ABSTRACT

Title of Document: PRODUCT VARIETY, SERVICE VARIETY, AND THEIR IMPACT ON DISTRIBUTORS

Xiang Wan, Ph.D. 2011

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Abstract: Despite considerable research relating to product variety, few studies have analyzed the impact of product variety on distributors. Furthermore, compared to research on product variety, service variety has been overlooked in the literature. This dissertation consists of three essays: *Essay One* examines the direct effect of product variety on sales, its indirect effect on sales through stockouts, as well as the total impact of product variety on sales performance. *Essay Two* develops a moderated mediation model to investigate how service quality and market performance are affected by service variety and the interaction impacts of different types of services. *Essay Three* analyzes a dynamic system, which includes influences of product and service variety on demand and costs and their reverse impacts on variety decisions.

PRODUCT VARIETY, SERVICE VARIETY, AND THEIR IMPACT ON DISTRIBUTORS

By

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Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2011

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Acknowledgements

First and foremost I would like to express my deep gratitude to my advisors: Dr. Martin Dresner and Dr. Philip Evers, who introduced me to this interesting research field. They shared their knowledge and experience with me. My research work could not have been completed without their unselfish support. I have achieved more than I have ever dreamed of in five years through their guidance and help, and I am so proud of being one of their students.

I would also like to thank my committee members: Dr. Thomas Corsi, Dr. Yan Dong, and Dr. Paul Schonfeld. They always found the time to listen to my ideas and provide timely advice and thoughtful feedback. Their helpful comments and suggestions have encouraged me since I started this dissertation

The faculty and staff in the Logistics, Business, and Public Policy Department have all been extremely supportive over the five years that I have been at the University of Maryland. They literally taught me everything I know about research and teaching.

The writing of a dissertation is obviously not possible without the guidance and support of many people. I owe my gratitude to all the people who have made this dissertation possible, and because of all this support, my graduate experience has been one that I will cherish forever.

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Chapter 1 Introduction

1.1 Background and Brief Literature Review

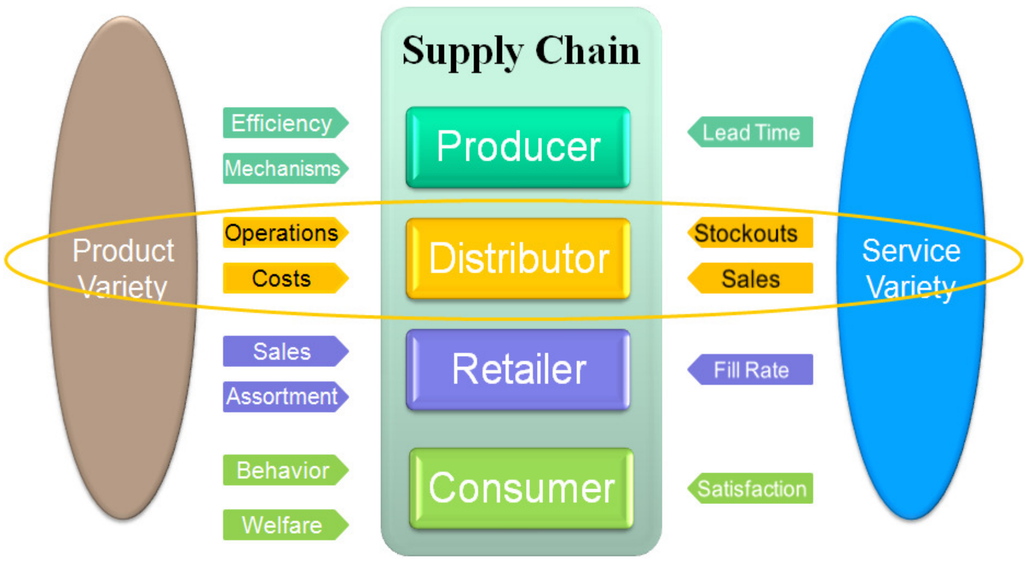
Over the last couple of decades, product variety has been used as a popular strategy to increase sales and ultimately raise profits in many industries. In 1999, Home Depot carried over 40,000 SKUs in each of its stores in North America (Balakrishnan et al., 2000). In the food industry, Kellogg Co. produces food products in more than 15 brands, such as Kellogg's, Keebler, Pop-Tarts, etc. Products produced by the Honda Motor Company (Honda) cross 6 categories, including motorcycles, automobiles, bikes, engines, robots, and aircraft. In the U.S. automobile market, Honda has sold more than 10 auto models, such as Accord, Civic, Pilot, Element, and Odyssey. Finally, in the soft drink industry, Coca-Cola Co. introduced 37 new flavors to the market between 2005 and 2009 (Coca-Cola press center).

Aside from the variety of physical products, services provided by firms also deserve attention. In order to facilitate the transaction of products, firms need to provide a variety of services to their downstream customers in the supply chain. For example, Amazon.com offers up to 6 delivery methods for online shoppers: free super saver shipping, standard shipping, free two-day shipping with AmazonPrime, two-day shipping, one-day shipping, and local express delivery. Payment options provided by Fedex Co. include online billing, electronic data interchange (EDI), credit card, mail, telephone, etc.

There are major incentives for firms to implement a strategy that includes product and service variety. By providing higher product variety, firms can capture consumer demand in different market segments, thus increases sales and market share. High service variety satisfies customer needs in the purchasing process and the delivery performance at the post-purchase stage. At the same time, the development of information technology, such as the internet and Enterprise resource planning (ERP), along with flexible manufacturing technologies, such as mass customization, component sharing, and modularization, has facilitated a high-variety strategy in products and services, with relatively low operational and production costs.

Studies related to product and service variety have been conducted in many academic fields, such as Industrial Engineering, Economics, Strategy, Marketing, and Operations Management (Ramdas, 2003, Xia and Rajagopalan, 2009). Figure 1.1 provides a supply chain perspective on how product and service variety affects consumers, retailers, distributors, and manufacturers.

Figure 1.1 The Framework of Product Variety, Service Variety, and Supply Chains



Product variety affects consumer purchase behavior and consumer welfare. High product variety allows for the satisfaction of the needs and desires of heterogeneously distributed consumers. In addition, product variety allows consumers to enjoy a diversity of options through “variety seeking” behavior, which satisfies intellectual curiosity (Kahn, 1998). Thus, increasing product variety enhances consumer welfare (Brynjolfsson et al., 2003). In contrast, a reduction in variety has a negative effect on both shopping frequency and purchase quantity (Borle et al., 2005). However, it has also been shown that too much variety may lead to customer confusion or frustration (Huffman and Kahn, 1998). Therefore, the relationship between product variety and consumer purchase behavior may be non linear.

Literature on product variety related to retailers is mainly concerned with product assortment, product display, and the impact of variety on sales. High product variety helps to increase retailer sales since product variety provides customer segmentation, which provides a better fit for consumer preferences. Retail stores that offer high product variety and display products in a manner that allow consumers to perceive the variety of products can better satisfy their consumers (Hoch et al., 1999). However, adding product variety also increases a retailer’s operations costs and may lead to lower consumer service. For example, increasing variety adds to total inventory levels and may increase backorders at the retailer (Ryzin and Mahajan, 1999). High product variety will also increase the difficulty in managing inventory for retailers. For example, increasing product variety may result in products that are physically present in the store, but only in storage areas where customers cannot find them (Ton and

Raman, 2010). Thus, the retailer may not be able to present the complete variety of products at all times.

For producers, high product variety allows firms to deter new entry into the market, and thus charge higher prices (Bayus and Putsis, 1999, Dewan et al., 2003, Xia and Rajagopalan, 2009). By increasing product variety, firms decrease the opportunities for new firms to enter a market, since product segments are already occupied. However, on the downside, a product variety strategy may lead to the loss of efficiency due to an increase in production costs; that is, shorter production runs, higher setup costs, etc. Thus, many mechanisms have been proposed allow for a firm to offer a high product variety, but minimize efficiency loss and cost increases. These mechanisms include modularization, component sharing, assembly postponement, and mass customization (Heese and Swaminathan, 2006, Hopp and Xu, 2005, Huang et al., 2008, Ramdas et al., 2003).

Despite a broad range of research related to product variety, few studies are found that analyze the impact of product variety on distributors and their variety decisions. Anderson and Narus (1984, p. 62) define a distributor as ‘‘a firm that resells products and provides attendant services to other firms for use in the production of those firms’ goods and/or services.’’ By reselling products, distributors have control over the variety of products offered to retailers. For example, distributors can balance the degree of product variety offered by discontinuing orders for products with low sales performance in certain markets. Thus, distributors can differentiate between locations or markets by offering different levels of product variety.

Furthermore, as intermediates between producers and retailers, distributors are uniquely impacted by product variety. This impact will affect various aspects of the performance of distributors, such as sales, costs, and operational factors. Compared to retailers, distributors face demand at an aggregate level (e.g., store-level orders rather than individual consumer orders) and the impact of product variety on consumer purchase behavior may not be reflected in these aggregate orders. Compared to producers, distributors may be more sensitive to costs and efficiency concerns from operations and logistics, since, unlike manufacturers, distributors do not have costs of production. Whereas, the impact of product variety on operational costs and efficiency may be a minor concern for producers, they could be a major concern for distributors.

In order to respond to demands from producers and retailers, distributors need to provide a variety of services to facilitate product delivery (Mudambi and Aggarwal, 2003). According to Anderson and Narus (1984), distributors need to both deliver products for producers and provide services to retailers. Thus, service is an indispensable function of distributors that deserves similar attention to the provision of physical products.

However, in comparison to research on product variety, studies on the variety of services are rare (Apte et al., 2008, Ramdas, 2003, Smith et al., 2007). Most papers related to services in supply chains investigate service levels (fill rates), lead time at producers and retailers, and the impact of service on customer satisfaction (Chen and Yu, 2005, Krishnan et al., 1999, Ryzin and Mahajan, 1999). Service levels and lead time are used to measure the impact on customers of service providers. On the other hand, service options offered by distributors and the influence of these options on the performance of service providers (e.g. distributors) have not been well studied.

Variety of physical product and services and their impact on the distributor is a focus of this research. In particular, this research examines the relationship between product variety, service variety, and distributor performance (demand, sales, and costs). In order to analyze theses relationships, I focus on the bottlers in the soft drink industry, which is further discussed in the following section.

1.2 Industry Background

Soft drinks include beverages that contain no alcohol. The most common soft drinks include cola, flavored water, sparkling water, iced tea, etc. The two largest worldwide soft drink producers are the Coca-Cola Co. and PepsiCo. In 2009, these two companies accounted for a 71.8 percent share of the U.S. soft drink market in terms of sales volume (Business Week, March 24, 2010. 41.9 percent for Coca-Cola Co. and 29.9 percent for PepsiCo). These two companies have various competing brands of soda and other drinks. Coca-Cola Co., the largest beverage company in the world, was founded in 1892. The Company offers nearly 400 brands in over 200 countries, and 1.6 billion servings each day (Coca-Cola Press Center, 2008). Besides its namesake Coca-Cola beverage, Coca-Cola Co. also produces Fanta, Sprite, Aquarius, and other well-known brands. PepsiCo's predecessor company, the Pepsi Cola Company, was started in 1898 by a Pharmacist and Industrialist, Caleb Bradham, and became known as PepsiCo when it merged with Frito Lay in 1965.

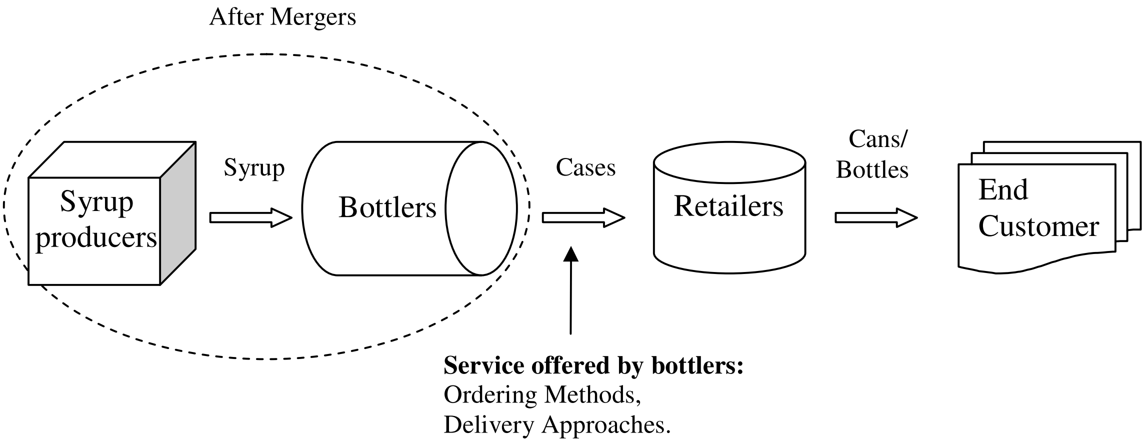
Aside from the Pepsi-Cola brands (such as Pepsi, Mountain Dew, and Sierra Mist), PepsiCo also owns Gatorade, Frito-Lay, SoBe, Tropicana, Copella, and Mirinda.

The soft drinks industry, as shown in Figure 1.2, usually has a two-tiered production structure. Syrup manufacturers produce concentrates and sell them to bottlers, that pack, sell, and distribute products with the syrup producers' trademarks to local retailers (Katz, 1978). Finally, end customers purchase the various soft drink products at retail stores, such as grocery stores and convenience stores.

Service variety is defined in this dissertation as service options provided by distributors to facilitate transactions, operations, and logistics, such as order methods and delivery methods. Order methods include telephone orders, "conventional" orders, pre-selling, and electronic ordering. Telephone ordering allows customers to place orders via phone with the customer service center of the distributor. Using "Conventional" orders, truck drivers check the shelves for stock at each retail store on their route, then stock the shelves from inventory on their trucks and receive payment from the retailers; "Pre-sell" order method is the most commonly used approach by the bottler. Distribution centers send sales representatives to retailer stores who check the stock on the shelves and then place orders on behalf of the retailers; Using electronic Orders, retailers place orders via an electronic ordering system operated by the distributor.

Variety of delivery methods includes bulk delivery, dispatchable bay, non-dispatchable bay. Bulk delivery is normally used to provide stock to larger stores; for example, to supermarkets. Each bulk truck can carry up to 11 pallets on each delivery route. Products are loaded onto the truck in pallets and then unloaded at the retail stores by pallet jack; Dispatchable Bay delivery uses trucks to deliver products packed with the exact amount requested in cases and unloaded by a two-wheel dolly; Non-dispatchable Bay delivery uses sideload trucks are used to deliver products after drivers survey a retail store on a route.

Figure 1.2 The Supply Chain Structure in the Soft Drinks Industry



Recently, the two giant syrup producers: Coca-Cola Co. and PepsiCo, signed a series of merger agreements with their major bottling companies. On February 26, 2010, PepsiCo completed mergers with its two largest bottlers: the Pepsi Bottling Group and PepsiAmericas, forming a new wholly-owned division of the PepsiCo North American Beverages unit, Pepsi Beverages Company (PBC). At the same time, Coca-Cola Co. and its largest bottler, Coca-Cola Enterprises (CCE), entered into the process of merging CCE's North American division into Coca-Cola Co. The acquisition of CCE's North American Business was completed in October, 2010 and the integrated units are named Coca-Cola Refreshments USA, Inc. and Coca-Cola Refreshments Canada Company (Coca-Cola-Co.-Press-Center, 2010).

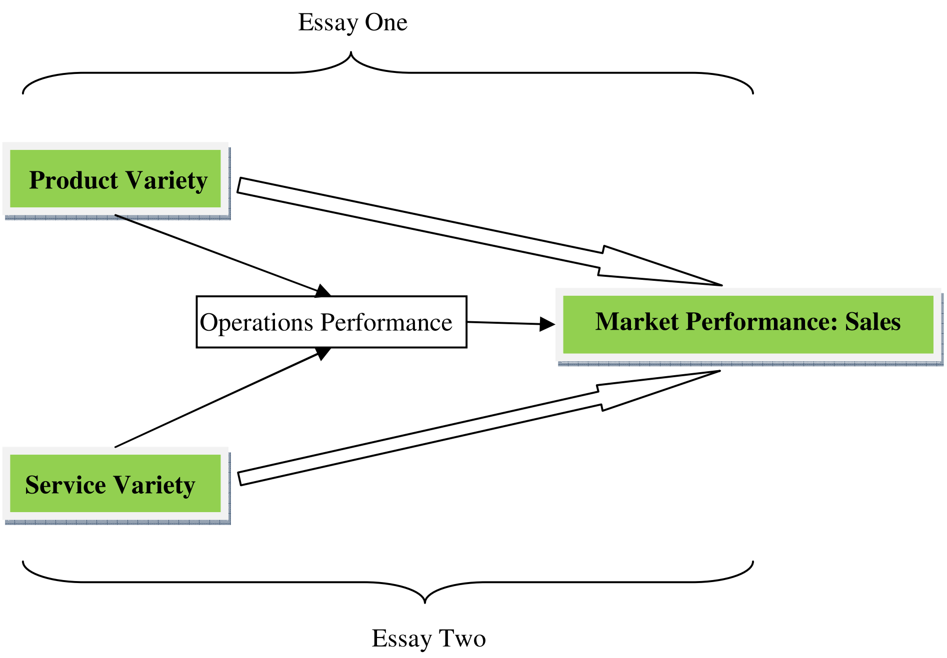
In general, neither syrup producers, nor bottlers, can solely determine product variety decisions. These decisions require a complex coordination process before a variety decision is finalized. Given these mergers, syrup producers and bottlers are now integrated beverage producers, with more freedom to leverage soft drink product variety in brands, flavors, and packages. Product variety and service variety, therefore, may become an even more important factor for soft drink producers' strategies.

