreases. For the observed market assortment, there are 36 unique branded products supplied in the market, while in the simulated assortment, consumers may choose from 32 products.

The counterfactual analysis studies how vertical contracts that allow for positive economic transfers from producers to retailers might impact market outcomes. These transfers capture both cash payments from producers and incentives in the form of retailers' cost savings. The simulation eliminates both economic transfers. It would be instructive to study how market outcomes might change if only cash transfers from producers to retailers were banned. The changes from such a ban will differ from the presented counterfactual if producers rely on non-cash vendor transfers. For example, the discussion at the end of Section 6 suggests that the vendor allowances paid by Dean Foods consist of provision of stocking service. If only cash transfers are eliminated, then economies of scope in distribution may keep Dean Foods' products and profits unchanged. To answer this question, I would need data on producers' and retailers' distribution costs. Instead, the analysis focuses on understanding the use of economic transfers from producer to retailers in a setting with endogenous retailers' product selections.

8 Conclusion

This paper seeks to further our understanding of the competitive implications of vertical contracts and their influence on product availability in the retail sector. Contracts between producers and retailers commonly consist of wholesale prices and vendor allowances. Despite the widespread use of vendor allowances in the retail sector, the Federal Trade Commission does not have a conclusive position on the market effects of vendor allowances. Due to lack of data on the size of vendor allowances received by retailers, I quantify vendor allowances and assess their importance for retailers' profitability in the grocery industry using data on yogurt products. The framework incorporates both retail price competition and endogenous product assortment decisions. By exploiting information from observed retailers' product selections, vendor allowances are estimated as the payments needed to rationalize observed assortments. To my knowledge, this is the first paper to exploit the identities of observed product selections to infer information about vertical contracts. Constructed vendor allowances suggest that these transfers correspond to 4.21% of retailer revenues. These payments are likely important for retailers' profitability, given that public grocery chains in the U.S. report profit margins on the order of 2-4% of revenues.

A counterfactual simulation analyzes the effects of vertical contracts on market outcomes. I study how product availability and wholesale prices would change if contracts were restricted to only include wholesale prices. Counterfactual results suggest that the vendor allowance contract facilitates retailers' strategies to distort assortments in order to obtain better terms of trade from producers. Hence, a retailer may find it optimal to exclude a popular product from its assortment to use it as a profitable replacement threat in contract negotiations. If wholesale prices were kept fixed, such a distortion would decrease total vertical profits and consumer surplus. Alternatively, if we focus only on wholesale prices, then retailers' credible threats of profitably replacing a product allow them to capture wholesale price discounts and vendor allowances from producers. These lower wholesale prices may benefit consumers and generate higher vertical profits. Counterfactual results show that vertical profits and consumer surplus increase when the contract is restricted. This suggests that, for the studied market, the assortment distortion effects are larger than the benefits from lower wholesale prices. These results illustrate the importance of incorporating endogenous product selections in the analysis of vertical contracts.

References

Asker, J. and H. Bar-Isaac (2014): "Raising retailers' profits: On vertical practices and the exclusion of rivals," *American Economic Review*, 104, 672–686.

Aydin, G. and W. H. Hausman (2009): "The role of slotting fees in the coordination of assortment decisions," *Production and Operations Management*, 18, 635–652.

Berry, S. (1994): "Estimating discrete-choice models of product differentiation," *RAND Journal of Economics*, 25, 242–262.

Berry, S., A. Eizenberg, and J. Waldfogel (2016): "Optimal product variety in radio markets," *The RAND Journal of Economics*, 47, 463–497.

Berry, S., J. Levinsohn, and A. Pakes (1995): "Automobile prices in market equilibrium," *Econometrica*, 63, 841–890.

Berry, S. and J. Waldfogel (1999): "Free entry and social inefficiency in radio broadcasting," *RAND Journal of Economics*, 30, 397–420.

Binmore, K., A. Shared, and J. Sutton (1989): "An outside option experiment," *The Quarterly Journal of Economics*, 104, 753–770.

