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PRODUCT VARIETY AND VERTICAL INTEGRATION

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Research summary: *In vertical relationships, the potential for scale economy in manufacturing often calls for specialization and outsourcing. Specialization, however, depends critically on the stability of the task and contractual environment. In a highly uncertain environment, the need for frequent mutual adjustments favors integration instead of outsourcing. To evaluate vertical relationships in value chains where one stage competes on product variety under great uncertainty and the other stage competes on scale, we compare operations data at about 300 distribution centers within a major soft-drink bottler before and after it was integrated into an upstream concentrate producer. We find that vertical integration improved coordination for the integrated firm by aligning incentives and reducing strategic information asymmetry, but it worsened coordination for upstream rivals that shared the same downstream facilities.*

Managerial summary: *Managers make frequent decisions about outsourcing versus integration. This article helps to crystalize the costs and benefits of integration by pointing to two important factors: the potential for economies of scale and the need for coordination under uncertainty. It studies an industry where one stage of the value chain competes on product variety under great uncertainty and the other stage competes on scale. Based on operations data at about 300 distribution centers within a major soft-drink bottler before and after it was integrated into an upstream concentrate producer, we find that vertical integration improved coordination for the integrated firm (by reducing both stockouts and inventory, and improving sales forecasts), but it worsened coordination for upstream rivals that shared the same downstream facilities.*

INTRODUCTION

Repeated exchange relationships along the value chain are vulnerable to coordination problems when an upstream firm competes on product variety, with the products manufactured and distributed by a downstream firm that competes on scale. From the upstream firm's perspective, vertical integration helps to coordinate product sequencing and successive innovations that require frequent mutual adaptation along the value chain (Helfat and Campo-Rembado, 2016; Helfat and Raubitschek, 2000), thereby accommodating product variety and differentiation (Argyres and Bigelow, 2010). From the downstream firm's perspective, contracting enables gains to specialization by allowing the downstream firm to pool contacts from multiple customers to achieve economies of scale and learning (Jacobides and Hitt, 2005). Uncertainty aggravates these incentive conflicts and makes contracting costly (Klein, 2000; Teece, 1996; Williamson, 1975). Should the two stages vertically integrate to pursue product differentiation despite the higher production cost, or should they continue to contract for scale and compromise

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product variety? In this article, we investigate the mechanisms by which contracting solution gives way to vertical integration when demand uncertainty with respect to product variety increases, and upstream competitors are affected when one of them vertically integrates the downstream facilities.

We propose that the downstream firm producing for multiple upstream firms exacerbates vertical coordination challenges and jeopardizes the upstream firm's product variety strategy. In particular, sharing downstream capacity among multiple upstream firms creates problems of strategic information asymmetry. On the one hand, a downstream firm seeking to maximize its profits may under-forecast sales for one upstream firm so that it produces less for this firm, but more for another (Yehezkel, 2008). On the other hand, an upstream firm may not fully share strategic information down the value chain (Novak and Eppinger, 2001). For instance, even though providing incomplete or untimely information makes the downstream firm's sales forecasts noisy, the upstream firm may still keep promotion or new product launch plans in secrecy until shortly before the actual event because it fears the information being leaked to competing upstream firms that share the same downstream facilities. If one of the upstream firms integrates the downstream firm, the coordination between these two firms can be enhanced by aligning incentives and sharing information, albeit at a cost to the other upstream firms that still share the downstream facilities.

We test these in the soft-drink industry, where the two dominant concentrate producers (CPs), Coca-Cola and Pepsi, compete fiercely on product variety and on-time store delivery. For decades, the CPs have been taking advantage of their market power and securing supply through exclusive contracts with the bottlers. The large CPs also allow their bottlers to produce for other smaller CPs. This sharing arrangement maximizes scale, but creates obstacles along other dimensions, such as making it more difficult to introduce and coordinate new products. These difficulties became more pronounced over the last decade as the CPs faced increasing pressure to diversify their product categories from traditional carbonated soft drinks (CSDs) to healthier, noncarbonated soft drinks (NonCSDs). However, bottlers have strongly opposed this change as their existing capital-intensive production process relies heavily on economies of scale from CSD products (*Financial Times*, 2009a). To overcome the burden of increased coordination, both Coca-Cola and Pepsi restructured their largest bottlers from minority shareholdings to fully-owned subsidiaries—a change that makes it possible for us to compare multiple operations variables before and after the full integration.

Our analyses are based on operations data at the product (stock-keeping unit, or SKU) level across hundreds of distribution centers (DCs) within a major bottling company (the Bottler) for one dominant CP between 2008 and 2011, during which time the Bottler was fully acquired by the CP. Our focus is a key measure of coordination performance along the value chain: stockouts. Stockouts happen when customer orders are not completely fulfilled. Frequent stockouts result in customer dissatisfaction, and ultimately, hurt sales, profitability, and future demand (Anderson, Fitzsimons, and Simester, 2006a; Musalem *et al.,* 2010; Wan, Evers, and Dresner, 2012). It is therefore an important performance measure in the product variety literature.

We first examined about 1,200 SKUs that were produced and distributed by the Bottler for the parent CP both before and after full integration. We found that despite the Bottler's significantly increased product offerings in the NonCSD category after integration, the stockout rate for an average DC–SKU pair in our sample dropped by two percent (from a pre-integration sample average of 26%), and that the reduction was significantly more for NonCSDs than for CSDs.

We then explored the mechanisms of incentive and information that could influence stockouts. A downstream firm wants to lower its production and distribution costs, mainly through producing and delivering a single category of products with large volumes and avoiding products with relatively low and uncertain demand as well as through minimizing excess inventory. Because NonCSDs have smaller and less certain demand, and producing them requires bottlers to frequently adjust their process away from producing CSDs, bottlers have less incentive to carry NonCSDs, notwithstanding the greater strategic value of NonCSDs for the CPs. A full integration reduces incentive conflicts; we therefore expected our analysis to show DCs carrying higher inventories after integration, particularly among NonCSDs. However, to our surprise, we found that the inventory of NonCSDs decreased (relative to both actual and forecasted sales) after integration. The reduction in *both* stockouts and

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inventory suggests that integration created an overall improvement in coordination efficiency.

We next examined if the improved efficiency was consistent with an improvement in information sharing along the value chain. We compared DCs' sales forecasts before and after integration. We found that DCs adjusted their sales forecasts upward, especially if they were located close to the CP, where integration could enable closer monitoring by the CP. We also found that DCs reduced the noise (standard deviation) in their sales forecasts. This reduction was greater for DCs located far from the CP, where they could not easily observe the CP's plan for product launches and promotions, and would therefore benefit more from explicit notification from the CP after integration. We also found that DCs reduced forecasting noise more for newer products, for which the DCs would have less experience in estimating the impact of disturbance caused by promotion and other product launches.