1.3 The Framework of the Dissertation

This dissertation consists of three essays (organized in Chapters 2, 3, and 4 respectively) that examine three aspects of the relationships among product and service variety and performance (service level, sales, and costs) of distributors. The central theme of this research is how distributors should best manage product and service variety in supply chains.

As shown in Figure 1.3, Essay One in Chapter 2 studies the direct effect of product variety on sales and its indirect effect on sales through the operations performance metric: out-of-stock. High product variety stimulates sales by segmenting customers and attracting variety-seeking shoppers (Bayus and Putsis, 1999, Xia and Rajagopalan, 2009). However, increasing variety also raises the difficulty of inventory management, potentially resulting in decreases in service level, and perhaps undermining sales (Alfaro and Corbett, 2003, Lee and Tang, 1997, Randall and Ulrich, 2001).

Figure 1.3 The Framework of Essay One and Two



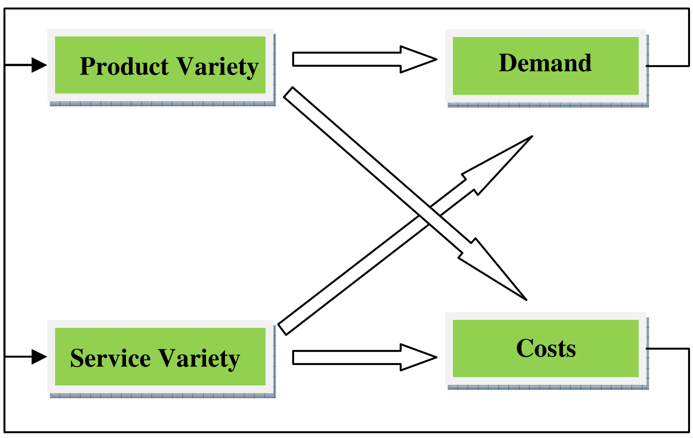
When considering both the negative impact of the increased out-of-stock due to high product variety and the positive impact of variety on sales, it is unclear what the net impact of product variety on sales performance will be. The determination depends on the trade-off between the positive and negative impacts of product variety on sales. As a result, both the positive and the negative impact of product variety on sales are investigated. Furthermore, product variety and its impact on out-of-stock and on sales are analyzed in multiple dimensions (brand variety, pack-size variety, and SKU variety). The objectives of this study are the following 1) to analyze how service levels affect the impact of product variety on sales; 2) to develop a clearer indication of how product variety impacts sales both directly and indirectly through mediating logistics variables; and 3) to examine how the impact of product variety on the service levels and sales varies across product variety dimensions.

Service variety, as shown in Figure 1.3, is introduced in Essay Two (Chapter 3). A variety of services, ranging from shipping options to ordering options, allow firms to better obtain demand information and to more efficiently supply downstream firms. High service variety in ordering methods offered by distributors provides a large ordering option pool to retailers, allowing retailers to choose the most efficient method for placing orders. In addition, more options in delivery methods help to better satisfy retail demand and to delivery products on a more flexible time schedule, since different delivery methods appeal to retailers with different needs. For example, if a distributor offered only bulk delivery, it would likely deliver batch shipments in bulk sizes with low delivery frequency, meeting the needs of only one type of customer. Thus, high service variety in order methods and delivery methods would help distributors satisfy a greater variety of customers. However, service variety management has received little attention in the literature (Ramdas, 2003).

This second essay analyzes the relationships among service variety, service quality (fill rate), and market performance (sales). Specifically, the questions addressed are the following: (1) What impact does service variety have on service quality and market performance? (2) Does this impact vary among different types of services provided? (3) Does the link between service quality and market performance that has been found in pure service firms also hold for a manufacturing-based firm? (4) Are there interaction effects among the different types of service variety in the provision of service quality?

Essay Three (Chapter 4), as shown in Figure 1.4, investigates product variety and service variety and their impact on demand and costs. Product and service variety studies are normally considered at the firm level. Firms have various policies to maintain their product variety. Given a certain variety decision made by a firm, different degrees of product and service variety can be assigned to its distribution channels. Thus, within a distributor, distribution centers will have different degrees of product and service variety. The differences in the variety of products and service affect demands and costs at the various distribution centers.

Figure 1.4 The Framework of Essay Three



Previous research, largely theoretical in nature, has identified three streams of relationships among product variety, demand, and costs. In the demand stream, high variety in products has been found to allow a firm to satisfy the wants and needs of heterogeneous consumers and, thus, to increase demand (Smith and Agrawal, 2000). In the cost stream, from a supply perspective, high product variety increases operations costs by raising the complexities in production, assembly, inventory, and logistics management (Fisher and Ittner, 1999, Heese and Swaminathan, 2006, Ramdas, Fisher and Ulrich, 2003). Finally, in the stream of literature on variety decisions, firm managers must balance demand increases due to product variety with the associated increases in costs.

Despite the theoretical interest in variety and its impact on operational performance, there has been very little empirical research addressing this topic. Moreover, no empirical study has simultaneously considered all three of the possible effects associated with product and service variety. All three streams of relationships form a dynamic loop system of variety, demand and cost as shown in Figure 1.4. Any simple explanation for the impact of product and service variety on performance is likely to be incomplete. Consequently, in this Essay, I attempt to provide a more complete empirical framework that captures the impact of variety on both demand and costs, and the influence of demand and cost outcomes on future variety decisions.

Finally, concluding remarks, implications, and future research directions are discussed in Chapter 5.

Chapter 2 The Impact of Product Variety on Firm Performance

2.1 Introduction

Product variety has long been used to increase firm performance. It is generally assumed that a firm can raise its overall market share by increasing its product selection and, thereby, appeal to a larger, more diverse set of customers (Ho and Tang, 1998). Coca-Cola Co., for example, has long followed this strategy, introducing new brands, flavors, and packages on a regular basis. The company introduced ten new flavors to the market between 2008 and 2009 and an additional 18 flavors in 2010 (Coca-Cola Co. press center, 2011). However, greater product variety does not always lead to higher sales. For example, when Procter & Gamble Co. *reduced* the number of versions of its Head and Shoulders shampoo from 26 to 15, sales actually *increased* ten percent (Schwartz, 2000).

An extensive body of literature has examined the influence of product variety on sales. The literature can be divided into two main streams: marketing and operations management. In the marketing literature, high product variety has been found to allow a firm to satisfy the wants and needs of heterogeneous consumers and, thus, to increase the probability of completing a sale. Hence, high product variety is said to stimulate sales by segmenting customers and attracting variety-seeking shoppers (Bayus and Putsis, 1999; Xia and Rajagopalam, 2009). In the operations management literature, researchers argue that increasing variety raises the difficulty of managing inventory, reduces operational performance (for instance, the fill rate), and ultimately undermines sales (Alfaro and Corbett, 2003; Fisher and Ittner, 1999; Ton and Raman, 2010). Higher product variety makes it harder to precisely forecast demand and maintain continuous supply, resulting in mismatches between product supply and demand, thus leading to product stockouts. In industries where product substitutes are imperfect, such as the automobile and weapons industries, customers backorder in the case of stockouts. However, in other industries where products can be easily substituted, such as the soft drink and cereal industries, lost sales may be the most prevalent outcome of a stockout. Thus, stockouts that result from a high product variety strategy may ultimately hurt sales performance.

Given the negative operational impact of product variety on sales, and the positive marketing impact, it is unclear as to the overall effect. The outcome depends on the trade-off between these positive and negative impacts. Since this overall impact plays a critical role in assessing the usefulness and effectiveness of a product variety strategy, the determination of this impact can have key managerial implications.

The key contribution of my research, therefore, is to jointly consider both the operational and marketing impacts of product variety on performance outcomes. In particular, I examine the impact of product variety decisions on the operational outcome, unit fill rate, and on sales. Integrating both operational and marketing factors within a firm is an important, yet challenging, issue (Berry and Cooper, 1999, Boyer et al., 2005, Jayaram and Malhotra, 2010, Singhal and Singhal, 2002). I find, not surprisingly, that greater variety is generally associated with lower fill rates and higher sales, but that the trade-offs between these two effects depends on the dimension (type) of product variety examined.

Therefore, my second contribution is to study the differential impacts of various dimensions of variety on firm performance. Specifically, after considering marketing and operational trade-offs, I examine the impact on performance of a broad measure of variety: the number of stock keeping units (SKUs), and of two more focused variety measures: the number of brands and the number of package sizes carried. Whereas I find that carrying greater numbers of brands is generally associated with better overall performance ("not enough of a good thing"), carrying greater numbers of pack-sizes is not ("too much of a good thing").

Third, I examine both linear and nonlinear impacts of product variety on performance. Researchers have built theoretical models connecting product variety to inventory decisions, suggesting that product variety should have a positive, but nonlinear, relationship to inventory-related variables (Zipkin, 1995). I use the same reasoning to examine potential nonlinear impacts of product variety on fill rate and sales performance. In particular, I find a U-shaped relationship between brand variety and fill rate indicating, surprisingly, that distribution centers that carry a very diverse holding in brands actually have higher fill rates than those with less diverse holdings, after controlling for other relevant factors.

Finally, as noted below, I use data from a distribution network to test my hypotheses. The distributor has often been overlooked in previous research on product variety, which has generally focused on either manufacturers or retailers (Bozarth et al., 2009; Duray et al., 2000; Hess and Swaminathan, 2006; Ramdas et al., 2003; Ton and Raman, 2010; Xia and Rajagopalam, 2009). My research, therefore, will help in the understanding of how these key intermediaries affect the performance outcomes of supply chains.

My analysis is conducted using data from 108 soft drink distribution centers operated by a major bottler collected on a weekly basis over a three year period. The soft drink industry provides an excellent forum for the study of how product variety influences operational and sales performance for a number of reasons. First, there is rapid new product development in the soft drink industry. In recent years, Coca-Cola Co. and PepsiCo have invested more than $3 billion each year in new product development and advertising (Fosfuri and Giarratana, 2009). Second, variety in the soft drink industry can be found across a number of dimensions, such as package sizes and brands. Finally, due to the mature duopoly between Coca-Cola Co. and PepsiCo, the U.S. soft drink market is characterized by stable prices, slow demand growth, and the absence of exogenous shocks. These characteristics help to isolate the impact of product variety on operational performance and sales.

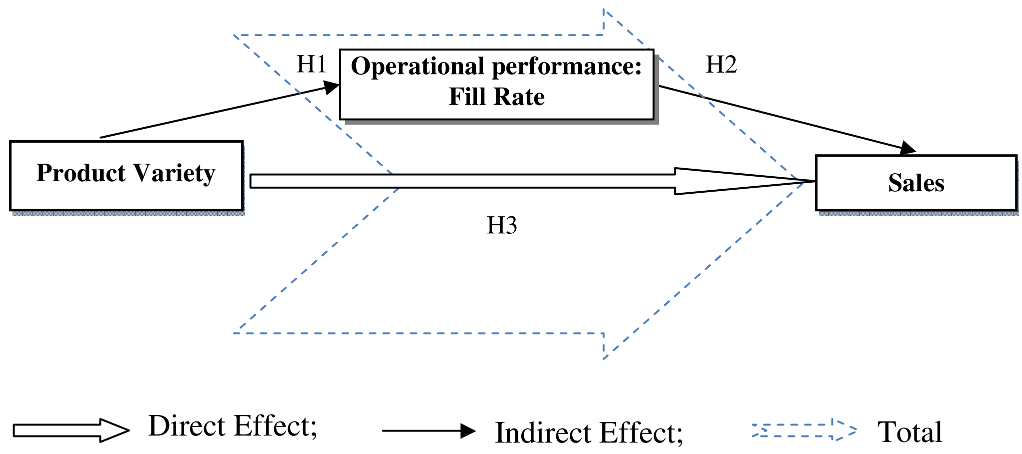
The remainder of this essay is organized as follows. The next section provides a review of the product variety literature and hypotheses are put forth based on the existing literature. The research methodology is developed in the third section. The fourth section reports the main statistical results. A discussion of the results is in the fifth section, while conclusions, implications, and research limitations are discussed in the last section.

2.2 Literature review and hypotheses development

2.2.1 Product variety and general framework of conceptual model

Figure 2.1 provides the general framework for this research. Product variety is hypothesized to have direct impacts on both operational performance, as measured by the fill rate, and on sales. In addition, operational performance is hypothesized to impact sales performance. Finally, both the direct and indirect impacts of product variety on sales are determined.

Figure 2.1 Hypotheses and model for product variety, fill rate, and sales



Numerous papers have examined product variety strategies (Berry and Cooper, 1999; Closs et al., 2008; Salvador et al., 2003). This work can be classified into two main categories: the methods for efficiently and effectively following a high product variety strategy and the influences of variety on performance. Although the second category of work has more relevance to this research, literature in the first category is briefly discussed below.

Many manufacturing approaches, such as modularization, component sharing, and assembly postponement, have been suggested for effectively and efficiently delivering a variety of products (Fisher et al., 1999; Heese and Swaminathan, 2006; Lee and Tang, 1997; Salvador et al., 2003). Salvador (2003) found that no singular modularity approach can be applied to effectively deliver product variety, and that the most effective approach depends on the total production volume to be attained. Furthermore, Heese and Swaminathan (2006) found that component sharing in production helps to obtain high product variety while also achieving high product quality and revenue at a relatively low cost. Finally, Lee and Tang (1997) investigated the benefits of a postponement strategy on reducing market mismatch costs for companies that followed a high product variety strategy.

The influences of product variety can be characterized by both the degree and the dimensions of variety (Fisher and Itter, 1999; Randall and Ulrich, 2001; Ramdas, 2003). The dimensions of variety refer to the specific types of product attributes, such as brands and pack-sizes, while the degree of variety indicates the number of options in each variety dimension, such as the number of brands or pack-sizes produced by a firm. Numerous researchers have sought to determine the optimal degree of variety as measured by the number of dimensions (Berry and Cooper, 1999; Fisher and Ittner, 1999; Ramdas, 2003). Fisher and Itter (1999) examined that the impacts of product variety in two dimensions (option content and option variability) in the automobile industry. They found that these two dimensions have different influences on total labor cost per car produced, assembly line downtime, and inventory levels. Berry and Cooper (1999) suggested that firms need to maintain product variety to the degree that closely aligns marketing strategies with manufacturing strategies. If a firm's marketing strategy requires that the customer base be segmented into very small slices, then the manufacturing strategy should produce a greater degree of variety.

While much research has focused on how best to implement a product variety strategy, the impact of product variety on both operational and sales performance has been largely overlooked. In addition, the impact of variety on operational performance has mainly been examined for manufacturing firms, while its impact on sales (marketing) performance has generally been studied for retailers (Bozarth et al., 2009; Duray et al., 2000; Hess and Swaminathan, 2006; Ramdas et al., 2003; Ton and Raman, 2010; Xia and Rajagopalam, 2009). My research examines the impact of product variety on both operational and sales performance using data from a distributor, a key component in many supply chains often overlooked in previous research.

2.2.2 Product variety and operational performance

In this paper, operational performance is represented by a well-recognized measure—the unit fill rate—the ratio of the number of units filled to the total units ordered (Bowersox et al., 2006; Closs et al., 2010). High product variety can lead to a lower fill rate since variety increases the difficulty of inventory management (Closs et al., 2010; Thonemann and Bradley, 2002). When product variety increases, the preparation and handling time needed for an order increases as well. Orders with high variety require additional warehousing operations, such as unloading, locating, and handling within distribution centers. Since the time period for receiving an order and delivering products is limited, complicated operations increase the likelihood of misplaced shipments and mismatches between deliveries and orders, ultimately resulting in lower fill rates at distribution centers.