Bloom, P. N., G. T. Gundlach, and J. P. Cannon (2000): "Slotting allowances and fees: schools of thought and the views of practicing managers," *Journal of Marketing*, 64, 92–108.

Bonnet, C. and P. Dubois (2010): "Inference on vertical contracts between manufacturers and retailers allowing for nonlinear pricing and resale price maintenance," *The RAND Journal of Economics*, 41, 139–164.

——— (2015): "Identifying two part tariff contracts with buyer power: empirical estimation on food retailing," Working paper.

Bronnenberg, B. J., M. W. Kruger, and C. F. Mela (2008): "Database paper: the IRI Marketing data set," *Marketing Science*, 27, 745–748.

Calvani, T. and G. Breidenbach (1991): "An introduction to the Robinson-Patman Act and its enforcement by the government," *Antitrust Law Journal*, 59, 765–775.

Conlon, C. and J. H. Mortimer (2017): "Efficiency and foreclosure effects of vertical rebates: empirical evidence," Working paper.

Crawford, G. and A. Yurukoglu (2012): "The welfare effects of bundling in multichannel television markets," *The American Economic Review*, 102, 643–685.

Draganska, M., D. Klapper, and S. B. Villas-Boas (2009a): "A larger slice or a larger pie? An empirical investigation of bargaining power in the distribution channel," *Marketing Science*, 29, 57–74.

Draganska, M., M. Mazzeo, and K. Seim (2009b): "Beyond plain vanilla: modeling joint product assortment and pricing decisions," *Quantitative Marketing and Economics*, 7, 105–146.

Dubé, J., J. Fox, and C. Su (2012): "Improving the numerical performance of static and dynamic aggregate discrete choice random coefficients demand estimation," *Econometrica*, 80, 2231–2267.

Eizenberg, A. (2014): "Upstream innovation and product variety in the U.S. home PC market," *The Review of Economic Studies*, 81, 1003–1045.

Fan, Y. and C. Yang (2017): "Competition, product proliferation and welfare: a study of the U.S. smartphone market," working paper.

Federal Trade Commission (2001): "Report on the Federal Trade Commission workshop on slotting allowances and other marketing practices in the grocery industry," `http://www.ftc.gov/reports/report-federal-trade-commission-workshop-slotting-allowances-other-marketing-practices`, accessed Nov 2014.

——— (2003): "Slotting allowances in the retail grocery industry: selected case studies in five product categories," `http://www.ftc.gov/reports/use-slotting-allowances-retail-grocery-industry`, accessed Nov 2014.

——— (2014): "Guides for advertising allowances and other merchandising payments and services," `https://federalregister.gov/a/2014-23137`.

Foros, O., H. J. Kind, and J. Y. Sand (2009): "Slotting allowances and manufacturers' retail sales effort," *Southern Economic Journal*, 76, 266–282.

Ghili, S. (2017): "Network formation and bargaining in vertical markets: the case of narrow networks in health insurance," Working paper.

Gowrisankaran, G., A. Nevo, and R. Town (2015): "Mergers when prices are negotiated: evidence from the hospital industry," *American Economic Review*, 105, 172–203.

Grennan, M. (2013): "Price discrimination and bargaining: empirical evidence from medical devices," *American Economic Review*, 103, 145–177.

Hendel, I. (1999): "Estimating multiple-discrete choice models: an application to computerization returns," *Review of Economic Studies*, 66, 423–46.

Ho, K. (2009): "Insurer-provider networks in the medical care market," *American Economic Review*, 99, 393–430.

Ho, K. and R. Lee (2017): "Equilibrium provider networks: bargaining and exclusion in health care markets," Working paper.

Horn, H. and A. Wolinsky (1988): "Bilateral monopolies and incentives for merger," *RAND Journal of Economics*, 19, 408–419.

Innes, R. and S. F. Hamilton (2013): "Slotting allowances under supermarket oligopoly," *American Journal of Agricultural Economics*, 95, 1216–1222.

Israilevich, G. (2004): "Assessing supermarket product-line decisions: the impact of slotting fees," *Quantitative Marketing and Economics*, 2, 141–167.