As a comparison, we examined about 300 SKUs (mostly CSDs) produced and distributed by the Bottler for its CP parent's competitors under license agreements. We find that for these products, stockout rates increased after integration, while both inventory and sales forecasts reduced. In addition, the noise in sales forecasts increased. This is consistent with a worsened incentive and information problem between the upstream competitors of the CP parent and the CP parent's now fully integrated Bottler.

Overall, our results suggest that, on the one hand, vertical integration enhances coordination by aligning incentives and facilitating monitoring and information sharing along the value chain. On the other hand, vertical integration introduces a competitive disadvantage for the CP parents' competitors that share the same downstream facilities through contracts.

Our theoretical analyses and empirical findings have relevance for several strands of literature. First, they complement recent studies on the relationship between firms' horizontal and vertical scopes. On the one hand, they confirm the coordination benefits of vertical integration for enhancing firms' adaptability across markets (Forbes and Lederman, 2009; Novak and Stern, 2009), and the benefit of integrative capability for seizing strategic opportunities in industries dominated by successive innovations (Helfat and Campo-Rembado, 2016; Helfat and Raubitschek, 2000). On the other hand, the finding that integration worsens coordination with rival upstream firms is consistent with the hypothesis that firms' horizontal and vertical scopes could also be substitutive due to constraints in a firm's total coordination capacity (Zhou, 2011).

Second, for the literature on product variety, our focus on coordination problems echoes prior research on the operational risk of product variety despite its strategic value (Barnett and Freeman, 2001; Cottrell and Nault, 2004; Sorenson, 2000). While the operations issues that arise with product variety in stockouts, inventory, and forecasting error have been studied in the operations management literature (Fisher, 1997; Fisher and Ittner, 1999; Wan and Dresner, 2015), studies about product variety and organizational interactions along the supply chain are rare (Ramdas, 2003). By focusing on vertical integration, this article introduces organizational factors to the analyses.

Finally, our analyses add to a rich body of case studies on vertical integration in general and the soft-drink industry in particular (Karnani, 2010; Klein, 2000; Muris, Scheffman, and Spiller, 1992; Yoffie and Kim, 2012). While the majority of prior cases examine transaction costs arising from relationship-specific investments, the current article focuses on a narrow time window around vertical integration, during which no significant physical investments were made. This allowed us a unique vantage from which to analyze adaptation-related coordination issues.

THEORETICAL DEVELOPMENT

Product variety and vertical coordination

By catering to a wider range of customer preferences, product variety increases the aggregated demand for a firm's products, but often reduces the demand and increases the sales volatility for individual variety (e.g., Anupindi *et al.,* 2011; Cachon and Terwiesch, 2012), which exacerbates coordination problems along the value chain. First, it increases incentive conflicts between the upstream and downstream firms. For the downstream firms, product variety increases production costs by compromising economies of scale, increases equipment and overhead costs, and lowers worker productivity. It also increases distribution costs as the downstream firm has to deliver each variety in smaller batches and keep extra inventory (wasting working capital) to account for unexpected variation in consumer demand across varieties.

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In addition, product variety exacerbates information asymmetry between the upstream and downstream firm. The information asymmetry can be in both directions. On the one hand, a downstream firm has better information about consumers' willingness to pay for various varieties and may not accurately share that information with the upstream firm. In our context, the Bottler collects most of the demand information directly from the stores when its truck drivers make deliveries or when its sales representatives conduct routine inspections of store shelves. The downstream firm may under-forecast demand so that (1) the upstream firm extracts less value (e.g., in the form of franchise or license fees); (2) the downstream firm produces less of the variety that does not maximize its profit; or (3) the downstream firm has more freedom to manufacture other varieties (Yehezkel, 2008), including varieties for other upstream firms. Sharing markets, facilities, and production processes across multiple product varieties makes it difficult for the upstream firm to separate the demand, costs, and performance of individual varieties for evaluation, compensation, and therefore, contracting.

On the other hand, an upstream firm might hesitate to share proprietary information down the value chain, especially if the downstream firm also manufactures for other upstream firms. The upstream firm's proprietary knowledge about technological innovation and product design, as well as its plans for promotions and new product launches, can be more readily leaked to competitors with whom they share production or distribution facilities. Strategic information withholding by upstream firms due to concerns over leakage in the supply chain is prevalent in many contexts with differentiated products (Anand and Goyal, 2009). These concerns may cause the upstream firm to restrict its downstream firm's access to strategic information, even if such restrictions hinder coordination (Novak and Stern, 2009). In private conversations with us, the Bottler's forecasting staff often complained about how, before integration, the CP waited until the last minute to give it accurate information about promotion and launch plans, leaving the Bottler too little time to refine its sales forecasts and plan production. When the CP launches a new variety without giving the Bottler sufficient lead time, the Bottler will not be able to adequately account for the substitution effect between the demand for the new variety and the demand for the existing varieties; it will therefore over-forecast the demand for the existing varieties. On the other hand, when the CP announces a price promotion for an existing variety too late, the Bottler might under-forecast the demand for the existing variety. Therefore, secrecy on the part of the CP about either new variety launch or old variety promotion against the Bottler leads to forecasting noise.

In sum, expanding in a new product category increases sales volatility as well as production and distribution costs. If the strategic value of product variety outweighs these additional costs, then the jointly optimal decision along the value chain should be to increase variety. However, contracting between the upstream and downstream firms to achieve a jointly optimal outcome is not easy. Increasing product variety increases the number of contingencies that need to be covered, monitored, and enforced under a contract. In addition, to the extent that different product varieties are interdependent in their needs for resources and adjustments, the contract may get overly complex or even infeasible. Because of these contracting problems, w*e expect the Bottler to have a higher stockout rate for NonCSDs than for CSDs before integration.*

Vertical integration and coordination

Vertical integration can improve coordination in several ways. First, it aligns incentives by providing both transacting parties ownership over residual claims (Hart and Moore, 2005; Williamson, 1985). It subjects organizational units to more compatible profit objectives that facilitate an integrated response to changes in global circumstances (Gulati, Lawrence, and Puranam, 2005; Lawrence and Lorsch, 1967), such as rapidly evolving technology and consumer demand (Weigelt and Sarkar, 2012). Second, vertical integration enables closer monitoring of employee effort (Hart, 1995; Williamson, 1975). Similar to arguments made by Joskow (2008), employees within a subsidiary have more incentive (e.g., avoiding termination for false reporting) and obligation to reveal information to the parent company than employees within a less closely affiliated contractor; the parent company also has more authority and means (e.g., internal auditing) to collect information from its own subsidiary than from a less closely affiliated contractor. Finally, vertical integration facilitates information sharing by weakening the incentives for knowledge appropriation and better protecting

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propriety information (Nickerson and Zenger, 2004; Novak and Stern, 2009).