In addition, increased product variety creates problems in demand forecasting for distributors. Based on observations at the soft drink bottler studied in this paper, planners predict future demand based mainly on historical order records. Increasing product variety implies that new products are introduced. Demand for a new product can often be forecast using historical records of a related, existing product; however, these forecasts are often unreliable. Lack of relevant historical records due to increased product variety adversely affects the accuracy of forecasting and, consequently, reduces the distributor's fill rate.

Furthermore, the relationship between product variety and the fill rate may be curvilinear. Zipkin (1995) extended the square root rule (Eppen, 1979) that depicts the relationship between the number of locations and inventory levels to the relationship between the number of products and inventory levels. The impact on inventory of product variety was found to be proportional to the square root of the number of products (Zipkin, 1995). Similarly, the impact of product variety on the fill rate may not be linear, especially since lower fill rates often result from poor inventory management. As additional products are distributed, one might expect that that the marginal effect to be lower on the fill rate of the $n+1^{st}$ product than the marginal effect of the n^{th} product. Consequently, a potential negative relationship with a diminishing marginal increment between product variety and the fill rate leads to Hypothesis 1.1:

Hypothesis 1.1: The fill rate decreases with product variety at a diminishing marginal rate.

2.2.3 Operations and sales performance

When demand is not fully satisfied (i.e., the fill rate is lower than 100%), stockouts occur. In the case of an out-of-stock at a distribution center, product cannot be immediately shipped to retail stores. Customers may respond by substituting for the desired product or by delaying their purchases (Zinn and Liu, 2001). For convenience products that are highly substitutable, unsatisfied demand will not likely roll over to the future. For example, in the soft drink industry, customers are likely to choose substitutes when product is not available. Even though some of this substitution may happen among brands belonging to the same producer (Pepsi vs. Caffeine Free Pepsi), at least a portion of sales will be lost because end customers switch to another producer's products (Pepsi vs. Coke). These lost sales are passed from end customers, through retailers, to distributors. Therefore, considering the sales lost from end customers and retailers due to lower fill rates at distributors, the following hypothesis is proposed:

Hypothesis 1.2: Sales increase with the fill rate.

2.2.4 Product variety and sales performance

Many marketing studies suggest increasing product variety to satisfy the needs of different customer segments (Xia and Rajagopalam, 2009). High variety is considered a way to improve sales by meeting the specialized demands of customer segments. Given heterogeneity in consumer preferences, high product variety implies increased probability that a firm's product offerings will closely match an individual consumer's preference. Moreover, customers who like variety-seeking prefer a large choice set, which is increased by high product variety (Smith and Agrawal, 2001).

Studies of customer segmentation and variety-seeking behaviors explain higher sales as a function of increasing variety across product categories. In addition, raising variety within a product category increases the number of substitutes in that category for a given company and, hence, potentially decreases lost sales when customers cannot find their first choice (Mahajan and van Ryzin, 2001). Thus, the literature on customer segmentation, variety seeking, and product substitution suggests higher sales from increased product variety, and this positive impact of product variety on sales from end customers passes through retailers to distributors.

The positive impact of product variety on sales may be at a diminishing rate, however. On the one hand, for end customers, (1) the more dispersed a firm's products are in the product attribute space, the more difficult it is to find an incrementally beneficial unoccupied location, and (2) cannibalization and product overlap become increasingly likely with high product variety (Bayus and Putsis, 1999). Through analytical models, Xia and Rajagopalam (2009) found that increasing product variety can boost sales from end customers, but with diminishing returns. On the other hand, the demand from retailers is not always proportional to increased product variety. Since storage space is generally costly and limited, retailers do not increase their order quantities in a constant proportion to a distributor's product variety. Thus, the following hypothesis is proposed:

Hypothesis 1.3: Sales increase directly with product variety at a diminishing marginal rate.

All hypotheses are shown in Figure 2.1. H1 and H2 represent the indirect path from product variety to sales via the fill rate. The direct sales impact of product variety is identified by H3. The total effect of product variety on sales includes both direct and indirect effects and is assessed by the combination of the impacts put forth in the three paths.

2.3 Research methods

2.3.1 Data

Three years of data were collected from a major soft drink bottler that distributes 113 brands, 12 package sizes, and 328 total SKUs. An SKU is defined as a unique combination of brand, flavor, weight, container material, container size, and pack-size. In order to avoid inconsistency in sales quantity measurement, data on only one major beverage container size (i.e., 12-ounce cans) is used in my analysis. Thus, the sample contains data on soft drink products sold in 12-ounce cans from 108 distribution centers over three years (2007-2009). Each calendar year includes 52 weeks of data. In total, the sample contains 14,909 distribution center-week observations, after eliminating observations with missing values and mismatches between operational and financial records. The distribution center level data consists of the number of products sold, fill rates, and sales per week for each soft drink product.

The data sample was collected directly from the central database of the soft drink bottler. The fill rate and sales for each distribution center were recorded weekly. Product variety is calculated first as the number of SKUs carried by a distribution center and then as the number of brands and number of package sizes stocked by the distribution center.

Since all data are from the distribution centers of a single bottler, unobserved cross-sectional heterogeneity, such as differences in production functions, are controlled. Moreover, using data from a single firm allows for consistent measures in the analysis.

2.3.2 Measurements

Through field study at the soft drink distributor's operations, and given conversations with bottling managers in both operations and sales, the following measures for product variety, operational performance, and marketing performance were derived with both practical and theoretical support (see Table 2.1):

Table 2.1 Description of variables

Variable Name	Description
Product Variety$_{it}$	Measured by No. SKU$_{it}$, No. Brand$_{it}$, and No. Pack-size$_{it}$.
No. SKU$_{it}$	The number of stock keeping units (SKUs) sold at distribution center i in week t.
No. Brand$_{it}$	The number of soft drink brands sold at distribution center i in week t.
No. Pack-size$_{it}$	The number of package sizes sold at distribution center i in week t, such as 6 pack, 12 pack, etc.
Fill Rate$_{it}$	The percentage of product cases filled in the total cases ordered at distribution center i in week t.
Fill Rate$^{e}_{it}$	The estimated fill rate at distribution center i in week t.
Fill Rate$_{it-1}$	The percentage of product cases filled in the total cases ordered at distribution center i in week t-1.
Sales$_{it}$	The number of cases sold at distribution center i in week t.
Order Quantity$_{it}$	The amount of orders in cases received by distribution center i in week t.
Onhand Inventory$_{it}$	The number of cases stocked in distribution center i at the beginning of week t.
OverForecast Error$_{it}$	The ratio of difference between forecast demand two weeks in advance and actual order amount received by distribution center i in week t to the actual order amount.
Unit Price$_{it}$	The average price per case in dollars offered by distribution center i in week t.
Return Quantity$_{it}$	The number of cases returned by retailers to distribution center i in the week t.

2.3.2.1 Product variety

Product variety is my key independent variable, hypothesized to impact both fill rate and sales, my two dependent variables. The number of stock keeping units (SKUs) is a well-accepted measure of product variety (Alfaro and Corbett, 2003). However, product introduction decisions are normally made on the basis of brands or pack-sizes, rather than on SKUs. For example, a soft drink company may decide to introduce a new diet version of an existing drink (in my terms, a new brand), or a new "16-pack" of an existing soft drink (i.e., a new pack-size). Thus, product variety is measured in three dimensions for this paper: SKUs (the overall measure), brands, and pack-sizes.

2.3.2.2 Operations performance

Operational performance, my first dependent variable, is measured on the basis of unit fill rate, a well-known ratio of the number of units filled to the number of units ordered (Bowersox et al., 2006; Closs et al., 2010; Thomas, 2005). As shown in Table 2.1, the $FillRate_{it}$ is calculated as the percentage of product cases filled to the total cases ordered at distribution center i in week t. The fill rate is not only a common measure in the operations literature, but also an important performance measure for the bottler's operations department.

2.3.2.3 Sales performance

My second dependent variable, $Sales_{\mathrm{it}}$ represents the total number of cases sold from distribution center i in week t in multiples of 10,000 cases. One case is defined as a pack of 24 12-ounce cans, so a 12-can pack is equal to 1/2 case in the dataset.

Since the data only contain soft drink products packed in 12-ounce cans, no inconsistencies arise from cases with different container sizes.

Table 2.2 provides descriptive statistics for the variables used in the analysis. Table 2.3 summarizes the correlations among these variables across all observations. I also calculate variance inflation factors (VIF) for each of the variables in order to determine if multicollinearity may be present. The VIFs are all found to be less than 3, thus implying that multicollinearity is not a concern in my analysis.

Table 2.2 Descriptive statistics for variables

Variable	Min	Mean	Max	Std. Deviation
No. SKU$_{it}$	8	48.67	114	13.85
No. Brand$_{it}$	8	31.35	48	7.14
No. Pack-size$_{it}$	1	3.79	7	1.06
Fill Rate$_{it}$	69.29	99.31	100	1.21
Sales$_{it}$ (10,000 units)	0.01	2.09	34.38	2.52
Order Quantity$_{it}$ (10,000 units)	0	2.80	44.01	3.26
Onhand Inventory$_{it}$ (10,000 units)	0.03	3.72	56.39	4.77
OverForecast Error$_{it}$	-1	-0.17	15.5	0.52
Unit Price$_{it}$ (U.S. dollar)	4.35	7.38	20.65	1.34
Return Quantity$_{it}$ (10,000 units)	0	0.09	11.73	0.18

Table 2.3 Pearson correlation matrix

	Variable	1	2	3	4	5	6	7	8	9	10
1	No. SKU$_{it}$	1.00									
2	No. Brand$_{it}$	0.87***	1.00								
3	No. Pack-size$_{it}$	0.55***	0.22***	1.00							
4	Fill Rate$_{it}$	-0.08***	-0.06***	-0.08***	1.00						
5	Sales$_{it}$	0.42***	0.42***	-0.29***	0.47***	1.00					
6	Order Quantity$_{it}$	0.57***	0.58***	0.43***	-0.07***	0.68***	1.00				
7	Onhand Inventory$_{it}$	0.65***	0.64***	0.52***	0.03***	0.70***	0.08	1.00			
8	OverForecast Error$_{it}$	-0.10**	-0.10**	-0.09**	0.07***	0.04	-0.46***	0.18	1.00		
9	Unit Price$_{it}$	0.12***	0.09	0.09	0.06	-0.19***	-0.24***	-0.18	0.07	1.00	
10	Return Quantity$_{it}$	0.17	0.21	0.08	-0.04	-0.21***	0.26***	0.32	-0.03	-0.02**	1.00

** indicates significance at 5% level
*** indicates statistical significance at 1% level

2.3.3 Model

In order to better understand the relationships among product variety, the fill rate, and sales, a model system of two equations is applied. In Equation (1), $FillRate_{it}$ is estimated from $ProductVariety_{it}$, its square, and a number of control variables, while in the Equation (2), $Sales_{it}$ is estimated from the fitted value of $FillRate_{it}$, $ProductVariety_{it}$, its square term, and an overlapping, but distinct, set of control variables (in order that both equations can be identified).

Since there may be a causal relationship between product variety and the fill rate, $FillRate_{it}$ may not be an exogenous variable in Equation (2) along with $ProductVariety_{it}$. Therefore, a two-stage regression approach is used to estimate the two equations and control for the potential endogeneity. In the first stage, the fill rate is estimated by the independent variable, control variables, and exogenous variables (instrumental variables) such as the fill rate in the previous week ($FillRate_{it-1}$) and over-forecast error two weeks in advance ($OverForecastError_{it}$). In the second stage, the fitted value of the fill rate ($FillRate^{e}_{it}$) from Equation (1) is calculated and then used in Equation (2) (Zhang et al., 2009). The two equations are shown below:

$$\begin{aligned} FillRate_{it} &= FillRate^{e}_{it} + \varepsilon_{it} \\ &= \beta_0 + \beta_1 ProductVariety_{it} + \beta_2 \left(ProductVariety_{it}\right)^2 \\ &\quad + \sum_{j=1}^{107} \beta_{3j} LocDum_{ij} + \sum_{k=1}^{11} \beta_{4k} YrSnDum_{kt} + \beta_5 OrderQuantity_{it} \\ &\quad + \beta_6 OnhandInventory_{it} + \beta_7 OverForecastError_{it} + \beta_8 FillRate_{it-1} + \varepsilon_{it} \end{aligned} \tag{1}$$

$$
\begin{aligned}
Sales_{it} = \gamma_0 + \gamma_1 ProductVariety_{it} + \gamma_2 \left(ProductVariety_{it}\right)^2 + \gamma_3 FillRate^e_{it} \\
+ \sum_{j=1}^{107} \gamma_{4j} LocDum_{ij} + \sum_{k=1}^{11} \gamma_{5k} YrSnDum_{kt} + \gamma_6 OrderQuantity_{it} \\
+ \gamma_7 OnhandInventory_{it} + \gamma_8 UnitPrice_{it} + \gamma_9 ReturnQuantity_{it} + \delta_{it}
\end{aligned}
\quad (2)
$$

Both product variety and its squared term are included in Equation (1) to properly investigate Hypothesis 1.1: a potential nonlinear relationship between product variety and fill rate. (An alternate option would be to include the square root of product variety as an independent variable, but models with linear and quadratic terms are more flexible in functional form. For comparison purposes, models with the square root term were also estimated and produced similar results to those presented below.) Since fill rate is calculated as a percentage, the dependent variable in Equation (1) can range from 0 to 100, with the data containing a great many 100 values (i.e., no stockouts). In order to account for this non-normal left-skewed distribution, a Tobit model is used to estimate Equation (1) (Cassiman and Veugelers, 2006).

Aside from product variety, there are many other potential influences on the fill rate. Thus, Equation (1) also includes a number of control variables (see Table 2.1). These controls include the order quantity for a particular SKU received by a given distribution center during the week of the observation ($OrderQuantity_{it}$), the on-hand inventory for an SKU at the beginning of the week at a given distribution center ($OnhandInventory_{it}$), the fill rate from the previous week ($FillRate_{it-1}$), and a variable that measures the over-forecast error two weeks in advance ($OverForecastError_{it}$) - two weeks being the forecast period for the company studied for this research (negative values indicate demand was under-forecast). Higher retail orders placed at the distribution center, as reflected in the order quantity variable, may be associated with lower fill rates. Higher on-hand inventory may be associated with higher fill rates, while the over-forecast error should be positively associated with fill rates. The fill rate in the previous week is expected to be positively associated with the fill rate in the current week. Finally, dummy variables are included for distribution centers ($LocDum_{ij}$ = 1 if i=j; 0 otherwise) to control for other unobserved variations in performance between distribution center locations (e.g., due to variances in areas served, distribution routes, managerial ability, etc.), and for time differences across seasons and years ($YrSnDum_{kt}$ = 1 if week t belongs to the year-season k; 0 otherwise).

Equation (2) models the second dependent variable ($Sales_{it}$) in relation to both the independent variable ($ProductVariety_{it}$), its square term, and the fitted value of $FillRate_{it}$, along with control variables. Due to the skewed distribution of sales values in my dataset, natural log transformations are applied to normalize the distribution (Randall et al., 2006). (Note that natural log transformations are also used for control variables $OrderQuantity_{it}$ and $OnhandInventory_{it}$ in both Equations (1) and (2) for the same reason.) Product variety is expected to have a positive relation to sales, but its squared term is also included to account for a potential marginally diminishing impact. The fitted value for fill rate (i.e., the estimated dependent variable from Equation (1), $FillRate^{e}_{it}$) should have a positive effect on sales, as stated in Hypothesis 1.2.

Control variables in Equation (2) include $OrderQuantity_{it}$, $UnitPrice_{it}$ (average price per unit), $OnhandInventory_{it}$, and $ReturnQuantity_{it}$. $OrderQuantity_{it}$ represents orders placed on a distribution center from its retail customers and is, thus, an indicator of demand. The variable is expected to be positively associated with sales. On the other hand, given downward sloping demand curves, $UnitPrice_{it}$ is expected to have a negative impact on sales. High $OnhandInventory_{it}$ should be associated with high sales. Returns are expected to result in lower sales performance, since products are returned by retailers due to quality issues, damage in the logistics process, or other factors. As was the case with Equation (1), dummy variables are included in Equation (2) to control for differences between distribution centers and over time. Finally, since heteroscedasticity, contemporaneous correlation, and autocorrelation in error terms need to be considered in time series cross-sectional (TSCS) data, a Prais-Winsten regression with panel-correlated standard errors and an AR(1) process for the error terms is used to estimate Equation (2) (Beck and Katz, 1995; Lapre and Tsikriktsis, 2006).