Kim, J., G. M. Allenby, and P. E. Rossi (2002): "Modeling consumer demand for variety," *Marketing Science*, 21, 229–250.

Kuksov, D. and A. Pazgal (2007): "Research note - the effects of costs and competition on slotting allowances," *Marketing Science*, 26, 259–267.

Lariviere, M. A. and V. Padmanabhan (1997): "Slotting allowances and new product introductions," *Marketing Science*, 16, 112–128.

Marx, L. M. and G. Shaffer (2007): "Upfront payments and exclusion in downstream markets," *RAND Journal of Economics*, 38, 823–843.

——— (2010): "Slotting allowances and scarce shelf space," *Journal of Economics & Management Strategy*, 19, 575–603.

Misra, K. (2008): "Understanding retail assortments," Working paper.

Nevo, A. (2001): "Measuring market power in the ready-to-eat cereal industry," *Econometrica*, 69, 307–342.

Pakes, A., J. Porter, K. Ho, and J. Ishii (2015): "Moment inequalities and their application," *Econometrica*, 83, 215–334.

Piccolo, S. and J. Miklós-Thal (2012): "Colluding through suppliers," *The RAND Journal of Economics*, 43, 492–513.

Shaffer, G. (1991): "Slotting allowances and resale price maintenance: a comparison of facilitating practices," *RAND Journal of Economics*, 22, 120–135.

——— (2005): "Slotting allowances and optimal product variety," *The B.E. Journal of Economic Analysis & Policy*, 5, 1–28.

Su, C. and K. L. Judd (2012): "Constrained optimization approaches to estimation of structural models," *Econometrica*, 80, 2213–2230.

Sudhir, K. (2001): "Structural analysis of manufacturer pricing in the presence of a strategic retailer," *Marketing Science*, 20, 244–264.

Sudhir, K. and V. R. Rao (2006): "Do slotting allowances enhance efficiency or hinder competition?" *Journal of Marketing Research*, 43, 137–155.

Sullivan, M. W. (1997): "Slotting allowances and the market for new products," *Journal of Law and Economics*, 40, 461–493.

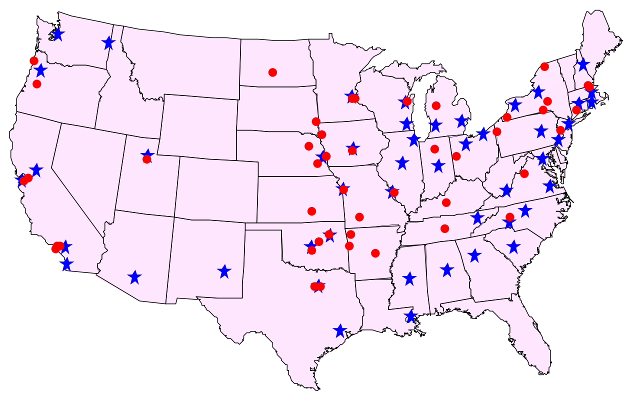
Villas-Boas, S. B. (2007): "Vertical relationships between manufacturers and retailers: inference with limited data," *Review of Economic Studies*, 74, 625–652.

Viswanathan, M. (2012): "Economic impact of category captaincy: an examination of assortments and prices," Working paper.

A Data Appendix

The data are obtained from the academic Information Resources Inc. (IRI) dataset that contains information on grocery chains' weekly sales and units sold in 47 distinct geographical markets in the U.S. for the period of 2001-2011. Markets cover major metropolitan areas (e.g. Boston, MA) or regions (e.g. New England). As shown in Figure A1, IRI market locations are scattered across the U.S..

Figure A1: Locations of Markets and Producer Plants



Notes: Stars identify market locations, while red dots show the locations of producer manufacturing facilities.