In our context, after integration, the Bottler has greater incentive to carry more NonCSDs; therefore, it will be more likely to increase inventory. The Bottler will also have more incentive and obligation to share information with the CP, and the CP will have more authority to visit the stores to assess demand and evaluate sales forecasts directly. Finally, the Bottler will have greater incentive and obligation to protect the CP's proprietary information, so that the CP will share its promotion and product launch plans with the Bottler in a timelier manner, thereby enabling the Bottler to make more accurate adjustments to its forecasts and production schedule. *We therefore expect the Bottler to have a lower stockout rate for the products of its CP parent after integration, particularly among NonCSDs.*

Vertical integration and competition

Vertical integration offers competitive advantages in oligopolistic industries. Mainly, the integrated firm can foreclose either sources of supply or channels of distribution to prevent their non-integrated rivals from accessing these sources or channels (Chipty, 2001; Hart *et al.,* 1990). In the soft-drink industry, the upstream segment is occupied by a small number of CPs, while the downstream segment is populated by a large number of bottling plants and distribution centers owned by a few dozen "bottlers." This gives the large upstream CPs more bargaining power over the bottlers. The large CPs' bargaining power is further enhanced by the bottler's need for large contracts to achieve economies of scale to improve their thin profit margin. Under such conditions, the large upstream firms can use exclusive contracts to secure supply.

However, even with business from the major upstream firms, some downstream firms may not have enough volume to maximize economies of scale. This makes it advantageous for them to contract with smaller upstream firms that need to source downstream production plants and distribution networks, but lack the volume to justify an exclusive contract. In such cases, the large upstream firm can share its downstream facilities with smaller upstream firms, provided that the downstream firm does not carry rival products that are in direct competition with products of the large upstream firm. For example, in our context, Coca-Cola and Pepsi each allow its bottlers to defray the high capital costs of bottling facilities and distribution networks by carrying products for its smaller rivals under license agreements. In fact, bottlers for Coca-Cola and Pepsi each manufacture and distribute about one-third of Dr. Pepper's products. Given that this sharing arrangement mainly results from concerns about economies of scale, it might create constraints along other dimensions (e.g., production introductions and coordination).

We do not conceptualize our particular context as a world where firms play strategic games with full rationality and foresight. Rather, we view the firms as following an evolutionary process in adapting their product-introduction and vertical-integration decisions. The old arrangement in which Coca-Cola and Pepsi owned a minority share (<40%) in their downstream facilities and share the facilities with smaller CPs through contracts discouraged (but did not totally prohibit) new product introductions. As new product introductions became more important due to the exogenous shift in consumer demand toward healthier NonCSDs, the disadvantage of the contractual arrangements became more and more constraining. One way to overcome these disadvantages is vertical integration.

Therefore, we examine a more subtle form of "foreclosure" that happens not through a total denial of the competitors' access to production resources or distribution channels, but through a substitution of coordination along the value chain. More specifically, vertical integration can align incentives and the flow of information between an upstream firm and its downstream subsidiary, while at the same time magnifying incentive and information problems between the subsidiary and the upstream parent's competitors that also source from the subsidiary. The subsidiary may now maximize its parent's market share at a cost to the parent's rivals. The subsidiary may reduce its inventory holding and demand forecasts for rival products. The rivals may also feel less comfortable sharing strategic information with the subsidiary, leading to noisier demand forecasts for their products[1]. Even when an integrated company does not intentionally foreclose its

[1] Of course, foreseeing that coordination problems could lead to a loss of revenue from other upstream firms after integration, the downstream firm's current shareholders may demand an acquisition premium from the acquiring parent. However, if the strategic value of integration is greater than the potential loss of revenue from the competitors, the parent and the downstream shareholders will be able to reach an agreement to split the net gain from integration.

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rivals, the increase in internal coordination demands between the subsidiary and its upstream parent after integration might crowd out coordination for rival products. Because of this substitution in coordination, *we expect the Bottler to have a greater stockout rate for upstream rivals' products after integration.*

THE SOFT-DRINK INDUSTRY AND THE BOTTLING COMPANY

The soft-drink industry is dominated by two CPs, Coca-Cola and Pepsi. Most bottlers used to be independently owned, but had exclusive long-term partnerships with a CP. Bottlers purchase concentrate from the CP, add carbonated water and high-fructose corn syrup, bottle the resulting beverage, and deliver it to customers. Coca-Cola and Pepsi bottlers provide direct store delivery, where the bottlers' sales or delivery staff routinely visit the stores to survey sales, check product display, stock the shelves, and place orders for replenishment (Cokesolutions, 2015). The bottling process is capital-intensive and relies on high-speed production lines; changing between products of different type or sizes is difficult. In contrast, the distribution process is largely influenced by "drop size" (size of each delivery). As a result, bottlers prefer to distribute standard products with steady and high demand. To achieve greater scale economy, anchor bottlers for Coca-Cola and Pepsi also produce and distribute for their CP partner's rivals, provided these products do not compete directly with their CP partner's products.

Over the last decade, major soft-drink companies have been under increasing pressure to expand their product lines because consumers are shifting to healthier, NonCSD drinks. For example, while U.S. soda consumption slid for the tenth straight year in 2014, the U.S. bottled-water consumption jumped by 7.3 percent (*Wall Street Journal*, 2015). According to a recent Gallup survey, more than 60 percent of Americans now avoid soda (*Beverage Daily*, 2015). This has shifted both Coca-Cola and Pepsi's strategic focus toward NonCSDs.

In response to the pressing need from the market to expand their product lines, and the lack of incentive for bottlers to cooperate with that expansion, in 2009–2010, both Coca-Cola and Pepsi fully integrated their largest bottlers. Before the integration, each CP had owned a 30–40 percent shareholding stake in its anchor bottlers; the rest of the shares were publicly traded. After the integration, both CPs established wholly owned subsidiaries that bought out all the shares in the bottlers[2]. Both CPs claimed that the change would give them greater flexibility to adapt to consumer tastes, more direct control over investments in the bottling processes, and the ability to coordinate. According to Indra Nooyi, CEO of Pepsi, "The fully integrated beverage business will enable us to bring innovative products and packages to market faster, streamline our manufacturing and distribution systems and react more quickly to changes in the marketplace, … Ultimately it will put us in a much better position to compete and to grow both now and in the years ahead" (Pepsi Press Release, 2009). Muhtar Kent, CEO of Coca Cola, gave similar comments: "The market and industry have changed dramatically. … With this transaction, we are converting passive capital into active capital, giving us direct control over our investment in North America to accelerate growth and drive long-term profitability"(Coca Cola Press Release, 2010).