2.3.4 Measures for the effects of product variety

The direct effect of product variety on sales, adjusted for the fill rate, is represented by the parameters γ_1 and γ_2 in Equation (2). The indirect effect of product variety on sales through the fill rate is indicated by the combination of product variety's impact on the fill rate (β_1 and β_2 in Equation (1)) and the fill rate's impact on sales (γ_3 in Equation (2)). The total effect of product variety on sales is the first derivative of sales (using the natural logarithm transformation) with respect to product variety:

$$\frac{\partial Sales_{it}}{\partial ProductVariety_{it}}$$

$$= \gamma_1 + 2\gamma_2 ProductVariety_{it} + \left(\frac{\partial Sales_{it}}{\partial FillRate^e_{it}} \right) \left(\frac{\partial FillRate^e_{it}}{\partial ProductVariety_{it}} \right)$$

$$= \gamma_1 + 2\gamma_2 ProductVariety_{it} + \gamma_3 (\beta_1 + 2\beta_2 ProductVariety_{it})$$

$$= \gamma_1 + \beta_1\gamma_3 + 2(\gamma_2 + \beta_2\gamma_3) ProductVariety_{it} \tag{3}$$

2.4 Analysis and results

2.4.1 Impact of SKU variety

The estimated results for the impact of product variety measured by SKUs are summarized in Table 2.4. The estimations for Equation (1) are reported in Models 1.1, 1.2, and 1.3. Estimations with sales as the dependent variable (Equation (2)) are reported in Models 2.1, 2.2, and 2.3.

Table 2.4 Estimated results for SKU variety in models of the fill rate and sales

Variable	Model 1.1 Fill Rate	Model 1.2 Fill Rate	Model 1.3 Fill Rate	Model 2.1 Sales	Model 2.2 Sales	Model 2.3 Sales
No. SKU_{it}		-0.0083***	-0.0209***		0.0095***	0.0301***
		(0.0017)	(0.0059)		(0.0005)	(0.0011)
$(\text{No. } SKU_{it})^2$			0.0001**			-0.0002***
			(0.000)			(0.000)
Fill $Rate_{it}$					0.2349***	0.2395***
					(0.0431)	(0.0437)
Fill $Rate_{it-1}$	0.2867***	0.2856***	0.2854***			
	(0.0086)	(0.0086)	(0.0086)			
Over-Forecast $Error_{it}$	0.1944***	0.2178***	0.2227***			
	(0.0595)	(0.0596)	(0.0596)			
Order $Quantity_{it}$	-0.2090***	-0.1944***	-0.1899***	0.9456***	0.9411***	0.9392***
	(0.0329)	(0.0329)	(0.0330)	(0.0064)	(0.0063)	(0.0065)
Onhand $Inventory_{it}$	0.1619***	0.1906***	0.1909***	0.0552***	0.0215***	0.0219***
	(0.0401)	(0.0405)	(0.0405)	(0.0072)	(0.0076)	(0.0072)
Unit $Price_{it}$				-0.0845***	-0.0792***	-0.0763***
				(0.0039)	(0.0040)	(0.0039)
Return $Quantity_{it}$				-0.2339***	-0.2249***	-0.2176***
				(0.0094)	(0.0098)	(0.0097)
Constant	71.0279***	71.1929***	71.5544***	-3. 8945***	-3.5982***	-4.5544***
	(1.4605)	(1.0410)	(1.0536)	(0. 6467)	(0.4368)	(0.44211)
Distribution Center Dummies	Included in the model but not shown					
Year-Season Dummies	Included in the model but not shown					
MAD	0.789	0.768	0.708	0.149	0.146	0.143
Pseudo-R^2 or R^2	0.13	0.21	0.33	0.91	0.93	0.94
χ^2 test statistic	3,912***	3,851***	3,827***	6,700e+5***	380e+5***	7e+5***
Observations	14,909	14,909	14,909	14,909	14,909	14,909

** indicates significance at 5% level
*** indicates statistical significance at 1% level
Standard errors are reported in parenthesis.
Chi-Square test statistic indicates the rejection of the null hypothesis that all model coefficients are zero.

2.4.1.1 Impact of the number of SKUs on the fill rate

The base model for the fill rate, Model 1.1, includes only the control variables in Equation (1). As expected, the fill rate in the previous week has a significant ($p< 0.01$) and positive coefficient. The results show that on-hand inventory at the beginning of the week is also significant ($p< 0.01$) and positively related to the fill rate. The overforecast error two weeks in advance has a significant ($p<0.01$) and positive coefficient as well.

Model 1.2 adds a linear term for the number of SKUs. The estimate confirms the negative relationship between product variety in SKUs and the fill rate; in other words, greater variety contributes to a lower fill rate. Model 1.3 includes both linear and quadratic terms for the number of SKUs. The increasing Pseudo R^2 from Model 1.2 to Model 1.3 suggests that Model 1.3 explains the variation in the dependent variable better than the model with only a linear term (Model 1.2). Furthermore, χ^2 statistics and the Mean Absolute Deviation (MAD) decreases from Model 1.2 to that in Model 1.3. Note that both the linear and quadratic terms for variety are significant ($p<0.05$) and that the coefficient is negative for the linear term and positive for the quadratic term.

Given the negative linear term and the positive quadratic term, my results suggest either a monotonic decreasing curve or a U-shape curve. To check the shape of the relationship between the number of SKUs and the fill rate, the minimum point of the dependent variable, the fill rate, is calculated at $No.SKUs_{\mathrm{minFillRate}} = 105$ (i.e., $0.0209 - 2\times0.0001\times No.SKUs = 0$). In the data sample, 99.83% of the observations have fewer than 105 SKUs. This result suggests that an increase in SKUs reduces the fill rate at a diminishing marginal rate for the vast majority of observations. Thus, Hypothesis 1.1 is supported.

2.4.1.2 Impact of the number of SKUs on sales

Model 2.1 contains only the control variables for sales. As expected, the coefficient for order quantity is significant ($p<0.01$) and positive. Return quantity has a significant and negative coefficient ($p<0.01$). Unit price is negatively associated with sales.

Model 2.2 adds the fill rate and the linear term for the number of SKUs. Model 2.3 adds the quadratic term for the number of SKUs and has the largest R^2 and the smallest MAD and χ^2 statistics of the three models. Thus, Model 2.3 best explains the variation in sales, and the subsequent analysis is developed based on the results for this model. The fill rate has a significant ($p<0.01$) and positive coefficient in Model 2.3, indicating that sales are gained when the fill rate increases at a distribution center. Hypothesis 1.2 is, therefore, supported.

The direct effect of SKUs on sales is represented by the coefficients of linear and quadratic terms for the number of SKUs in Model 2.3. Both the linear and quadratic terms for the number of SKUs are significant ($p<0.01$), and the coefficient is positive for the linear term and negative for the quadratic term. Sales reaches its maximum point when $No.SKUs_{\mathrm{maxDirectSales}} = 75$ (i.e., $0.0301 - 2\times 0.0002\times No.SKUs = 0$). Therefore, an increase in SKUs directly raises sales at a decreasing rate (0.0004) when the number of SKUs is less than 75; otherwise, an increase in SKUs actually leads to reduced sales. Since only 3.6% of the observations in the sample include distribution centers with greater than 75 SKUs, Hypothesis 1.3 is supported for over 96% of the observations in the dataset.

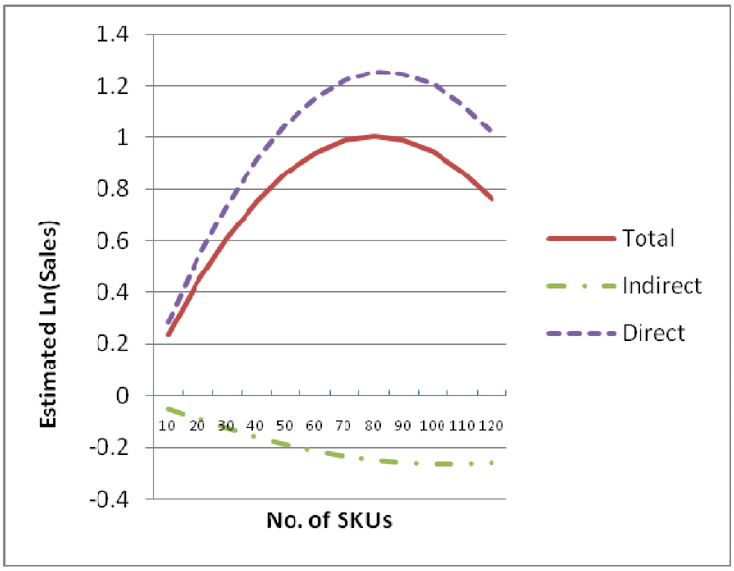
The indirect effect of product variety on sales is represented by the product of coefficients $\gamma_3\beta_1$ for the linear effect and $\gamma_3\beta_2$ for the quadratic effect. Since the distribution of the product of two normally distributed coefficients is in general not normal, nor known, both Sobel's and bootstrapping approaches are used to obtain standard errors for these two products to confirm the significance of the indirect effect (Sobel, 1982; MacKinnon et al., 2007).

Sobel (1982) derived an asymptotic approximation using the multivariate method, which calculates standard errors of these two products by $\sigma_{\gamma_3\beta_1} = \sqrt{\gamma_3^2\sigma_{\beta_1}^2 + \beta_1^2\sigma_{\gamma_3}^2}$ and $\sigma_{\gamma_3\beta_2} = \sqrt{\gamma_3^2\sigma_{\beta_2}^2 + \beta_2^2\sigma_{\gamma_3}^2}$, respectively. In order to conduct a robust analysis of the model, the bootstrapping method is also used, which provides an empirical sampling distribution for each product above by re-sampling from the data with replacement and applying the indirect effect analysis to each sample (MacKinnon et al., 2007). The indirect effect of the number of SKUs on sales is significant ($p<0.05$) using both the Sobel and the bootstrapping approaches.

The indirect effect is indicated by the coefficients of the linear and quadratic terms for the number of SKUs in Model 1.3 and the coefficient for the fill rate in Model 2.3. The total effect of the number of SKUs on sales is the sum of the direct and indirect effects. This total effect varies in the range of [0, 114] SKUs. When the number of SKUs is less than 84 (i.e., $0.0251 - 0.0003 \times No.SKUs=0 \rightarrow No.SKUs_{\mathrm{maxTotalSales}}=84$), an increase in SKUs raises sales at a decreasing rate (0.0003). Only when the number of SKUs is in the range [84, 114], a range that contains 1.8% observations, is an increase in SKUs associated with decreasing sales.

In order to better illustrate all effects (direct, indirect, and total) of the number of SKUs on sales, a plot of changes in ln(Sales) resulting from increases in the number of SKUs is shown in Figure 2.2. It clearly shows that the number of SKUs has a curvilinear relationship with sales, where the direct effect and the indirect effect through the fill rate are in opposite directions. This result suggests that the effect of product variety in SKUs would be overestimated if the indirect effect is overlooked. Furthermore, the positive direct effect dominates the negative indirect effect. As a result, the total effect of the number of SKUs on sales is generally positive.

Figure 2.2 The effects of SKU variety on sales



2.4.2 Brand and pack-size variety

In this section, the analysis of product variety is narrowed from the aggregate level of SKUs to the dimensions of brands and pack-sizes. Due to potential multicollinearity, separate models are used for brands and pack-sizes. Table 2.5 contains the estimated results of the models with linear impacts.

Table 2.5 Estimated results for the linear impacts of brand and pack-size variety

Variable	Model 1a.1 Fill Rate	Model 2a.1 Sales	Model 1b.1 Fill Rate	Model 2b.1 Sales
No. $Brand_{it}$	-0.0061*	0.0119***		
	(0.0034)	(0.0005)		
No. $Pack\text{-}Size_{it}$			-1.3572**	-0.05134***
			(0.0177)	(0.0033)
Fill $Rate_{it}$		0.1306***		0.1364 ***
		(0.0429)		(0.0424)
Constant	70.9149***	-3.1742***	70.8671***	0. 7073
	(1.0420)	(0.4289)	(1.0389)	(0.0725)
Control Variables and Distribution Center Dummies	Included in the model but not shown			
Year-Season Dummies	Included in the model but not shown			
MAD	0.799	0.160	0.780	0.167
Pseudo-R^2 or R^2	0.23	0.89	0.20	0.87
χ^2 test statistic	3,937***	216e+5***	3,832***	3,661e+5***
Observations	14,909	14,909	14,909	14,909

* indicates significance at 10% level
** indicates significance at 5% level
*** indicates statistical significance at 1% level
Standard errors are reported in parenthesis.
Chi-Square test statistic indicates the rejection of the null hypothesis that all model coefficients are zero.

The models that include non-linear impacts of brand and pack-size variety are summarized in Table 2.6. Since these models with non-linear terms of variety measures have higher R^2 (or Pseudo- R^2), and lower χ^2 statistics and MAD than the models, they are discussed in the subsequent analysis.

Table 2.6 Estimated results for brand and pack-size variety in models of the fill rate and sale

Variable	Model 1a.2 Fill Rate	Model 2a.2 Sales	Model 1b.2 Fill Rate	Model 2b.2 Sales
No. $Brand_{it}$	-0.0459 ***	0.0651 ***		
	(0.0157)	(0.0032)		
(No. $Brand_{it})^2$	0.0006 **	-0.0006 ***		
	(0.0002)	(0.0001)		
No. $Pack\text{-}Size_{it}$			-0.1872 **	-0.0614 ***
			(0.0868)	(0.0213)
(No. $Pack\text{-}Size_{it})^2$			0.0059	0.0051 ***
			(0.0086)	(0.0023)
Fill $Rate_{it}$		0.1385 ***		0.1364 ***
		(0.0445)		(0.0438)
Fill $Rate_{it-1}$	0.2861 ***		0.2863 ***	
	(0.0086)		(0.0086)	
Over-Forecast $Error_{it}$	0.2066 ***		0.1985 **	
	(0.0596)		0.0595	
Order $Quantity_{it}$	-0.1994 ***	0.9394 ***	-0.2074 ***	0.8998 ***
	(0.0333)	(0.0068)	(0.0329)	(0.0160)
Onhand $Inventory_{it}$	0.1684 ***	0.0349 ***	0.1742 ***	0.0878 ***
	(0.0401)	(0.0068)	(0.0405)	(0.0209)
Unit $Price_{it}$		-0.0838 ***		-0.0681 ***
		(0.0037)		(0.0089)
Return $Quantity_{it}$		-0.2246 ***		-0.2421 ***
		(0.0109)		(0.0112)
Constant	72.0922 ***	-7.2543 ***	70.9679 ***	-8.2995 ***
	(1.4818)	(0.2655)	(1.0492)	(0.4568)
Distribution Center Dummies	Included in the model but not shown			
Year-Season Dummies	Included in the model but not shown			
MAD	0.768	0.146	0.697	0.148
Pseudo-R^2 or R^2	0.34	0.93	0.26	0.89
χ^2 test statistic	3,831***	160e+5***	3,831***	2,500e+5***
Observations	14,909	14,909	14,909	14,909

** indicates significance at 5% level
*** indicates statistical significance at 1% level
Standard errors are reported in parenthesis.
Chi-Square test statistic indicates the rejection of the null hypothesis that all model coefficients are zero.

In estimating operating performance as measured by the fill rate (Model 1a.2), both the linear and quadratic terms for brand variety are significant ($p<0.05$). The coefficient is negative for the linear term and positive for the quadratic term. The relationship between the number of brands and the fill rate demonstrates an inverted-U shape with the minimum fill rate reached at 38 brands (i.e., $No.brands_{\text{minFillRate}}=$

0.0459/(2×0.0006)). Since this value is within one standard deviation (7.14) of the mean number of brands (31.35), Hypothesis 1.1 is only supported when the number of brands is less than 38. Beyond this point (16.75% of the total observations), fill rate actually increases with brand variety, a surprising result.

In Model 1b.2, the linear term for pack-size variety is significant ($p<0.05$) and negative, while the quadratic term is not significant. Thus, increasing pack-size variety is always associated with lower fill rates. Because I hypothesized a non-linear relationship between pack-size variety and fill rates, Hypothesis 1.1 is not supported.