The academic dataset is drawn from the IRI's national sample of stores; IRI samples supermarkets with annual sales of more than \$2 million. The academic dataset includes information on a sample of grocery and drug stores, hence, mass merchandisers, such as Walmart, are not included in the sample. In the analysis I use data on grocery chains only. As a result, I observe between 4% and 16% of all stores in a geographic market, for a total of 80 grocery chains in the sample.[21] For each chain in the sample, the dataset contains information on an average of 25% of its stores. Chains vary in size; their estimated market yearly sales range from \$5 million to \$1,147 million. Most of the chains in the IRI dataset are among the main competitors in their respective markets. For each market, I observe at least 2 and, on average, 3 to 4 of the 5 major grocery chains. The five main competitors in a market account for 50-94% of sales in the grocery sector for the analyzed markets.

[21] Information on all stores and their estimated yearly sales is gathered from ReferenceUSA data on U.S. Businesses. ReferenceUSA collects data on U.S. businesses and continuously updates the information. The data are assembled through public sources along with regular phone interviews with stores' managers to verify the information and collect additional data on businesses.

To calculate the reported measures, I use information on grocery stores with sales of more than \$2 million a year.

In the analysis, I use 44 markets in which I observe information for at least two chains in the market at any given quarter. The sample used covers ten years, 2001-2010. The unit of analysis is 'product line'-retailer-market-quarter. As a result, a product is defined at the product line (e.g. *Stonyfield Smooth & Creamy, 6 ounce*), which includes a variety of flavors (e.g. Stonyfield Smooth & Creamy, 6 ounce, french vanilla). I aggregate to the product line level because (according to industry practitioners) assortment decisions and contracts are determined at the product line. I infer that a product line is supplied in a retailer if it records non-zeros sales for the period. Concerns about a situation in which a product is on the shelf and records zero sales are alleviated by the data aggregation at the quarter-retailer-market level.

Prices are converted to constant 2010 dollars using the Consumer Price Index by region. The average price of a 6 ounce cup of yogurt is $0.80. Most of the price variation is across products and retailers. The price variation over time due to temporary promotions is wiped out due to the aggregation at the quarter level. Retail prices do not vary across flavors.

I define five product characteristics: natural, marketed for children, soy creamy, or light. Over the sample period the ingredients for most products change and a number of products are discontinued. As a result, I rely on dummy variables to describe yogurts. These characteristics are neither comprehensive nor exclusive, that is, a product can have none of the characteristics or it may be defined as, for example, both natural and marketed for children. The natural characteristic identifies organic products, or products that are marketed as using only natural ingredients. The products identified as natural are product lines under following brands: *Brown Cow* (Groupe Danone), *Cascade Fresh* (Cascade) *Chiobani* (Agro Farma), *Cultural Revolution* (Kalona Organics), *Danone Natural* (Groupe Danone), *Fage Total* (Fage USA Corp.), *Horizon Organic* (Dean Foods), *Mountain High* (Dean Foods), *Nancy's* (Springfield Creamery), *OIKOS* (Groupe Danone), *Old Home* (Old Home Foods), *Rachel's* (Dean Foods), *Silk* (Dean Foods), *Stonyfield Farm* (Groupe Danone), *Wallaby Organic* (Wallaby Yogurt), *White Mountain* (Purist Foods). To categorize products as creamy, light, or children's, I inspect product line names and use key words. The soy products in the dataset are *Silk*, *Silk Live*, *Stonyfield Farm O'Soy*, and *Whole Soy*.

The sample consists of 24 national and regional producers and 44 private label brands. Table A1 shows market shares and market presence by producer. During the sample period, the two main competitors are Groupe Danone and General Mills; they collectively control, on average, 70% of yogurt sales. Groupe Danone produces the *Dannon*, *Stonyfield Farm*, and *Brown Cow* brands, while General Mills distributes the *Yoplait* and *Colombo* brands. Private labels are offered by 44 of the 80 chains and these products account for 15% of market