Our data come from the largest anchor bottler for one of the two dominant CPs. The Bottler owns dozens of bottling plants and hundreds of distribution centers (DCs), accounting for more than half of the beverages its CP sold in North America. Like most of its competitors, the Bottler employs a make-to-stock (as opposed to make-to-order) inventory system. Products are produced and stocked at a stable pace according to a forecast of future sales, that is, before customers place actual orders. Orders are placed based on the CPs' product lists, national advertisements, and promotion deals without knowledge of the DCs' actual inventory.

The Bottler delivers its products on trucks to retailer stores both large (e.g., supermarkets) and small (e.g., convenience stores). Stockouts occur when a DC cannot deliver an entire order to a given retail outlet. Unfilled demand is not backordered. New orders are placed based on the retail store's current inventory levels. Demand is forecasted for eight, four, and two weeks in the future, and updated every week on a rolling-horizon basis. Production

[2] Because of the big difference between the CP's and the bottler's business models and profit margins, partial ownership does not sufficiently solve the incentive or information problems between the two parties. Vertical integration fully aligns the two entities' incentives, thereby improving coordination. Empirically, studying a transition from partial ownership (as opposed to from an arms-length relationship) to integration implies that our estimation of the integration impact is more conservative.

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plans are based on the four-week-advance forecasts and the current inventory level. The Bottler tries to retain four weeks of forecasted demand in inventory at the beginning of every four-week period, though actual inventory varies both across product categories and over time.

EMPIRICAL DESIGN

The exogenous shock in the demand for NonCSDs became especially salient toward the end of the last decade. The upstream CPs responded with an increased rate of product introductions in the NonCSD category. The newness of these products implies more information asymmetry: The upstream firm will have greater uncertainty about consumers' willingness to pay, while the downstream firm will find it more difficult to predict the upstream firm's product promotion and launch plans. This is therefore a valuable period of time to carry out our empirical investigation.

Data and sample

We obtained operations data for all of the Bottler's U.S. DCs from the beginning of 2008 to the second month of 2011. Together, these 264 DCs delivered thousands of SKUs over the sample period, including SKUs owned by the CP parent and SKUs delivered for other companies under license agreements. A SKU is defined as a unique combination of brand, flavor, weight, container material, container size, and package size. It is a commonly used measure of product variety (Fosfuri and Giarratana, 2009). Our data is weekly except for inventory, which is only available at the period level. Each period contains four weeks. In order to accommodate the frequency of the inventory data and to save computation time, we aggregated the data to the period level.

We first examined some summary statistics at the DC level. We found that on average about 37 percent of the SKUs and 20 percent of the sales carried by a DC were for NonCSDs. In addition, there was a significant increase in both the number of SKUs and total sales at the DC level after integration, especially for NonCSDs. The number of NonCSD SKUs increased by 27 percent, NonCSD sales per DC increased by 15 percent, and the share of NonCSD sales increased by two percent.

To compare operations before and after integration, we limited our sample to those SKUs that the 264 DCs carried at the time of integration, including about 1,200 SKUs owned by the CP parent and 300 SKUs delivered to other upstream CPs under license agreements. Our final sample contains about two million DC–SKU–period observations.

Variables

We first examined $Stockout_{sit}$, a dummy variable that takes the value of 1 if SKU *s* experiences at least one stockout at DC *i* in period *t*, and is 0 otherwise. We then examined a few other operations variables in order to explain any change we observed in stockouts. Among them, $Inventory_{sit}$, is inventory (in days of sales) of SKU *s* carried by DC *i* in period *t*. $Sales\ forecasts\_level_{sit}$ is the ratio between actual and forecasted sales. It is also called AF ratio, a standard measure of forecasting accuracy in operations management. It reflects the bias in sales forecasts. $Sales\ forecasts\_noise_{sit}$ is the standard deviation in weekly AF ratios. It reflects the noise in sales forecasts.

Our main independent variables include $Integration_t$, a dummy variable that indicates the time periods after the integration, $NonCSD_s$, a dummy variable that indicates whether the SKU is a NonCSD product, and the interaction term between $Integration_t$ and $NonCSD_s$. We also included several control variables. Among them, $Sales_{sit}$ is the quantity (in standardized cases) of SKU *s* sold by DC *i* in period *t*, log transformed. $Sales\ volatility_{sit}$ is measured using the coefficient of variation in sales, or the standard deviation of sales normalized by its mean.

Table 1 provides sample descriptive statistics and correlation matrix for the combined sample of own and rival products. An average SKU had a 25 percent chance of stockouts at a DC in every period. Forty-two percent of the observations were for NonCSDs. An average SKU was sold in 154 (exp(5.04)) cases per period per DC. The volatility in weekly sales for an average DC–SKU–period was 0.17. The average inventory was about 31 days of actual sales. The average AF ratio was 1.01. That is, on average, sales forecasted by DCs were about 99 percent of actual sales. The standard deviation in forecasts was 0.14.

Table 2 compares mean values before and after integration, for own CSDs, own NonCSDs,

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Table 1. Summary statistics and correlation matrix

Variable	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Stockout (1,0)	0.25	0.44	1.00							
(2) Integration (1,0)	0.37	0.48	−0.001	1.00						
(3) NonCSD (1,0)	0.42	0.49	0.01	−0.002	1.00					
(4) Sales	5.04	1.68	0.15	−0.05	−0.31	1.00				
(5) Sales volatility	0.17	0.16	0.01	0.03	0.08	−0.54	1.00			
(6) Inventory (in days of sales)	31	32	−0.10	−0.01	0.20	−0.45	0.36	1.00		
(7) Sales forecasts_level (AF ratio)	1.01	0.34	0.12	0.03	−0.05	0.18	−0.07	−0.31	1.00	
(8) Sales forecasts_noise	0.14	0.10	−0.03	−0.004	0.06	−0.25	0.35	0.11	−0.03	1.00

and rival brands, respectively[3]. A few key differences can be observed from the table. First, before integration DCs sold far more own CSDs (exp(5.58) = 265 cases per DC-SKU-period) and rival CSDs (exp(5.39) = 219 cases) than own NonCSDs ((exp(4.47) = 89 cases). Second, there was no significant change in stockout rates for own CSDs after integration. In comparison, there was a significant reduction in stockout rates for own NonCSDs (p-value = 0.040) and an increase in stockout rates for rival products (p-value = 0.080). Third, there was a reduction in sales per SKU and an increase in sales volatility across the board, most likely due to increased product variety. Fourth, DCs kept more inventory for NonCSDs than for both own and rival CSDs, reflecting the extra buffer needed to satisfy uncertain and more volatile NonCSD sales. After integration, inventory increased for own CSDs and rival products, but decreased for own NonCSDs (p-values < 0.0001). Finally, DCs' sales forecasts became less noisy for own products, but more noisy for rival products (p-values < 0.0001). Of course, these mean comparisons do not control for any factor that might influence these variables, such as time trend, seasonal fluctuation, or unobservable heterogeneity at the DC–SKU level. We consider these factors in our econometric analyses.