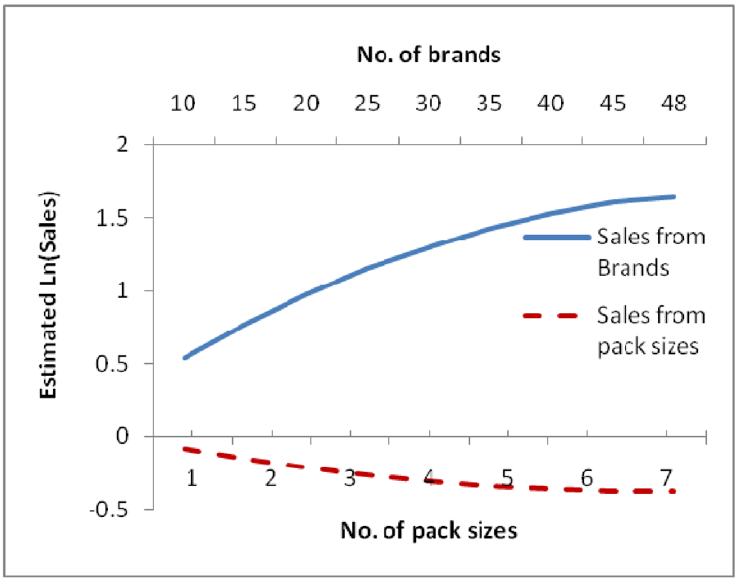
The coefficients for the fill rate in Models 2a.2 and 2b.2 are significant and positive ($p<0.01$). This confirms a positive relationship between the fill rate and sales for both models, hence, Hypothesis 1.2 is supported. Tests using both Sobel's approach and the bootstrapping approach indicate that the indirect effect of both the number of brands and the number of pack-sizes on sales is significant.

The significant linear and quadratic terms for brand and pack-size variety in Models 2a.2 and 2b.2 imply that they both have curvilinear direct impacts on sales. However, the results for the two measures of variety are very different. Brand variety is associated with *increasing* sales at a diminishing rate, while pack-size is associated with *decreasing* sales at a diminishing rate. Hence, Hypothesis 1.3 is supported only for brand variety.

Holding other factors constant, the total effects of brand and pack-size variety on sales are plotted in Figure 2.3. It is apparent that product variety as measured by brands and pack-sizes have opposite effects on sales.

Since the maximum point for the total effect on sales is reached at 59 brands (i.e., $No.brands_{\text{maxTotalSales}}$=0.0588/0.0010) and is out of its actual range of brands in the data sample ([0, 48]), the impact of brand variety on sales follows a monotonic concave shape. As the number of brands increase, sales increase at a diminishing marginal rate. On the other hand, the total effect of pack-size variety on sales shows a general monotonic convex shape with the minimum sales point reached at a pack-size variety of 9 (i.e., $No.packsizes_{\text{minTotalSales}}$ = 0.0870/0.0102), which is beyond the actual range of the number of pack-sizes ([0, 7]) in the dataset. Thus pack-size variety is associated with decreasing sales over the range of pack-sizes in my dataset. Potential reasons for the different impact on sales from these two variety dimensions are discussed below.

Figure 2.3 The effects of brand and pack-size variety on sales



2.5 Discussion

2.5.1 Impact of product variety on the fill rate

An interesting finding from my research is that brand variety has a curvilinear impact on the fill rate, following a U-shape. Beyond the minimum point, the positive relationship between brands and the fill rate indicates that greater variety is, surprisingly, associated with improved operational performance. In my discussions with managers at the soft drink distributor, the potential explanation for this effect most often offered was that the personnel in the distribution centers with high brand variety have greater experience than those in the other centers. Managers in the distribution centers with greater numbers of brands are required to do more demand forecasting and production planning, and thus are able to learn from their experience. This experience may help personnel to better managing inventories, control stockouts, and maintain fill rates at distribution centers (Azadegan and Dooley, 2010; Hult et al., 2003).

In order to confirm this hypothetical association between experience and the product variety assignment decisions, correlation coefficients were calculated. Cumulative performance volume is used as a proxy for operational experience (Lapre and Tsikrisktsis, 2006). In particular, cumulative sales are used to measure experience at distribution centers. A variable, $experience_{it}$, is calculated to measure the cumulative sales volume at distribution center i from the first week in 2007 until week t. Based on this definition of experience, the correlation coefficient between experience and number of SKUs is 0.59 (0.52 between experience and number of brands and 0.61 between experience and number of pack-sizes), supporting the notion that experienced distribution centers tend to be assigned higher product variety.

A second interesting finding is that pack-size variety is linearly and negatively associated with the fill rate. As opposed to the brand variety findings, there does not appear to be any gains from experience in managing pack-size variety; that is, more pack-size variety is equated with poorer operating performance. This result may be attributed to difficulties in logistics and operational management caused by increased pack-size variety. When a new pack-size is introduced, complexity is increased in multiple logistics and operations processes, such as packing for transportation, storage in warehouses, and loading and unloading from trucks. All of these complexities may lead to delays in deliveries and mismatches between supply and demand, jointly contributing to lower fill rates at distribution centers. Multiple complexities raised by increased pack-size variety result poorer operational performance; experience may not be sufficient to overcome these difficulties.

2.5.2 Total impact of product variety on sales

The total impact of brand variety on sales is as might be expected: brand variety raises sales at a diminishing rate. Increased brand variety results in variety-seeking behavior among customers and, consequently, higher sales (i.e., “not enough of a good thing”). The diminishing rate results from cannibalization of existing products within the product space (Bayus and Putsis, 1999; Xia and Rajagopalam, 2009). Finally, the positive impacts of variety-seeking on sales more than offsets the negative, indirect impacts of increased variety on sales through operational performance. The distributors are able to overcome the operating problems of handling additional brands without unduly impacting sales.

On the other hand, the total (direct plus indirect) impact of pack-size variety on sales is negative. The insufficient attraction of pack-sizes on demand, as well as the negative effects of handling additional pack-sizes (i.e., more complex demand forecasting, order-taking, packing, distributing, etc.), contributes to the overall reduction in sales. Thus, the soft drink distributor can expect to lose sales as it increases pack-size variety (i.e., “too much of a good thing”).

Finally, the overall impact of variety, as measured by SKUs, on sales is mainly positive. But, the relationship between number of SKUs and sales does follow an inverted U-shape. After a particular level of SKU variety is reached at a distribution center, the distributor can expect decreases in sales. This latter finding aligns with existing literature that suggests that simply increasing variety does not guarantee benefits and can, in fact, worsen a firm’s competitiveness (Berry and Cooper, 1999; Ramdas, 2003).

2.6 Conclusions and contributions

This study is an attempt to better understand how product variety affects operational and sales performance. Most research has examined either the impact of product variety on operational performance or the impact of product variety on sales performance (Randall and Ulrich, 2001; Swaminathan and Tayur, 1998; Xia and Rajagopalam, 2009). My work is differentiated from previous research by analyzing the curvilinear impacts of product variety on both operational and sales performance.

In addition, this study measures product variety along three different dimensions and obtains distinct results, depending on the variety measure used. Finally, rather than using retail or manufacturing data, this research employs distribution center data, as distributors play a key role in determining various aspects of product variety.

Major findings in this essay suggest that product variety often has nonlinear impacts on operational and sales performance and that these impacts vary across different dimensions of product variety. Brand variety is found to have a U-shaped relationship with operating performance, as measured by the fill rate. Higher brand variety is associated with greater operating experience, and this experience may be sufficient to overcome the negative aspects of increasing variety on the fill rate. In addition, increased brand variety is associated with higher sales; that is, brand variety is "not enough" for distributors and their customers. On the other hand, pack-size variety is associated with poorer operating performance and lower sales. In the case of pack-sizes, it appears that "too much" variety is provided. The overall measure of variety, as assessed by SKUs, generally exhibits a negative association with fill rate and an inverted U-shaped relationship to sales.

The results advance the understanding of the trade-offs between operations and sales resulting from product variety. The findings provide a number of implications to industrial practitioners such as: 1) ignoring the indirect effect of product variety leads to an overestimation of its benefits; 2) taking advantage of the benefits of product variety requires an understanding of different influences across various dimensions of product variety; and 3) increasing certain types of variety may have positive impacts on sales, while increasing other types of variety may have negative impacts.

Since this study is based on a data sample from a single soft drink bottler, the estimated results may not be easily generalized to other industries. Nevertheless, focusing on a single firm avoids having to control for unobservable firm-level factors, such as managerial characteristics or merchandising systems of firms, which may be correlated with important variables used in the models. The results may be generalized to distributors with large logistics networks and high product variety in other industries, especially those that employ exclusive distributors. Future research could examine the impact of product variety on operational and sales performance across a wide range of firms within an industry or across a diverse range of firms in multiple industries.

Chapter 3 The Influence of Service Variety Strategy on Service Quality and Market Performance

3.1 Introduction

With the emergence of global competition and a customer-oriented business environment, and given the maturation of manufacturing industries in the developed world, the service sector has played an increasingly important role in the economy. In the U.S., the percentage of workers in the service sector has increased from 58.1% in 1960 to 78.6% in 2005 (Heineke and Davis, 2007). Similar increases in workers in the service sector are found in many other countries, such as the U.K., Canada, and Australia (U.S. Department of Labor, 2011). In 2006, US services accounted for roughly 83% of employment, while manufacturing accounted for only about 10% (Chase and Apte, 2007). However, academic research has not closely followed the swift changes in the balance between production operations and service operations. Over the decades, there has been a rich body of research on product variety with a focus on product attributes, the effective and efficient manufacturing approaches to providing product variety, and the influences of product variety on consumer purchase behavior (Fisher et al., 1999, Fisher and Ittner, 1999, Ramdas, Fisher and Ulrich, 2003, Randall and Ulrich, 2001). In comparison to research on physical product variety, few studies have been conducted on service variety (Apte, Maglaras and Pinedo, 2008, Chase and Apte, 2007, Heineke and Davis, 2007, Karmarkar and Apte, 2007, Ramdas, 2003)..

Although research on service operations is a relatively new field, in recent years, service operations management has attracted increasing attention from academic researchers and industry practitioners (Smith, Karwan and Markland, 2007). Service operations management has been recently recognized as a new discipline, with a connection to traditional manufacturing, operations management, marketing, and other existing disciplines. In the service operations management discipline, researchers focus on the service operations taxonomy, new service development, retailing and electronic services, and service quality (Ata and Van Mieghem, 2009, Heineke and Davis, 2007, Hill et al., 2002, Menor and Roth, 2008, Roth et al., 1997). In practice, firms in various industries have realized the importance of service operations. For example, IBM has dramatically increased the proportion of revenue from services over the last 20 years, realizing $54 billion from services out of $99 billion in total revenue in 2007 (Spohrer and Maglio, 2008). In the soft drink industry, major syrup producers have recognized the importance of bottlers that provide delivery and packaging services for soft drink products. In February, 2010, PepsiCo completed mergers with its two largest bottlers, Pepsi Bottling Group and PepsiAmericas, forming a new wholly-owned division (Pepsi Beverages Co. (PBC)) of the PepsiCo North American Beverages unit. At the same time, Coca-Cola Co. and its largest bottler, Coca-Cola Enterprises (CCE), entered into the process of merging CCE's North American division into Coca-Cola Co. The acquisition of CCE's North American Business was completed in October, 2010 and the integrated units are named Coca-Cola Refreshments USA, Inc. and Coca-Cola Refreshments Canada Company (Coca-Cola-Co.-Press-Center, 2010).

This study is motivated by the pioneering service operations research by Roth and Jackson (1995). They investigated the operations capabilities-service quality-performance (C-SQ-P) triad in the retail banking industry and found that generic operations capabilities affect service quality and performance. Based on the linkage between service quality and performance, my study is among the first to introduce service variety as a service operations strategy, and empirically measure its impacts on both service quality and market performance in a service variety-service quality-market performance triad. In addition, this research extends prior work from a pure service firm environment (such as retail banking) to the business-to-business (B2B) service operations in manufacturing-based firms (soft drink bottlers). Service operations in industries with physical products are traditionally viewed as complementary to and facilitating of production operations. Furthermore, my study not only links service strategy (variety) with service quality (Menor et al., 2001, Roth, 1993, Soteriou and Zenios, 1999), but also builds an empirical connection from service operations strategy (service variety) and service quality to the market performance of physical products.

My empirical findings highlight the operational and market benefits of applying a service variety strategy. The direct effect of service variety on service quality, as well as the indirect effect on market performance, is better understood through a moderated mediation model (i.e., the impact of service variety on market performance is moderated by service quality). Moreover, the results indicate that the influence of one type of service variety is conditional on a second type of service variety.

The research questions I aim to answer in this essay include the following: (1) What impact does service variety have on service quality and market performance? (2) Does this impact vary among different types of services provided? (3) Does the link between service quality and market performance that has been found in pure service firms also hold for a manufacturing-based firm? (4) Are there interaction effects among the different types of service variety on service quality?

In answering these research questions, the empirical model is tested using weekly data over three years from 108 distribution centers of a major soft drink bottler. My research contributes to the service operations management literature in several ways. First, as stated above, to my best knowledge, this is the first empirical research that considers the service variety strategy - service quality - market performance linkage in the provision of physical products. By doing this, I extend the service operations research in pure service industries, such as financial services, retailing, and electronic services (Boyer et al., 2002, Froehle and Roth, 2007, Lyons et al., 2007), to a manufacturing-based industry. The findings build the connections between the service operations, traditional operations management, and marketing disciplines. Second, I show that the impact of service variety on service quality varies among different types of services. Third, I use a number of theoretical bases, namely Resource-Based View (RBV), the law of requisite variety, and neocontingency theory, to aid in the understanding of the impact of service variety operations. My findings support the view that service variety is an important resource for firms to use in raising service quality and market performance. This result is in line with the complementary resources arguments of Powell and Dent-Micallef (1997) and the complex systems arguments from Bromiley (2005). Fourth, the mediating role of service quality in the relationship between service variety and market performance is identified. Furthermore, this mediating role is moderated by the different types of services.

The remainder of this essay is organized as follows: The next section provides a review of service management literature with several hypotheses put forth based on the literature. The research methodology is developed in the third section. The fourth section reports the main statistical results, while conclusions, contributions, and implications are discussed in the last section.

3.2 Literature Review and Hypotheses

3.2.1 Literature Review and Framework of Conceptual Model

Given the development of service operations in many industries, researchers have started to pay attention to service operations management (Roth and Menor, 2003, Smith, Karwan and Markland, 2007). The topics for these papers can be categorized into the following groups: service theory building and application (Menor, Roth and Mason, 2001, Rosenzweig and Roth, 2004, Sampson and Froehle, 2006), service design (Froehle and Roth, 2007, Hill, Collier, Froehle, Goodale, Metters and Verma, 2002, Menor and Roth, 2008), service quality (Apte et al., 2007, Field et al., 2004, Hays and Hill, 2001), and interfaces between service operations and other disciplines, such as strategic management, human resources, information systems, and marketing (Apte and Mason, 1995, Boyer and Hult, 2006, Cook et al., 2002, Rabinovich et al., 2008, Stewart and Chase, 1999, Vickery et al., 2003). With this research, I contribute to the literature in service strategy, service theory application, and the interface between service operations and marketing.

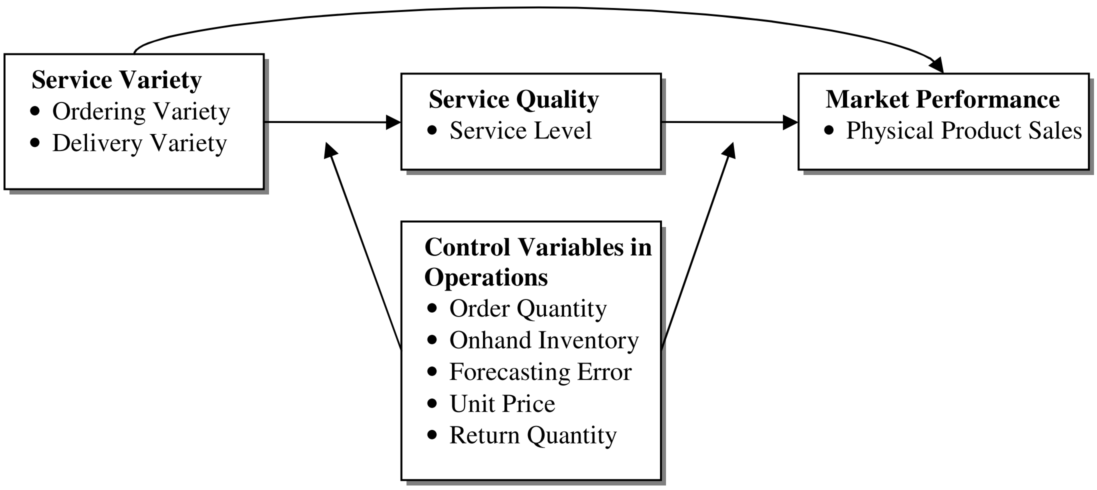
First, this essay contributes to the body of service strategy literature by introducing service variety as a strategic decision for firms. Although it has been argued that the operations management literature needs to be broadened from a view of strategy (Boyer, Swink and Rosenzweig, 2005), strategic decisions in service variety management have received little attention (Ramdas, 2003). Based on an extensive review of service operations research in the operations management literature, Roth and Menor (2003) point out the imbalance between the economic importance of service operations management and the lag in research in the operations management journals. They suggest a service management research agenda for future studies which includes broadening operations strategy studies to include services, and expanding the boundaries of existing service operations literature. Following this basis, this essay investigates service operations strategy from a service variety perspective.