Table A1: Producer market shares and distribution

	mean	median	sd	min	max	#markets	#retailers
Agro Farma	0.03	0.02	0.04	0.00	0.21	42	53
Anderson-Erickson	0.12	0.09	0.13	0.00	0.37	4	4
Auburn Dairy	0.01	0.01	0.01	0.00	0.02	2	3
Belfonte	0.13	0.13	0.01	0.11	0.14	1	3
Breyers	0.06	0.03	0.07	0.00	0.33	44	77
Cabot Creamery	0.00	0.00	0.00	0.00	0.01	16	16
Cascade Fresh	0.00	0.00	0.01	0.00	0.05	25	25
Dean Foods	0.02	0.01	0.02	0.00	0.09	44	70
Fage USA Corp.	0.01	0.01	0.02	0.00	0.09	44	61
General Mills	0.39	0.39	0.10	0.16	0.64	44	80
Groupe Danone	0.31	0.33	0.10	0.06	0.47	44	80
Johanna Foods	0.02	0.01	0.02	0.00	0.07	20	29
Kalona Organics	0.00	0.00	0.00	0.00	0.01	4	4
LALA Foods	0.03	0.02	0.05	0.00	0.29	44	73
Northwest Dairy	0.01	0.01	0.01	0.00	0.04	4	8
Old Home Foods	0.07	0.08	0.07	0.00	0.16	2	4
Prairie Farms	0.02	0.01	0.03	0.00	0.13	13	17
Purist Foods	0.00	0.01	0.00	0.00	0.01	1	3
Springfield Creamery	0.01	0.00	0.02	0.00	0.06	24	29
Sun Valley Dairy	0.00	0.00	0.00	0.00	0.01	28	14
Tillamook Creamery	0.08	0.07	0.02	0.05	0.12	3	8
Wallaby Yogurt	0.00	0.00	0.00	0.00	0.01	30	29
Whole Soy	0.00	0.00	0.00	0.00	0.01	41	40
Private Label	0.15	0.14	0.07	0.00	0.37	44	44

Market shares are calculated before data cleanup. # markets column shows the number of markets in which the producer is available in any year; analogously for # retailers. Smaller producers are not included in the table.

Table A2: Producer Supply across Retailers

	total	mean	median	sd	min	max
Agro Farma	2	1	1	0.4	1	2
Anderson-Erickson	2	2	2	0.1	1	2
Auburn Dairy	2	1	1	0.5	1	2
Belfonte	1	1	1	0.0	1	1
Breyers	11	4	4	1.9	1	10
Cabot Creamery	1	1	1	0.0	1	1
Cascade Fresh	1	1	1	0.0	1	1
Dean Foods	10	3	3	1.5	1	8
Fage USA Corp.	1	1	1	0.0	1	1
General Mills	17	10	10	2.4	3	16
Groupe Danone	26	14	14	3.4	2	23
Johanna Foods	5	3	3	0.9	1	5
Kalona Organics	1	1	1	0.0	1	1
LALA Foods	9	3	2	1.5	1	8
Northwest Dairy	1	1	1	0.0	1	1
Old Home Foods	4	3	3	0.9	1	4
Prairie Farms	3	1	1	0.2	1	2
Purist Foods	1	1	1	0.0	1	1
Springfield Creamery	1	1	1	0.0	1	1
Sun Valley Dairy	1	1	1	0.0	1	1
Tillamook Creamery	1	1	1	0.0	1	1
Wallaby Yogurt	1	1	1	0.0	1	1
Whole Soy	1	1	1	0.0	1	1

The variable total displays the average number of product options available each a year.

sales. There is substantial variation in market shares across markets. For example, Breyers accounts for 20% of yogurt sales in Charlotte in 2004 while LALA Foods is the second biggest producer in the Omaha market. The sample includes 6 branded producers that distribute products in all 44 markets; and 17 regional producers, whose products are sold in only some of the markets.

Variation in the number of products supplied by producer is shown in Table A2. The average chain in the sample offers 31 products selected from more than 71 non-private label possible options. In terms of number of existing products, Groupe Danone produces the most product options from which chains can select offerings: an average of 26 in a year; followed by General Mills (with 17 options) and Breyers (11). On average, I observe 6 producers in a market who offer 43 unique products. Groupe Danone and General Mills supply more than half of their products to grocery chains.