Specifications

We designed most of our specifications based on standard textbooks of operations management (e.g., Anupindi *et al.,* 2011; Cachon and Terwiesch, 2012). We included DC–SKU and seasonal fixed effects and an annual trend in all main specifications. For linear regression models, we also clustered robust standard errors at the DC level to account for correlation among SKUs carried by the same DC.

Our main regression estimated the probability of SKU s experiencing a stockout at DC i in period t:

$$E[Stockout_{sit}] = DCSKU_{si} + Season_t + \alpha_0 Annual\,trend_t + \alpha_1 Integration_t + \alpha_2 Integration_t * NonCSD_s + X_{sit}\gamma, \quad (1)$$

where $DCSKU_{si}$ and $Season_t$ are DC-SKU pair and season fixed effects, respectively. Assuming sales follow a normal distribution, the probability of stockouts can be illustrated as the probability of the actual demand being greater than the available inventory; such probability depends on sales quantity and volatility. We therefore included them as control variables in X_{sit}.

We then compared a few operations variables that might have contributed to the change in stockouts. To do that, we estimated the following specification:

$$DV_{sit} = DCSKU_{si} + Season_t + \alpha_0 Annual\,trend_t + \alpha_1 Integration_t + \alpha_2 Integration_t * NonCSD_s + X_{sit}\gamma + \varepsilon_{sit}, \quad (2)$$

where DV_{sit} represents different operations variables such as inventory and sales forecasts (both level and noise), as defined before.

Finally, we replicated Equations 1 and 2 on the subsample of rival products to identify any difference between the own and rival products in changes after integration.

[3] The majority (95%) of rival products were CSDs; we therefore did not separately examine rival NonCSD products. Even though the Bottler carried mostly CSD products for the upstream rivals, the upstream rivals could still learn from the Bottler Coca-Cola and Pepsi's plans for NonCSDs and use this information to develop their own NonCSD products bottled by themselves or other plants.

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Table 2. Mean comparison

Own CSDs	Pre-integration	Post-integration	Difference (*p*-value)
Stockout (1,0)	0.26	0.26	0 (0.907)
Sales	5.58	5.50	−0.08 (0.000)
Sales volatility	0.15	0.16	0.01 (0.000)
Inventory (in days of sales)	24.90	25.21	0.31 (0.000)
Sales forecasts_level (AF ratio)	1.01	1.03	0.02 (0.000)
Sales forecasts_noise	0.140	0.137	−0.003 (0.000)
Own nonCSDs	**Pre-integration**	**Post-integration**	**Difference (*p*-value)**
Stockout (1,0)	0.26	0.25	−0.01 (0.040)
Sales	4.49	4.30	−0.19 (0.000)
Sales volatility	0.18	0.19	0.01 (0.000)
Inventory (in days of sales)	38.69	36.85	−1.84 (0.000)
Sales forecasts_ level (AF ratio)	0.98	1.01	0.03(0.210)
Sales forecasts_noise	0.152	0.15	−0.002 (0.000)
Rival products (mostly CSDs)	**Pre-integration**	**Post-integration**	**Difference (*p*-value)**
Stockout (1,0)	0.24	0.25	0.01 (0.080)
Sales	5.39	5.13	−0.26 (0.090)
Sales volatility	0.16	0.17	0.01 (0.000)
Inventory (in days of sales)	25.75	26.77	1.01 (0.000)
Sales forecasts_level (AF ratio)	1.07	1.04	−0.03 (0.340)
Sales forecasts_noise	0.14	0.15	0.01 (0.000)

RESULTS

Pre-integration coordination (own products)

Table 3 compares operations variables for CSDs and NonCSDs owned by the CP parent before integration. The coefficients in Columns (1)–(4) are consistent with our expectation. NonCSDs had a higher rate of stockouts. A marginal effect calculation (keeping all other variables at their mean values) shows that NonCSDs were six percent more likely to experience a stockout than CSDs. This was despite the fact that NonCSDs had five more days of buffer inventory. DCs also tended to under-forecast sales more for NonCSDs, and the standard deviation in sales forecasts for NonCSDs tended to be higher than that for CSDs. The *p*-values were less than 0.001 for all these coefficients.

Column (5) investigates any time trend in stockouts before integration. For each DC–SKU pair, we compared the stockouts two years before the integration and the stockouts for the last period before integration. The dependent variable, pre-integration increase in stockouts, assumed the value of 1 if the DC–SKU pair did not experience a stockout two years before integration but experienced a stockout during the last period before integration. A marginal effect calculation based on the coefficient (keeping all other variables at their mean values) shows that NonCSDs were three percent (p-value < 0.001) more likely to experience an increasing stockout rate before integration.

Post-integration coordination (own products)

Table 4 estimates the probability of stockouts for the CP's own products. A marginal effect calculation based on Column (1) suggests that stockout rate fell by two percent age points (p-value < 0.001) after integration, from a pre-integration stockout rate of 26 percent. The change is sizable given that it happened during the short period of one year after integration. Interviews with the Bottler's management confirmed that there had not been any significant adjustments in the Bottler's operations, such as investments in physical assets and equipment or a reallocation of sourcing relationships, that would have reduced stockouts.

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Table 3. Coordination challenges for own products before integration

Dependent Variable	Stockout (1,0) (1)	Inventory (in days of sales) (2)	Sales forecasts_level (AF) (3)	Sales forecasts_noise (4)	Pre-integration increase in stockouts (0,1) (5)
NonCSD (1,0)	0.324	5.353	0.011	0.003	0.196
	[0.005]	[0.333]	[0.002]	[0.001]	[0.018]
Sales	0.362	−6.868	0.045	−0.004	0.278
	[0.002]	[0.236]	[0.001]	[0.000]	[0.005]
Sales volatility	2.002	34.506	0.147	0.200	2.659
	[0.016]	[0.903]	[0.010]	[0.004]	[0.055]
Season dummies	Yes	Yes	Yes	Yes	Yes
Observations	1,297,634	1,297,634	1,297,634	1,297,634	100,672
Log-likelihood	−711,038	−6.19E + 06	−408,500	1.27E + 06	−45,197
Pseudo R^2	0.036	0.243	0.041	0.135	0.045

Logit estimation is used for columns (1) and (5), and ordinary least square linear regressions are used for columns (2)–(4). The dependent variable in column (5) is the probability that a DC-SKU did not experience a stockout in the two years before integration, but experienced a stockout in the last four-week period before integration. Standard errors for columns (1) and (5) and robust standard errors clustered at DC level for columns (2)–(4) are included in square brackets. *p*-Values for all point estimates are less than 0.001. All tests are two-tailed.