In addition, my research contributes to the service theory literature by proposing the service variety-service quality-market performance triad, which links service strategy to market performance in manufacturing-based firms. Furthermore, this essay applies RBV, the law of requisite variety, and neocontingency theory to establish my hypotheses. My empirical results lend support to these theories.

Finally, a contribution of this paper includes my efforts to link the emerging service operations research to the traditional operations management and marketing disciplines. Heineke and Davis (2007) suggest that it is necessary to recognize service operations as a new discipline that interacts with traditional manufacturing, operations management, marketing, and other existing disciplines. Despite the commonality between service operations and these other disciplines, there has not been much work that empirically investigates interactions among these fields (Parente et al., 2008, Verma et al., 2001). Much of the work in service research focuses only on "pure service firms"; firms whose key functions and major competitive advantage relates to the provision of a service (e.g., banking, insurance, and hospitals). However, this work may not be directly generalized to manufacturing-based firms whose major function is to produce physical product, but which also provides complementary services in order to facilitate transactions with their customers. Manufacturing-based firms and pure service firms have different key functions. Pure service firms do not produce any physical products, while manufacturing-based firms focus on production and operations but only provide complementary services. This difference results in different weights on the importance of services in these two types of firms. According to Chase et al. (1992) service-based manufacturing will become the next key form of competition among manufacturers. Using service operations data from a manufacturing-based firm, this essay considers the impact of service variety strategy on both service quality and market performances.

Figure 3.1 provides the general framework for this research. I propose that service quality is affected through the provision of variety in two types of services: ordering and delivery. Furthermore, the two types of service variety, order and delivery methods, are hypothesized to have an additional interaction effect on service quality. Market performance is influenced directly by service variety and indirectly through service quality. Moreover, service quality is hypothesized to impact market performance and to mediate the relationship between service variety and market performance. Traditional operations variables are included in the framework in order to better isolate the impact of service variety on service quality and market performance. As a result, I am able to calculate the direct and indirect impacts of service variety on market performance.

Figure 3.1 The Service Variety – Service Quality – Marketing Performance Triad



3.2.2 Service Variety

While product variety has been extensively studied in the operations management field, service variety has received little attention (Fisher and Ittner, 1999, Ramdas, 2003, Randall and Ulrich, 2001). In this essay, I consider two types of service variety - order methods and delivery methods (as summarized in Table 3.1).

Table 3.1 Service Variety in Order and Delivery Methods in the Soft Drink Industry

Service	Description
Order Method	
Telephone	Retailers placed orders through telephone.
Conventional	The truck driver carries products in the truck on a certain route, where he/she checks each retailer store for demand, gets the amount requested from the truck, and receives payment.
Pre-sell	The distributor sends sales representatives to retail stores who place orders to be delivered at a later time.
Electronic	Retailers place orders via an electronic ordering system.
Delivery Method	
Bulk	Products are delivered to retailers by transport trucks in pallets. Products are unloaded by a pallet jack.
Dispatchable Bay	Pre-sold Products, which are packed with the exact amount requested, are delivered to retailers by 8-16 bay sideload truck in cases. Products are unloaded by a two-wheel dolly.
Non-dispatchable Bay	Bay sideload trucks are used to deliver products without knowing the demand quantity in advance. Products are unloaded from truck after surveying each retailer store on the route.

The law of requisite variety, as described by Ashby (1958), provides a theoretical perspective for the provision of service variety. In cybernetics and systems science, the law of requisite variety suggests that the number of states of a control mechanism must be greater than or equal to the number of states in the system being controlled in a stable system (Ashby, 1958). From an operations management perspective, having sufficient variety in a system translates into multiple and diverse options in the provision of physical products and services that contribute to the development of organizations (Menor, Roth and Mason, 2001). A single competitive service may be enough for a firm in a simple and stable environment. However, the development of information technology and the trend towards globalization makes the market environment (external variety) diverse. Following the law of requisite variety, internal variety generated by firms in their operations and marketing strategies can contend against external variety. Consequently, increased service variety, which contributes to internal variety, can be used as countermeasures for the turbulent and diverse environment. For example, order variety (such as ordering through sales representatives, phone ordering, and electronic ordering approaches) helps to satisfy heterogeneous needs from customers due to their preferences for various information technologies.

3.2.3 Service Variety and Service Quality

Order methods vary with the development of information technologies (IT). The emergence of advanced IT provides more options to the placement of orders, including traditional face-to-face orders, paper-based orders, phone calls, faxes, emails, electronic data interchange (EDI), and enterprise resource planning (ERP) based orders. Customers have distinct preferences for order methods (Rotem-Mindali and Salomon, 2007). In the ordering process between retailers and distributors, high service variety offered by distributors increases the order option pool for retailers, increasing the possibility that retailers will be able to choose the most efficient method for placing orders.

Furthermore, various order methods help organizations to direct, organize, and revitalize knowledge and resources, thereby creating better service (Froehle et al., 2000). For example, when a sales representative ordering option is added, the order option set has been enlarged. On the other hand, traditional retail store managers with little IT background may prefer talking with sales representatives to inputting data into an IT system. Sales representatives are approachable even when computer systems crash or the internet is disabled. Thus, increased order methods raise service quality by enhancing communication and generally speeding the service operations cycle, which improves the overall effectiveness of service. Hence, the following hypothesis is proposed:

Hypothesis 2.1a: Increased service variety in order methods raises service quality.

Order delivery (fulfillment) methods affect service quality by virtue of differences in operational execution (Boyer and Hult, 2006). Since different delivery methods are geared to serve various delivery sizes and routes, more options in delivery methods help to better satisfy buyer demands and to deliver products on a more flexible time schedule. For example, bulk delivery is used to ship large orders, while bay delivery is used for relatively small orders. If a distributor offers only bulk delivery, it would prefer to make batch shipments in bulk sizes, and thus provide relatively low delivery frequency (but at a low cost). When batching, orders are delayed until the bulk size is realized. With greater numbers of delivery methods, suppliers can satisfy retailers with various order sizes and order frequencies, and hence, raise overall service quality. Therefore, I propose:

Hypothesis 2.1b: Increased service variety in delivery methods raises service quality.

Moreover, there may be interactions between order variety and delivery variety in their impact on service quality. For example, without timely and accurate demand information being received through the various order methods, multiple delivery options offered by suppliers may not be efficiently used. For example, a supplier with multiple delivery truck options can offer various delivery methods, but still may only depend on one way to receive orders from buyers; for example, through sales representatives. Customer orders may be delayed because a representative is not on duty on a certain day due a number of reasons, such as health issues, accidents, and/or severe weather conditions. When demand information is not available or timely, service quality cannot be increased even with high delivery variety. Thus, increases in service variety in order and delivery methods are hypothesized to have a positive interaction impact on service quality.

Hypothesis 2.1c: There is a positive interaction effect between order service variety and delivery service variety on service quality.

3.2.4 Service Quality and Market Performance

Service quality is critical to the success of organizations and is widely believed to raise market performance, such as market share, sales volume, and customer satisfaction (Roth and Jackson, 1995, Voss et al., 2005). Service quality provided by a supplier affects a buyer's satisfaction and the supplier's market performance (Black et al., 2001). From an operations management perspective, fill rate is often used as an indicator for service quality. With low service levels, stockouts occur frequently. For convenience products that are highly substitutable, unsatisfied demand will not likely roll over to the future. For example, in the soft drink industry, customers are likely to choose substitutes when products are not available. Even though some of this substitution may happen among brands belonging to the same producer (Pepsi vs. Caffeine Free Pepsi), at least a portion of sales will be lost because end customers switch to another producer's products (Pepsi vs. Coke). Market performance, hence, is hurt by low service quality. Thus, high service quality provides a manufacturing-based firm with an extraordinary competitive advantage and improves market performance of physical products produced by the firm.

Hypothesis 2.2: Increased service quality is associated with higher market performance.

3.2.5 Service Variety and Market Performance

The resource-based view provides the theoretical foundation for the link between service variety and market performance. According to RBV theory, resources can make a firm different from its competitors in order to preserve its superior position (Barney, 1991, Boyer, Swink and Rosenzweig, 2005, Peteraf, 1993, Roth and Jackson, 1995, Wernerfelt, 1984). High service variety can be used to generate competitive advantage and is not easily replicated due to the requirements of experienced service workers and sufficient financial investment for providing various services. As a type of resource for firms, service variety provides a competitive advantage and the capability to enhance organizational growth and generate superior performance (Flynn et al., 1999, Miller and Roth, 1994).

In addition, contingency theory indicates that certain organizational structures are more appropriate for certain business competitive contexts (Anand and Ward, 2004, Boyer, Swink and Rosenzweig, 2005, Gupta and Lonial, 1998). Neocontingency theory incorporates the concept of strategic choice and resultant competitive capabilities, in addition to organizational structure (Roth and Jackson, 1995). An appropriate service strategy should result in higher firm performance, according to this theory. As a result, the provision of a larger variety of service options increases the probability that the best service strategy will be provided for customers, consequently improving market performance.

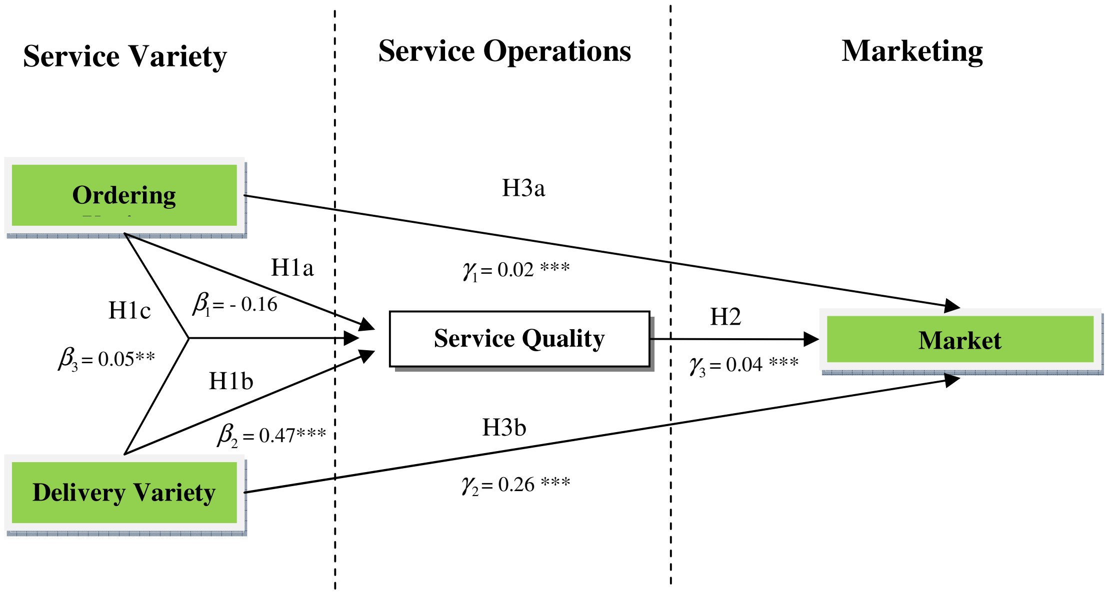
Service variety in order and delivery methods offered by distributors accommodates retailers when they place orders and receive deliveries. As a result, retailers will gain more transaction convenience. This convenience saves transaction costs for retailers. If a supplier offers only one order option and one delivery option, and if these options do not suit a buyer's current operating system, then the buyer may need to make adjustments or new investments in order to efficiently conduct transactions with the supplier. For example, a supplier offers only electronic ordering and bulk truck delivery, and they do not match the requirements at a buyer's facility. Then the buyer will need to upgrade its facilities in order to transact with this supplier. If the investment is costly (such as a ERP system and multiple loading docks) and will not be covered by additional revenues from the sale of goods, the retailer may decide to not do business with the distributor. On the contrary, when high order and delivery variety is provided by a supplier, the transaction convenience that results from variety may attract more buyers. Thus, the provision of a high variety in service options may increase a supplier's market performance.

Hypothesis 2.3a: There is a direct effect from order service variety on market performance.

Hypothesis 2.3b: There is a direct effect from delivery service variety on market performance.

All hypotheses are summarized in the theoretical model shown in Figure 3.2. Hypothesis 2.1 (a, b, and c) examine the relationship between service variety and service quality. The influence of service quality on market performance is investigated by Hypothesis 2.2. Hypotheses 2.3 (a and b) outline the direct impact on market performance from service variety.

Figure 3.2 Hypothesized Impacts of Service Variety on Service Quality and Market Performance



3.3 Research Methodology

3.3.1 Data Collection

My analysis is conducted using data from the distribution network operated by a major soft drink bottler collected on a weekly basis over a three year period (2007-2009). A distribution network in the soft drink industry provides an excellent forum for the study of how service variety influences service quality and market performance for a number of reasons: First, the soft drink industry has been traditionally viewed as a manufacturing-based industry, where, as discussed above, the provision of ancillary services has been overlooked. It is the case that most traditional manufacturing firms need to offer their customers services in order to sell their products. Therefore, my findings may be generalized to firms in many other manufacturing-based industries. Second, the services provided by the soft drink distributor contribute to the business-to-business (B2B) transactions between the distributor and the retailers in its supply chain. Therefore, my analysis extends the service operations discussion from the B2C market to the B2B market. Finally, due to the mature duopoly between Coca-Cola Co. and PepsiCo, the U.S. soft drink market is characterized by stable prices, slow demand growth, and the absence of exogenous shocks. This stable environment helps to isolate the impact of service variety on service quality and market performance.

The data sample was pulled directly from the central database of the soft drink bottler. Three years of data were collected from 108 distribution centers that distribute 328 total SKUs. An SKU is defined as a unique combination of brand, flavor, weight, container material, container size, and pack-size. In order to avoid inconsistency in sales quantity measurement, data on only one major beverage container size (i.e., 12-ounce cans) are used in my analysis. Thus, the sample contains data on soft drink products sold in 12-ounce cans with 113 brands, 12 package sizes, and 328 total SKUs from 108 distribution centers over three years (2007-2009). Each calendar year includes 52 weeks of data. In total, the sample contains 14,908 distribution center-week observations, after eliminating observations with missing values and mismatches between operational and financial records. The distribution center-level data consist of measures for the number of services provided, operations variables, and sales per week (my measure of market performance) for each soft drink product.

Since all of the data are from the distribution centers of a single bottler, unobserved cross-sectional heterogeneity, such as differences in production functions across observations, are controlled in my estimations. Moreover, using data from a single firm allows for consistent measures in the analysis.

3.3.2 Measures

Through field study at the soft drink distributor's operations, and given conversations with bottling managers in both operations and sales departments, the following measures for product variety, operational performance, and marketing performance were derived with both practical and theoretical support (see Table 3.2):

Table 3.2 Description of Variables

Variable Name	Description
Service $Variety_{it}$	Measured by two types of services: Order $Variety_{it}$ and Delivery $Variety_{it}$.
Order $Variety_{it}$	The number of order methods provided by distribution center i in week t.
Delivery $Variety_{it}$	The number of delivery methods provided by distribution center i in week t.
Service $Quality_{it}$	Measured by service level: the percentage of the number of cases filled compared to the total cases ordered at distribution center i in week t.
Service $Quality^{e}_{it}$	The estimated service quality at distribution center i in week t.
Service $Quality_{it-1}$	The service level at distribution center i in week t-1.
Market $Performance_{it}$	The number of cases sold from distribution center i in week t.
Order $Quantity_{it}$	The amount of orders in cases received by distribution center i in week t.
Onhand $Inventory_{it}$	The number of cases stocked in distribution center i at the beginning of week t.
Average Price per $Unit_{it}$	The average price per case in dollars offered by distribution center i in week t.
OverForecast $Error_{it}$	The ratio of difference between forecast demand two weeks in advance and actual order amount received by distribution center i in week t to the actual order amount.
Return $Quantity_{it}$	The number of cases returned by retailers to distribution center i in the week t.

3.3.2.1 Service Variety

Anderson and Narus (1984, p. 62) define a distributor as "a firm that resells products and provides attendant services to other firms for use in the production of those firms' goods and/or services." In order to satisfy requests from producers and demands from retailers, distributors need to provide a variety of services to facilitate product supply (Mudambi and Aggarwal, 2003). Thus, service is an indispensable function of distributors that deserves similar attention to the provision of physical products. Services offered by the distribution centers in the soft drink industry are categorized into two groups (order and delivery) and summarized in Table 3.1:

The soft drink bottler employs a variety of methods to take orders from its retail customers. These order-taking methods include:

- Telephone orders. The bottler takes orders over the telephone and delivers the orders at a later time;
- "Conventional" order taking. With this method, truck drivers check the shelves for stock at each retail store on their route, then stock the shelves from inventory on their trucks and receive payment from the retailers;
- "Pre-sell" orders, the most commonly used approach by the bottler. Distribution centers send sales representatives to retailer stores who check the stock on the shelves and then place orders on behalf of the retailers;
- Electronic Orders. Retailers place orders via an electronic ordering system operated by the distributor.