Table 4. Vertical integration and stockout rate for own products

DV = stockout (1,0)	(1) ALL	(2) ALL	(3) ALL	(4) CSD	(5) NonCSD
Integration	−0.049	−0.040	−0.054	−0.019[a]	−0.153
	[0.007]	[0.008]	[0.008]	[0.009]	[0.010]
NonCSD_X_Integration		−0.017[b]	−0.015[c]		
		[0.008]	[0.008]		
Sales			0.490	0.415	0.567
			[0.004]	[0.006]	[0.006]
Sales volatility			2.568	2.702	2.439
			[0.016]	[0.024]	[0.023]
Annual trend	Yes	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes	Yes
DC-SKU pair fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	2,016,158	2,016,158	2,016,158	1,048,436	967,772
Log-likelihood	−817,743	−817,741	−801,719	−416,493	−384,569
Pseudo R^2	0.021	0.021	0.021	0.019	0.025

[a] *p*-Value = 0.050, [b] *p*-Value = 0.035, [c] *p*-Value = 0.079.
Fixed logit estimation is used for all columns. Standard errors are included in square brackets. *p*-Values for all point estimates are less than 0.001 unless noted otherwise. All tests are two-tailed.

Columns (2) and (3) show a negative coefficient to the interaction between integration and NonCSD dummies (*p*-values are 0.035 and 0.079, respectively). The significance of the interaction term in logit models may not be read directly from the coefficients (Hoetker, 2007; Norton, Wang, and Ai, 2004; Wiersema and Bowen, 2009). To properly interpret the interaction term, we first examined the odds ratios (Buis, 2010). Our calculation based on Column (3) suggests that the odds of a stockout was five percent lower after integration, and the odds of a stockout after integration for NonCSDs was 0.98 percent of the odds for CSDs. In addition, we estimated stockouts separately for CSDs and NonCSDs in Columns (4) and (5). Results showed a highly significant reduction in stockouts for NonCSDs after integration (*p*-value < 0.001), and a less significant reduction in stockouts for CSDs (*p*-value = 0.050). A Wald's test confirmed that the difference in the integration coefficients across the two groups is statistically significant (*p*-value < 0.001)[4]. These additional tests supported our expectation that stockouts

[4] To account for potential difference in residual variations across the two groups, we also followed Hoetker (2006) and calculated

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decreased more for NonCSDs than for CSDs after integration.

Alternative explanations

Integration can bring about multiple benefits other than improving coordination between the CP and the Bottler (*Financial Times*, 2009b; *Wall Street Journal*, 2010). Some of these benefits are alternative explanations for the integration decision, although they will not necessarily reduce stockouts. For example, integration helps introduce more innovative products, but this will not reduce stockouts in our sample, which includes only products that the Bottler was already carrying at the time of the integration. If anything, increasing product variety increases rather than reduces stockouts (Anderson, Fitzsimons, and Simester, 2006b; Musalem *et al.,* 2010; Wan *et al.,* 2012). Integration benefits that are unrelated to stockouts would make our estimation less endogenous, and integration benefits that are positively related to stockouts would make our estimation more conservative. In addition to product innovation, integration might create opportunities for process innovation that could potentially reduce stockouts. Because a large number of own and rival products share the same facilities and processes (which drives scale economy for the Bottler in the first place), we estimated separately the change in stockouts for own and rival products after integration. Column (1) in Table 7 suggests that stockouts for rival products increased rather than decreased after integration, refuting the process-innovation story. Our interviews with company staff also confirmed that no significant process changes had been made during the short duration of our sample period.

An alternative explanation for the reduction in stockouts is unobserved factors (omitted variables). For example, the CP could have decided to integrate because the change in consumer preferences had made bottling NonCSD products more profitable than before. At the same time, if NonCSD products became more profitable for a DC, it would have also carried more NonCSDs, and thereby, reduced stockouts. Factors such as this could drive a spurious relationship between integration and stockouts. Unfortunately, we did not have price or profit information at the product level to control for this. Instead, we took a few steps to mitigate this concern. First, if DCs carried more NonCSDs because they became more profitable, these products should have experienced an increase in sales. Therefore, we controlled for sales quantity and time trend in all of our regressions. Second, as a robustness check we performed a test that corrects for selection at the DC level. We exploited the fact that a number of states had imposed and credibly threatened a penalty for soda consumption during our sample period[5]. Based on this information, we first estimated the likelihood that a DC had more than 20 percent of sales from NonCSDs during our sample period; we called these DCs diversified DCs. Our results show that DCs in states with a soda penalty were more likely to be diversified. In the second stage, we estimated the likelihood that a DC reduced stockouts after integration, correcting for self-selection using an Inverse Mills Ratio calculated from the first stage. Our results are included in on-line Appendix S1. They confirm that, after correcting for selection, diversified DCs were still more likely to see a reduction in their average stockout rate after integration, which is consistent with our main results in Table 4.

In sum, while multiple expected benefits can explain the CP's motivation to vertically integrate, not all of them can explain the reduction in stockouts that we observe in Table 4. The next subsection examines a few operations variables to shed light on the exact mechanisms through which stockouts reduced after integration.

Inventory and sales forecasts

Table 5 explores a few mechanisms that could reduce stockouts. The most obvious one is to increase inventory. While before integration the DCs might not be willing to hold too much inventory at the cost of working capital, after integration they should have more incentive to do so. Table 5 first compares inventory before and

the difference in a ratio of two coefficients, for example, coefficients for integration and log(sales quantity) (or sales volatility). These calculations confirmed that the negative effect of integration (relative to the effect of sales quantity or volatility) was both economically and statistically more significant for NonCSDs than for CSDs.

[5] For example, Washington imposed a \$0.02 per ounce tax on CSDs in 2010 (*Seattle Times*, 2010) and New York proposed a \$0.01 per ounce tax on soft drinks in its 2009 state budget (*New York Times*, 2010). Virginia imposed a state excise tax on soda in addition to a sales tax. A number of other states, such as Maryland, levy sales taxes on soda, but not on other grocery food (Pinho, 2012).

after integration. Coefficients in Column (1) suggest that, as expected, inventory of own CSDs increased by close to a day of sales after integration (p-value < 0.001). However, to our surprise, inventory of own NonCSDs decreased by three days (p-value < 0.001). This implies that if inventory for NonCSDs had not been reduced after integration, the stockout rate for NonCSDs would have fallen even more.

One potential explanation for the reduction in *both* stockouts and inventory is that within each four-week period the fluctuation in inventory more closely matched that in sales; as a result, stockouts fell despite less period-average inventory relative to sales. Unfortunately, we did not have daily or weekly inventory data to test this idea, even though we noticed that the standard deviation of inventory in days of sales during the post-integration period was two days less than before integration.

One of the most important ways to better match inventory to sales is through more accurate sales forecasting. After all, real-time inventory (in days of sales) is determined based on forecasted quantity, adjusted with the lagged actual-to-forecast (AF) ratio and forecasting noise (standard deviation in AF ratio) (e.g., Anupindi *et al.,* 2011; Cachon and Terwiesch, 2012). More accurate sales forecasts will not only better match inventory and sales to reduce stockouts, but also will give DCs the confidence to hold less "buffer" inventory.

Column (2) compares sales forecasts. It suggests that DCs increased their sales forecasts (reduced AF ratio) from about 99 percent to 100 percent of actual sales after integration (p-value = 0.004). We argue in the theory section that improved sales forecasting could be caused by better monitoring by the CP and more information sharing between the CP and the Bottler. To test this mechanism, column (3) adds a dummy to capture if the DC is in the same or a neighboring state of the CP parent. A number of scholars have found that the integration benefit of better monitoring is more prevalent for units that are geographically near headquarters than for units that are far away (Brickley and Dark, 1987; Kalnins and Lafontaine, 2013; Rubin, 1978). This is because monitoring often requires managers from headquarters to visit the units routinely, which can be costly for units in remote locations. Consistent with this line of logic, the coefficients in column (3) confirm that the upward correction in sales forecasts was mostly experienced by DCs that were located near the CP (p-value = 0.011). Column (3) also include the age of the product (number of periods since its initial launch). Older products have more sales information to reduce forecasting bias and should benefit less from integration. This coefficient is supportive but not statistically significant.

Columns (4) and (5) compare the noise in sales forecasts. Results suggest that DCs reduced the noise in their sales forecasts after integration, and the reduction was greater for NonCSDs (p-value < 0.001) and DCs far away from the CP (p-value = 0.001). Even before the integration, DCs close to the CP would be able to partially observe some "hint" that the CP will initiate a new product launch or promotion, whereas DCs faraway would have to wait for the CP's explicit notification. DCs faraway therefore experienced greater information disadvantage before integration and would benefit more from integration. Column 5 also confirms that forecasts of newer products benefited more from integration (p-value < 0.001).

Overall, results in Table 5 suggest that the joint reduction in *both* stockout rates and inventory after integration was due to an overall improvement in coordination efficiency, most likely reduced information asymmetry in both directions. While the reduction in the Bottler's information misrepresentation (i.e., the increase in sales forecasts) after integration can explain the reduction in inventory in days of forecasted sales, it cannot not explain the reduction in inventory in days of actual sales. We think the inventory reduction may also be caused by DCs reducing buffer inventory as they became more confident in less noisy sales forecasts. In a supplementary analysis, we did find that inventory was positively associated with both the downward forecasting bias and forecasting noise in the previous period.

In order to see if inventory and sales forecasts explain the reduction in stockouts, in Table 6, we re-estimated stockouts with the additional variables of inventory and sales forecasts. The results first confirm that stockouts were negatively related to inventory and positively correlated with AF ratio and noise in sales forecasts. In addition, columns (1) and (2) confirm that after controlling for the changes in inventory, stockouts increased for CSDs (p-value = 0.069) and reduced even more) for NonCSDs (p-value < 0.001). Columns (3) and (4) confirm that after controlling for the improvement in sales forecasts, the change in stockouts became smaller. Wald's tests of these coefficients across

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Table 5. Alternative mechanisms for stockout reduction: inventory and sales forecasts

Dependent Variable	Inventory (in days of sales) (1)	Sales forecasts_level (AF) (2)	(3)	Sales forecasts_noise (4)	(5)
Integration	0.808	−0.010[a]	−0.015[b]	−0.007	−0.051
	[0.210]	[0.003]	[0.014]	[0.001]	[0.003]
NonCSD_X_Integration	−3.843	0.001[c]	0.002[d]	−0.002	0.0001[e]
	[0.227]	[0.003]	[0.003]	[0.0004]	[0.0005]
Sales	−20.351	0.333	0.333	0.020	0.020
	[0.243]	[0.005]	[0.005]	[0.0005]	[0.0005]
Sales volatility	7.739	0.047	0.048	0.177	0.177
	[0.738]	[0.007]	[0.007]	[0.003]	[0.003]
DC near CP (1,0)_X_Integration			−0.016[f]		0.003
			[0.006]		[0.001]
Product age_X_Integration			0.002[g]		0.010
			[0.003]		[0.0006]
Annual trend	Yes	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes	Yes
DC-SKU pair fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	2,016,158	2,016,158	2,016,158	2,016,158	2,016,158
Log-likelihood	−8.94E + 06	−287854	−595,322	2.24E + 06	2.17E + 06
Adjusted R^2	0.593	0.303	0.308	0.308	0.308

[a] p-Value = 0.004.
[b] p-Value = 0.278.
[c] p-Value = 0.587.
[d] p-Value = 0.446.
[e] p-Value = 0.855.
[f] p-Value = 0.011.
[g] p-Value = 0.489.
Fixed effects linear regressions are used for all columns. Robust standard errors clustered at DC level are included in square brackets for all columns. p-Values for all point estimates are less than 0.001 unless noted otherwise. All tests are two-tailed.

models suggested that their differences are statistically significantly.

Vertical integration and rival products

To facilitate a comparison with the CPs' own products, Table 7 estimates the changes in stockouts, inventory, and sales forecasts for the products of rival CPs. The coefficients show that the stockout rate and forecasting noise increased while inventory and sales forecasts reduced after integration (p-value < 0.001), consistent with our expectation.

In sum, the results in Tables 4–6 imply that, despite the increased sales volatility that accompanies a greater level of variety in the NonCSD category, DCs were able to reduce both stockouts and inventory for own NonCSDs after integration. This is consistent with DCs having more incentive to increase sales forecasts and having better information to reduce forecasting noise. In contrast, Table 7 suggests that there was a deterioration in DCs' operational performance for rival products.

In addition to the main results in Tables 3–7, we ran a host of robustness checks. For example, to reduce potential simultaneity we lagged all independent variables. To avoid any estimation bias due to some dependent variables being left-censored, we re-estimated these variables using their log-transformed values and Tobit models, respectively. Our main results were robust to these alternative specifications.