In addition, the bottler employs a variety of delivery methods including the following:

- Bulk delivery. This method is normally used to provide stock to larger stores; for example, to supermarkets. Each bulk truck can carry up to 11 pallets on each delivery route. Products are loaded onto the truck in pallets and then unloaded at the retail stores by pallet jack;
- Dispatchable Bay. Sideload trucks are used for these deliveries. Pre-sold products, which are packed with the exact amount requested, are delivered to retailers in cases and unloaded by a two-wheel dolly;
- Non-dispatchable Bay. Sideload trucks are used to deliver products after drivers survey a retail store on a route.

3.3.2.2 Service Quality

Service quality is measured by a well-known criterion: service level on the basis of unit fill rate, the ratio of the number of units filled to the number of units ordered

(Bernstein and Federgruen, 2007, Bowersox et al., 2006, Closs et al., 2010, Thomas, 2005). As shown in Table 3.2, *Service Quality*$_{it}$ is calculated as the percentage of product cases filled to the total cases ordered at distribution center i in week t. The service level, indicating service quality, is not only a common measure in the operations literature, but also an important performance measure for the bottler's operations department.

3.3.2.3 Market Performance

Sales quantity of physical products is used to measure market performance. *Sales*$_{it}$ represents the total number of cases sold from distribution center i in week t in multiples of 10,000 cases. One case is defined as a pack of 24 12-ounce cans, so a 12-can pack is equal to 1/2 case in the dataset. Since the data only contain soft drink products packed in 12-ounce cans, no inconsistencies arise from cases with different container sizes.

Table 3.3 provides descriptive statistics for the variables used in the analysis. Table 3.4 summarizes the correlations among these variables across all observations. I also calculate variance inflation factors (VIF) for each of the variables in order to determine if multicollinearity may be present. The VIFs are all found to be less than 4, thus implying that multicollinearity may not be a concern in my analysis.

Table 3.3 Descriptive Statistics for Variables

Variable	Min	Mean	Max	Std. Deviation
Order Variety$_{it}$	1	3.13	4	0.69
Delivery Variety$_{it}$	1	2.58	3	0.66
Service Quality$_{it}$	69.29	99.31	100	1.21
Market Performance$_{it}$ (10,000 units)	0.01	2.09	34.38	2.52
Order Quantity$_{it}$ (10,000 units)	0	2.80	44.01	3.26
Onhand Inventory$_{it}$ (10,000 units)	0.03	3.72	56.39	4.77
OverForecast Error$_{it}$	-1	-0.17	15.5	0.52
Unit Price$_{it}$ (U.S. dollar)	4.35	7.38	20.65	1.34
Return Quantity$_{it}$ (10,000 units)	0	0.09	11.73	0.18

Table 3.4 Pearson Correlations for Service Variety, Service Quality, and Market Performance

	Variable	1	2	3	4	5	6	7	8	9
1	Order Variety$_{it}$	1.00								
2	Delivery Variety$_{it}$	0.30***	1.00							
3	Service Quality$_{it}$	0.02***	0.10***	1.00						
4	Market Performance$_{it}$	0.15***	0.27***	0.47***	1.00					
5	Order Quantity$_{it}$	0.35***	0.52***	-0.07***	0.68***	1.00				
6	Onhand Inventory$_{it}$	0.35***	0.58***	0.03***	0.70***	0.08	1.00			
7	OverForecast Error$_{it}$	-0.12	-0.09**	0.07***	0.04	-0.46***	0.18	1.00		
8	Unit Price$_{it}$	0.14	0.20	0.06	-0.19***	-0.24***	-0.18	0.07	1.00	
9	Return Quantity$_{it}$	0.11***	0.17***	-0.04	-0.21***	0.26***	0.32	-0.03	-0.02**	1.00

** $p < 0.05$, *** $p < 0.01$

3.3.3 Models

In order to better understand the service variety-service quality-market performance relationship, mediation analysis is applied. The mediation framework tests the role of a third variable in facilitating the process through which the independent variable affects the dependent variable (Baron and Kenny, 1986). This model includes a three-equation system, where the independent variable is service variety, the dependent variable is market performance, and the mediator is the service quality:

$$MarketPerformance_{it} = \alpha_0 + \alpha_1 OrderVariety_{it} + \alpha_2 DeliveryVariety_{it} + \sum_{j=1}^{107} \alpha_{3j} LocDum_{ij} + \sum_{k=1}^{11} \alpha_{4k} YrSnDum_{kt} + MarketPerformance_{it-1} + W_{it} A + \xi_{it} \quad (1)$$

$$\begin{aligned} ServiceQuality_{it} &= ServiceQuality_{it}^{e} + \varepsilon_{it} \\ &= \beta_0 + \beta_1 OrderVariety_{it} + \beta_2 DeliveryVariety_{it} + \beta_3 \left(OrderingVariety_{it} \times DeliveryVariety_{it} \right) \\ &\quad + \sum_{j=1}^{107} \beta_{4j} LocDum_{ij} + \sum_{k=1}^{11} \beta_{5k} YrSnDum_{kt} + V_{it} B + \varepsilon_{it} \end{aligned} \quad (2)$$

$$MarketPerformance_{it} = \gamma_0 + \gamma_1 OrderVariety_{it} + \gamma_2 DeliveryVariety_{it} + \gamma_3 ServiceQuality_{it}^{e} + \sum_{j=1}^{107} \gamma_{4j} LocDum_{ij} + \sum_{k=1}^{11} \gamma_{5k} YrSnDum_{kt} + MarketPerformance_{it-1} + W_{it} C + \delta_{it} \quad (3)$$

Since I am hypothesizing a causal relationship between service variety and service quality, *$ServiceQuality_{it}$* may not be an exogenous variable in Equation (3) along with *$OrderVariety_{it}$* and *$DeliveryVariety_{it}$*. Therefore, in order to produce consistent estimators, a two-stage regression approach is used to estimate Equations (2) and (3). In the first stage, service quality is estimated by the independent variable, control variables, and exogenous variables including service quality in the previous week (*$ServiceQuality_{it-1}$*) and over-forecast error two weeks in advance (*$OverForecastError_{it}$*). In the second stage, the fitted value of service quality (*$ServiceQuality^{e}_{it}$*) from Equation (2) is calculated and then used as an instrumental variable for *$ServiceQuality_{it}$* in Equation (3) (Zhang et al., 2009).

In Equation (1), *$MarketPerformance_{it}$* is estimated from the two types of service variety, *$OrderVariety_{it}$* and *$DeliveryVariety_{it}$*, and a control variable matrix *W_{it}*, including the order quantity received by a given distribution center during the week of the observation (*$OrderQuantity_{it}$*), the on-hand inventory for an SKU at the beginning of the week at a given distribution center ($OnhandInventory_{it}$), the fill rate from the previous week ($FillRate_{it-1}$), and a variable that measures the over-forecast error two weeks in advance ($OverForecastError_{it}$) - two weeks being the forecast period for the distributor studied for this research (negative values indicate demand was under-forecast). Finally, dummy variables are included for distribution centers ($LocDum_{ij}$ = 1 if i=j; 0 otherwise) to control for other unobserved variations in performance between distribution center locations (e.g., due to variances in areas served, distribution routes, managerial ability, etc.), and for time differences across seasons and years ($YrSnDum_{kt}$ = 1 if week t belongs to the year-season k; 0 otherwise).

Based on the setup in Equation (1), the fitted value of $ServiceQuality_{it}$ is added to the right hand side of Equation (3) in order to test the mediation effect of service quality. Due to the skewed distribution of sales values in my dataset, natural log transformations are applied to normalize the distribution (Randall et al., 2006). (Note that natural log transformations are also used for control variables $OrderQuantity_{it}$ and $OnhandInventory_{it}$ in all Equations for the same reason.) Furthermore, market performance in the previous week ($MarketPerformance_{it-1}$) is included in Equations (1) and (3).

In Equation (2), $ServiceQuality_{it}$ is estimated from two types of service variety, their interaction term, and an overlapping, but distinct, control variable matrix V_{it}, including $ServiceQuality_{it-1}$, $OrderQuantity_{it}$, $UnitPrice_{it}$ (average price per unit), $OnhandInventory_{it}$, and $ReturnQuantity_{it}$. As was the case with Equations (1) and (3), dummy variables are included in Equation (2) to control for differences between distribution centers and over time. Since service quality is calculated as a percentage, the dependent variable in Equation (2) can range from 0 to 100, with the data containing a great many 100 values (i.e., no stockouts). In order to account for this non-normal left-skewed distribution, a Tobit model is used to estimate Equation (2) (Cassiman and Veugelers, 2006).

3.3.4 Measures for the Effects of Service Variety

The effect of service variety on service quality is denoted by the parameters β_1, β_2, and β_3 in Equation (2), while the direct effect of service variety on market performance, adjusted for service quality, is represented by the parameters γ_1 and γ_2 in Equation (3). The indirect effect of service variety on market performance through service quality is indicated by the combination of service variety's impact on service quality (β_1, β_2, and β_3 in Equation (2)) and the service quality impact on market performance (γ_3 in Equation (3)). For example, the indirect effect of order variety is given by the following:

$$
\begin{aligned}
Indirect\ Effect_{OrderingVariety} &= \frac{\partial MarketPerformance_{it}}{\partial ServiceQuality_{it}^{e}} \times \frac{\partial ServiceQuality_{it}^{e}}{\partial OrderVariety_{it}} \\
&= \gamma_3(\beta_1 + \beta_3 DeliveryVariety_{it}) \\
&= \beta_1\gamma_3 + \beta_3\gamma_3 DeliveryVariety_{it}
\end{aligned}
\tag{4}
$$

Along the same lines, the indirect effect of delivery variety on market performance is $\gamma_2 + \beta_2\gamma_3 + \beta_3\gamma_3 OrderVariety_{it}$. If all coefficients and products of coefficients are significant in estimation results, the impact of one type of service variety on service quality and market performance does not only depend on itself, but is conditional on (moderated by) the other type of service variety. I will discuss the indirect effects based on my empirical results in the following section.

3.4 Results and Discussion

The three equations (Equations (1), (2), and (3)) are all estimated using hierarchical regression analysis. This approach helps to examine the relationships among the variables by adding additional variables stepwise (Rosenzweig et al., 2003). As shown in Table 3.5 (Models 1a, 2a, and 3a), the three equations are first estimated using only control variables (base model). Next, the variables of interest, $OrderVariety_{it}$, $DeliveryVariety_{it}$, and $ServiceQuality_{it}$, are added to the base models. I assess the contribution of these variables through F or χ^2 statistics, changes in R^2, and Mean Absolute Deviation (MAD). The increasing (Pseudo) R^2 and F statistics and decreasing MAD and χ^2 from Model 1a to Model 1b (Model 2a to 2b, Model 3a to 3b) suggests that the model with the variables of interest explains the variation in the dependent variable better than the base model.

Table 3.5 Estimated Results for Influences of Service Variety

	Market Performance		Service Quality		Market Performance	
Variable	Model 1a	Model 1b	Model 2a	Model 2b	Model 3a	Model 3b
Order Variety$_{it}$		0.03***		-0.16		0.03***
		(0.01)		(0.09)		(0.00)
Delivery Variety$_{it}$		0.29***		0.47***		0.26***
		(0.01)		(0.11)		(0.01)
Order Variety$_{it}$× Delivery Variety$_{it}$				0.05**		
				(0.02)		
Service Quliaty$^{e}_{it}$						0.04***
						(0.01)
Service Quality$_{t-1}$			0.24***	0.21**		
			(0.01)	(0.01)		
Over-Forecast Error$_{it}$			0.17***	0.13**		
			(0.06)	(0.06)		
Market Performance$_{t-1}$	0.01	0.01			0.01	0.01
	(0.01)	(0.01)			(0.01)	(0.01)
Order Quantity$_{it}$	0.80***	0.81***	-0.18***	-0.17***	0.81***	0.81***
	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)	(0.01)
Onhand Inventory$_{it}$	0.08***	0.06***	0.25***	0.22***	0.07***	0.06***
	(0.01)	(0.01)	(0.04)	(0.04)	(0.01)	(0.01)
Unit Price$_{it}$	-0.11***	-0.11***			-0.12***	-0.11***
	(0.01)	(0.00)			(0.01)	(0.01)
Return Quantity$_{it}$	-0.19***	-0.19***			-0.17***	-0.17***
	(0.01)	(0.01)			(0.01)	(0.01)
Constant	0.07	-0.42***	101.66***	99.93***	-4.79***	-4.50***
	(0.13)	(0.13)	(0.89)	(0. 94)	(0.22)	(0.22)
Distribution Center Dummies	Included in the model but not shown					
Year-Season Dummies	Included in the model but not shown					
MAD	0.21	0.18	0.85	0.71	0.15	0.14
R^2 or Pseudo-R^2	0.90	0.92	0.49	0.53	0.94	0.95
F or χ^2 test statistic	2,256***	2,425***	2,970***	2,741***	2,364***	2,507***
Observations	14,908	14,908	14,908	14,908	14,908	14,908

** $p < 0.05$, *** $p < 0.01$
Standard errors are reported in parenthesis.
F and Chi-Square test statistic indicates the rejection of the null hypothesis that all model coefficients are zero.

Therefore, my analysis is conducted based on the estimated result from Models 1b, 2b, and 3b in Table 3.5. Causal paths proposed by my hypotheses are summarized in Figure 3.2. Estimated coefficients, their significance, and hypotheses test results are indicated in the corresponding paths.

3.4.1 Impact of Service Variety on Service Quality

Hypotheses 1 (a, b, and c), which relate the impact of service variety on service quality, are tested using estimated results of Model 2b in Table 3.5. The coefficient of order variety is not significant, while the coefficient of delivery variety is significant ($p<0.01$) and positive. This result suggests that higher delivery variety leads to higher service quality, but higher order variety does not. Thus, Hypothesis 2.1a is supported, and Hypothesis 2.1b is not.

One explanation for the insignificant results may be the countervailing impacts from order variety on service quality. High order variety enhances order information from buyers to suppliers, while it also enlarges the order receiving windows at the supplier because order information through various order methods arrives at a distribution center at different times. According to my observations at a distribution center, the dispatch operator at a distribution center usually start dispatching orders after the orders from the call center (through telephone order) arrive since it is the major ordering source. Nevertheless, some orders through other order methods may arrive at the dispatch operator after the close of the daily dispatch time. Therefore, no dispatch actions are taken on these orders on the day that the orders are received. Thus, these unfilled orders lower the fill rate at the warehouse. This negative impact of order variety on service quality may counterbalance its positive influence. The overall effect, hence, becomes insignificant.

Furthermore, the interaction term between order variety and delivery variety has a significant ($p<0.05$) and positive coefficient. An increase in delivery variety with high order variety results in higher service quality. Hypothesis 2.1c, hence, is supported.

3.4.2 Impact of Service Quality on Market Performance

As expected in Hypothesis 2.2, the coefficient for service quality in Model 3b in Table 3.5 is significant and positive ($p<0.01$). This confirms a positive relationship between service quality and market performance. The link between service quality and market performance (Hypothesis 2.2) is supported by this result.

3.4.3 Direct Effect of Service Variety on Market Performance

The direct effect of service variety on market performance is represented by the coefficients of order and delivery variety in Model 3b. Both of the coefficients are significant ($p<0.01$) and positive. Therefore, Hypotheses 3a and 3b are supported. An increase in order variety or delivery variety directly raises market performance.

3.4.4 Indirect Effect of Service Variety on Market Performance

As shown in Equation (4), the indirect effect of service variety on market performance is represented by the products of coefficients (such as $\beta_1\gamma_3$, $\beta_2\gamma_3$, and $\beta_3\gamma_3$) and moderated by the other type of service. Both Sobel's and bootstrapping approaches are used to obtain standard errors and confidence intervals to confirm the significance of the indirect effect (MacKinnon et al., 2007, Sobel, 1982).

Sobel (1982) calculates standard errors of the product based on an asymptotic approximation using the multivariate method, and demonstrates the use of the first-order multivariate delta method in determining standard errors of conditional indirect effects (moderated mediation). However, Sobel's method is often limited by the assumption that products of coefficients are normally distributed (Muller et al., 2005, Preacher et al., 2007).