DISCUSSION AND CONCLUSIONS

This article studies how product variety creates coordination problems along the value chain, and how vertical integration helps to solve these problems through incentive alignment and information sharing. In particular, we examine challenges between a concentrate producer (CP) and its anchor Bottler in coordinating product introductions, manufacturing, and distribution. We show that, in this particular case, vertical integration had a positive impact on coordination (in terms of

Table 6. Impact of inventory and sales forecasts on stockouts

DV = stockout (1,0)	(1) CSD	(2) NonCSD	(3) CSD	(4) NonCSD
Integration	0.017[a]	−0.175	−0.011[b]	−0.121
	[0.010]	[0.010]	[0.010]	[0.010]
Sales	0.105	0.156	0.004[c]	0.046
	[0.006]	[0.007]	[0.006]	[0.008]
Sales volatility	2.763	2.491	1.809	1.749
	[0.024]	[0.023]	[0.032]	[0.033]
Inventory (in days of sales)	−0.019	−0.019	−0.017	−0.017
	[0.001]	[0.006]	[0.0002]	[0.0001]
Sales forecasts_level (AF)			0.669	0.550
			[0.011]	[0.012]
Sales forecasts_noise			1.860	1.362
			[0.042]	[0.045]
Annual trend	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
DC-SKU pair fixed effects	Yes	Yes	Yes	Yes
Observations	1,048,436	967,772	1,048,436	967,772
Log-likelihood	−408,828	−373,511	−393,025	−360,260
Adjusted R^2	0.037	0.053	0.054	0.067

[a] p-value = 0.069.
[b] p-value = 0.245.
[c] p-value = 0.523.
Inventory and sales forecasts are measured at the beginning of each period. Fixed effects linear regressions are used for all columns. Robust standard errors clustered at DC level are included in square brackets for all columns. p-Values for all point estimates are less than 0.001 unless noted otherwise. All tests are two-tailed.

Table 7. Integration and rival products

Dependent Variable	Stockout (1,0) (1)	Inventory (in days of sales) (2)	Forecasts_level (AF) (3)	Forecasts_noise (4)
Integration	0.055	−2.332	0.085	0.004
	[0.017]	[0.293]	[0.004]	[0.001]
Sales	0.526	−17.177	0.307	0.015
	[0.010]	[0.430]	[0.008]	[0.001]
Sales volatility	2.822	9.082	0.078	0.216
	[0.042]	[1.021]	[0.015]	[0.005]
Annual trend	Yes	Yes	Yes	Yes
Season dummies	Yes	Yes	Yes	Yes
DC-SKU pair fixed effects	Yes	Yes	Yes	Yes
Observations	315,870	315,870	315,870	315,870
Log-likelihood	−124828	−1.37E + 06	−62280	354696
Pseudo/Adjusted R^2	0.026	0.576	0.259	0.317

Fixed effects logit estimation is used for column 1, and fixed effects ordinary least square linear regressions are used for columns (2)–(4). Standard errors for column (1) and robust standard errors clustered at DC level in columns (2)–(4) are included in square brackets. p-Values for all point estimates are less than 0.001. All tests are two-tailed.

stockouts, inventory, and sales forecasts) for the CP's own products, but a negative impact on coordination for products the bottler carried for the CP's rivals.

The key theoretical contribution of the article is to marry two primarily unrelated streams of prior work on product variety and vertical scope. It relates product scope extension to coordination challenges along the value chain and examines the coordination benefits and trade-offs of vertical integration. It complements recent studies on the coordination challenges firms face when they pursue economies of scope, and studies on the coordination benefits of vertical integration for enhancing firms' adaptability. Finally, by highlighting how an integrated firm improves coordination at the cost of its upstream rivals, the article implies an intricate mechanism of nonprice discrimination.

A second theoretical contribution of the article is to bridge existing work on product variety in operations management and strategy. Even though there is a large body of mathematical models about variety-related problems in operations management, these models are usually built at the level of a single plant or production line. Studies about variety and the interaction between organizational units along the supply chain are rare. This article fills this gap. At the same time, while there is a large body of literature on the benefits of vertical integration in strategy, the empirical investigation has been limited to aggregate, firm-level performance under different governance modes or to a single performance measure at the transaction level. By incorporating basic models from operations management on stockouts, inventory, and sales forecasts, this article paints a more complete picture of the mechanisms behind coordination and vertical integration.

The article has a few limitations that create opportunities for future research. Because this is a case study of one company, it cannot answer the general question of whether an increase in product variety should be accompanied by an increase or a reduction in vertical scope. On the one hand, product scope and vertical scopes may be complementary because vertical integration allows firms to exercise stronger control over resources and processes that are shared across related markets (Forbes and Lederman, 2009; Novak and Stern, 2009). On the other hand, because firms are constrained in their total coordination capacity, their product and vertical scopes may be substitutive (Zhou, 2011). Our study presents one scenario where vertical integration improves product-level efficiency for the integrated company, to the disadvantage of its rivals. This is consistent with both the coordination-benefit and coordination-capacity-constraint arguments.

Firm scope is a dynamic phenomenon that shifts with the relative magnitude of transaction and integration costs. Integration is justified when benefits of a coordinated response to environmental changes outweigh the potential organization and production costs that can be saved through outsourcing. In the context of this study, the CPs integrated their bottlers, in spite of low profit margins in the bottling business, in order to achieve a coordinated response at a time when consumer demand for NonCSDs was evolving rapidly. Historically, the CPs have repeatedly integrated and disintegrated their bottlers. The recentness of this particular integration event prevents us from investigating whether the integration benefits are sustainable given the worsening service for rival CPs' products and the potential burden of coordinating the integrated firm. On the one hand, integration provides incentives for more information sharing. On the other hand, integration removes the boundary that used to insulate the upstream and downstream firms from each other and imposes more complex relationships between the two. Only a few years after acquiring their bottlers, both CPs announced that they intended to refranchise their distribution networks (*Beverage Daily*, 2013; Coca-Cola Company Press, 2016). Future studies may examine the CPs' performance in the now more mature NonCSD segment after franchising.

Studying hundreds of organization units and thousands of product varieties within a single company allowed us to eliminate unobserved firm heterogeneity and extract detailed operations data about key elements of coordination. However, we did not have a control group that could help us to identify the causal effect of integration more sharply. While we cannot fully solve this endogeneity issue, we tried to mitigate it by (1) ruling out alternative explanations, (2) adding a strict set of control variables and fixed effects, (3) adopting a selection model and other robustness checks, (4) comparing post-integration changes in multiple operations variables to construct a cohesive story, (5) exploiting pre- and post-integration differences across various product categories (CSDs versus NonCSDs, own versus rival, new versus old) and distribution centers (those close to versus those far away from the CP headquarters, those diversified versus those never significantly diversified), and (6) using rival products as a "placebo" or "falsification" test that further removes some time-varying DC characteristics. By using this comparative approach, the article aims to identify the exact mechanisms that could explain the change in coordination.

In conclusion, this article highlights the intricate and important challenges facing firms that pursue product variety. It shows that vertical integration plays a positive role in coordination by aligning incentives and facilitating information sharing along the value chain. At the same time, integration has the potential to crowd out coordination for rival products.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix S1. Correcting for selection into Non-CSD varieties at the DC level.

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