In fact, the distribution of the product of two normally distributed coefficients is in general not normal, but usually positively skewed and kurtotic (Shrout and Bolger, 2002, Stone and Sobel, 1990). Since the bootstrapping method has no assumptions about the shape of the sampling distribution of the statistic and allows for asymmetric confidence intervals, it is also used to test the significance of an indirect effect. Bootstrapping provides an empirical sampling distribution for each product by re-sampling from the data with replacement and applying the indirect effect (mediation) analysis to each sample (MacKinnon, Fairchild and Fritz, 2007). Specifically, I take 10,000 random draws (with replacement) from my data sample with 2,000 replications. Means and standard deviations of these coefficient products are estimated using these replicated random re-sampling data sets.

As shown in Table 3.6, the tests for the indirect effects of service variety using the two methods, given mean values for the moderators (order or delivery variety), suggest that the indirect effect of delivery variety on market performance is positive and significant (the confidence interval does not include zero), but the indirect effect of order variety is not significant. In order to conduct a robust analysis of the indirect effects, I further compute the conditional indirect effects for different moderator values, such as the mean of order variety +/- a standard deviation. The results are consistent with those reported.

Table 3.6 Moderated Indirect Effects of Service Variety on Market Performance

Indirect Effect	Notation	Method	Mean	Standard Error	95% Confidence Interval
Order Service Variety →	$\gamma_3(\beta_1 + \beta_3 DeliveryVariety_{it})$	Sobel	0.006	0.004	(-0.002, 0.014)
Market Performance		Bootstrap	0.008	0.006	(-0.003, 0.022)
Delivery Service Variety →	$\gamma_3(\beta_2 + \beta_3 OrderingVariety_{it})$	Sobel	0.026	0.001	(0.024, 0.028)
Market Performance		Bootstrap	0.020	0.008	(0.009, 0.039)

3.4.5 Mediating Role of Service Quality

The mediating role of service quality between service variety and market performance is investigated using the estimated results of Models 1b, 2b, and 3b. I apply the causal step approach by Baron and Kenny (1986). First, in Model 1b, both order and delivery varieties have significant coefficients. Second, order variety is not significant, while delivery variety is significant in Model 2b. Service quality, hence, fails to mediate the effect of order variety on market performance. Next, I continue the third step in the process for delivery variety: service quality is significant in Model 3b. Thus service quality mediates the relationship between delivery variety and market performance.

To further test whether there is complete or partial mediation, both Baron and Kenny's approach and the recommendation by James et al. (2006) are used. On the one hand, according to the fourth step in Baron and Kenny's approach, after service quality is added to the model (Model 3b), the coefficient for delivery variety is still significant but is diminished compared to the model without service quality (Model 1b). On the other hand, in the recommendation by James et al. (2006), delivery variety in Model 1b is significant, and the indirect effect of delivery variety is significant, as shown in Table 3.6. Therefore, results in both approaches support the conclusion that the impact of delivery variety on market performance is partially mediated by service quality (Judd and Kenny, 1981, Kristal et al., 2010). This finding highlights an important role that service quality plays in the service variety-service quality-market performance triadic relationship. This finding leads us to investigate the indirect effects of service variety on market performance, as discussed below.

3.5 Conclusions

This study is conducted to better understand how service variety affects service quality and market performance. Following the exploratory study by Roth and Jackson (1995), I propose a theoretical triadic relationship – service variety-service quality-marketing performance. In order to examine this relationship, I develop a mediating model, building upon the resource-based-view (RBV), contingency theory, and the law of requisite variety. My empirical findings contribute to the emerging service operations management research. This effort is differentiated from previous research by introducing the concept of service variety from a strategic perspective, and linking it to service quality and market performance.

Major findings in this essay suggest that service variety has direct impacts on service quality and sales performance and that these impacts vary across different types of services: order and delivery. Delivery variety is found to have a positive direct relationship with service quality and market performance, while order variety has a positive direct impact on market performance, but not on service quality.

Consistent with the literature, my findings indicate a significant and positive relationship between service quality and market performance.

In addition, increased delivery variety is found to have an indirect effect on market performance. Service quality acts as a mediator between delivery service variety and market performance. Furthermore, this indirect effect is positively conditional on order variety. On the other hand, order variety does not have an indirect effect on market performance. The findings in this study draw attention to service variety in academic research and industrial practice.

This research makes several major contributions to the existing literature in service operations management. First, service variety is introduced as a type of service strategy in this essay. I analyze the impact of service variety in two dimensions: order variety and delivery variety. Empirical results suggest that impacts of service variety vary over different variety dimensions. Increases in a certain type of service variety may or may not increase performance. Thus, service types need to be considered when variety investment is made. This work follows suggestions from previous studies by providing a new perspective in the consideration of service strategy (Boyer, Swink and Rosenzweig, 2005, Roth and Menor, 2003).

Second, I apply various theories to the application of service operations in this essay. RBV, neocontingency theory and the law of requisite variety are applied to investigate the impacts of service variety. By proposing the service variety-service quality-market performance triadic relationship, my work contributes to linking service operations to traditional operations management and marketing. Although many researchers raise the importance of the connections among service management and other traditional disciplines, little empirical work has been conducted in this area (Heineke and Davis, 2007, Parente, Lee, Ishman and Roth, 2008, Verma, Thompson, Moore and Louviere, 2001). My essay is an attempt to link service operations to other research fields. This is an extension of operations capabilities-service quality-market performance (C-SQ-P) triad proposed by Roth and Jackson (1995).

Third, this essay enriches our understanding of service operations in B2B transaction relationships. Roth and Jackson (1995) found a link between service quality and performance in the retail banking industry. By using weekly transactional data over three years between a major soft drink bottler and its retailers, I confirm that this link holds for the services offered by a manufacturing-based firm. Furthermore, I suggest that, even in a traditional manufacturing-based firm, service is not just a derivative activity of product manufacturing, but contributes directly and indirectly to market performance.

My empirical results provide numerous important implications for industrial practitioners. First, my findings highlight the positive role of service variety in service operations and market performance. Service variety not only raises service quality, which in turn increases marketing performance, but also directly improves market performance. Thus, service operations deserve the attention of managers working in manufacturing-based firms.

Moreover, managers need to understand the different impacts on performance across various types of service variety. My results show that providing variety in the ordering process provides little or no significant help in improving service quality. The service quality benefits from order variety are found only in conjunction with delivery variety. On the other hand, delivery variety directly raises service quality. Thus, a mixed strategy, combining a variety of various types of service initiatives, may be needed to best increase service quality and sales performance.

Finally, service quality plays a mediating role in the relationship between service variety and market performance. In addition to the direct effect of service variety on market performance, the indirect effect of service variety through service quality cannot be ignored. My findings suggest that the positive influence of service variety on market performance is larger than can be observed in the direct relationship.

Chapter 4 Product Variety, Service Variety, Demand and Costs: A System Wide Empirical Analysis

4.1 Introduction

By offering greater variety in products and services, firms may better satisfy their customers and stimulate demand (Bayus and Putsis, 1999, Boyer, Hallowell and Roth, 2002, Froehle and Roth, 2007). Consumers perceive high value from a high level of product and service variety (Ton and Raman, 2010, Xia and Rajagopalan, 2009). However, it is costly to maintain the high variety. Greater product and service variety is associated with higher costs from various aspects of operations, such as production line switches, logistics, loading labor, and inventory holding.

An extensive body of literature has examined the influence and determinants of product variety. Previous research, largely theoretical in nature, has identified three streams of relationships among product variety, demand, and costs. In the demand stream, high variety in products allows a firm to satisfy the wants and needs of heterogeneous consumers and, thus, to increase demand (Bayus and Putsis, 1999, Smith and Agrawal, 2000). In the costs research stream, from a supply perspective, high product variety increases operational costs by raising the complexities in production, assembly, inventory, and logistics management (Fisher and Ittner, 1999, Heese and Swaminathan, 2006, Ramdas, Fisher and Ulrich, 2003). Finally, in the stream of research on variety decisions, firm managers must balance demand increases due to product variety with the associated increases in costs. Compared to studies on product variety, little research is found to investigate service variety and its impact on firm performance. Nevertheless, these three theoretical research streams may be applied to service variety as well.

Despite the theoretical interest in variety decisions, most empirical work has used separate reduced-form models instead of an integrated approach. Little empirical work has simultaneously considered all three of the possible effects on determining variety (as mentioned in three streams of research), which includes the influences of product and service variety on demand and costs, as well as their reverse impact on variety decisions. Any unidimensional explanation for the impact of product and service variety is likely to be incomplete. Furthermore, service variety has been largely overlooked compared to research on product variety (Apte, Maglaras and Pinedo, 2008, Heineke and Davis, 2007, Ramdas, 2003). In this essay, I fill the gap in the literature by modeling a dynamic loop system covering product and service variety, demand, and costs for a firm.

The key contribution of my research, therefore, is to jointly capture the impacts of variety in product and service decisions on demand and cost outcome, as well as the determinants of future product and service variety decisions which depend on cost and demand. Integrating both operational (costs) and marketing factors (demand) within a firm is an important, yet challenging, issue (Berry and Cooper, 1999; Boyer and Hult, 2005; Jayaram and Malhotra, 2010; Singhal and Singhal, 2002). I find, not surprisingly, that greater variety is generally associated with higher demand and costs, but that the impacts are not simply linear and follow a curvilinear pattern.

Moreover, my second contribution is to extend variety research from the traditional products dimension to the service dimension. Although it has been argued that the operations management literature needs to be broadened (Boyer, Swink and Rosenzweig, 2005), strategic decisions in service variety management have received little attention (Ramdas, 2003). Service operations in industries with physical products are traditionally viewed as complementary to and facilitating of production operations. My research analyzes the important role of service operations strategy in the manufacturing industry.

Third, a contribution of this essay links the emerging service operations research to research from the traditional operations management (costs) and marketing disciplines (demand). Despite the commonality between service operations and these other disciplines, there has not been much work that empirically investigates the interactions among these fields (Parente, Lee, Ishman and Roth, 2008, Verma, Thompson, Moore and Louviere, 2001). In this essay, I not only examine the impact of product and service variety on costs in manufacturing operations and on demand from a marketing perspective, but also investigate how costs and demand performance affect future variety decisions in services and products.

Finally, my analysis is conducted using data from 108 soft drink distribution centers operated by a major bottler collected over three years on a periodic (4 week) basis. The distributor has often been overlooked in previous research on variety, which has generally focused on either manufacturers or retailers. My research, therefore, will help in the understanding of how the performance outcomes of distributors are affected by their product and service variety decisions in distributor centers-retailers transactions.

The remainder of this essay is organized as follows: The next section provides a conceptual framework for this research. Several hypotheses are put forth based on existing studies. The research methodology is developed in the third section. The fourth section reports the main statistical results, while conclusions, implications, and future research questions are discussed in the last section.

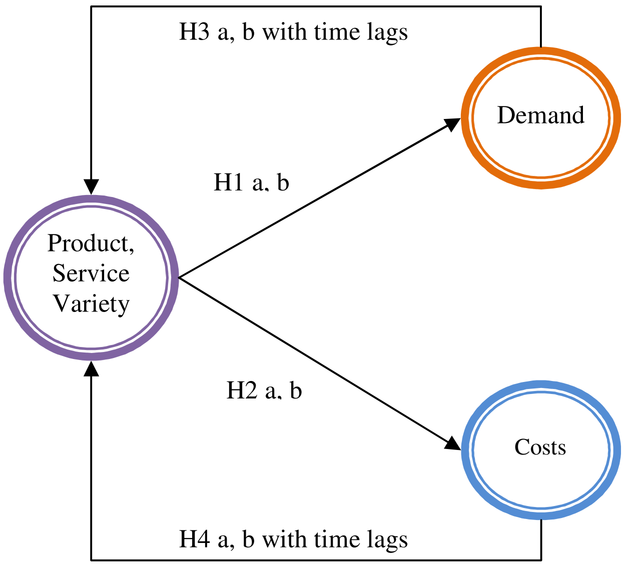
4.2 Literature Review and Hypotheses Development

4.2.1 Framework of Conceptual Model

The impacts of variety on firm performance have been well studied in the operations management and marketing literature (Fisher and Ittner, 1999, Ramdas, 2003, Ramdas, Fisher and Ulrich, 2003, Randall and Ulrich, 2001, Xia and Rajagopalan, 2009). However, the reverse influences of performance on both product and service variety decisions have been overlooked in empirical research. To decide on an optimal level of product and service variety, firm managers need to balance increased demand and increased costs from higher variety. In addition, variety decisions will also be influenced by other factors at distribution centers, such as the size of operations and the experience of the managers. These dynamics suggest that firm managers should consider variety decisions from both demand and supply perspectives

Figure 4.1 provides the general framework for this research. Product and service variety is hypothesized to have impacts on both demand and costs, which in turn affect future variety decisions. This framework aims to capture the dynamic system of variety, demand, and supply (costs), including influences of product and service variety on demand and costs and their reverse impact on variety decisions.

Figure 4.1 The Conceptual Model of Relationships among Variety, Demand, and Costs



4.2.2 The Impact of Variety on Demand

Many marketing studies suggest firms should increase product variety to satisfy the needs of different customer segments (Xia and Rajagopalam, 2009). High variety is considered a way to attract demand by meeting the various needs of customer segments. Given heterogeneity in consumer preferences, high product variety can lead to increased probability since a firm's product offerings will closely match an individual consumer's preference. Moreover, customers who like variety-seeking prefer a large choice set that is increased through product variety (Smith and Agrawal, 2000).

The positive impact of product variety on demand, however, may be at a decreasing rate. On the one hand, for end users, (1) the more dispersed a firm's products are in the product attribute space, the more difficult it is to find an incrementally beneficial unoccupied location, and (2) cannibalization and product overlap become increasingly likely with high product variety (Bayus and Putsis, 1999). On the other hand, demand is not always proportional to product variety. Since storage space is generally costly and limited, customers may not increase their order quantities in a constant proportion to their supplier's product variety. Thus, the following hypothesis is proposed:

Hypothesis 3.1a: Greater product variety leads to increased demand, but at a decreasing rate.

In most manufacturing industries, such as automobiles and soft drinks, delivery and transportation services are provided to facilitate the transaction of physical products on sales to retailers. Service variety provides a convenience for retailers in the receipt of deliveries from a distribution center. This convenience saves transaction costs for retailers. If a supplier offers only one service type, such as bulk truck delivery, and this type of delivery service does not match the requirements at a buyer's facility, then the buyer will need to upgrade its facilities in order to transact with this supplier. If the investment is costly and will not be covered by additional revenues from the sale of goods, the retailer may decide to not do business with the distributor. Conversely, the provision of service variety may generate higher demand by allowing for operations with greater numbers of customers who have diverse requirements and diverse facilities. However, similar to the product variety example, cannibalization may exist between various service options. For example, demand may not be doubled by adding a second service option; for example, a side load truck delivery option in addition to bulk truck delivery. Thus, I propose the following:

Hypothesis 3.1b: Greater service variety leads to increased demand, but at a decreasing rate.

4.2.3 The Impact of Variety on Costs from the Supply Perspective

Increases in product variety lead to higher costs since greater variety increases the complexity of operations (Closs, Nyaga and Voss, 2010, Thonemann and Bradley, 2002). When product variety increases, the preparation and handling work needed for an order increases. Orders with high variety require additional warehousing operations, such as unloading, locating, and handling within distribution centers. This extra work leads to higher inbound logistics costs.

In addition, increased product variety creates problems in demand forecasting for distributors. Based on observations at the soft drink bottler studied in this essay, planners predict future demand based mainly on historical order records. Increasing product variety implies that new products are introduced. Demand for a new product can often be forecast using historical records of a related, existing product; however, these forecasts are often unreliable. Lack of relevant historical records due to increased product variety adversely affects the accuracy of forecasting, which results in either more stockout costs or greater holding costs, or both.

Furthermore, the impact of product variety on costs may not be linear. Extra costs mainly result from increased variable costs due to greater product variety, such as higher handling and holding costs. However, an increase in product variety will not likely have much effect on fixed cost, such as warehouse leasing costs. As additional products are distributed, one might expect that the marginal effect on costs to be lower for the $n+1^{st}$ product than for the n^{th} product. Consequently, a potential positive relationship between variety and costs but at a decreasing marginal increment leads to Hypothesis 3.2a:

Hypothesis 3.2a: Greater product variety leads to increased costs, but at a decreasing rate.

When service variety increases, the setup costs for the new service, as well as the handling and delivery costs needed for satisfying orders increase. If a new delivery option is added, delivery costs will increase; for example, with the addition of new vehicles and new handling equipment. This leads to higher outbound logistics costs. Furthermore, labor costs will increase with the increased operational complexity because increased service variety reduces efficiency in operations. For instance, greater delivery variety results in more complexity in order dispatching. Extra work hours for dispatching managers lead to higher labor costs. These extra expenses contribute to higher variable costs, while certain fixed costs may not increase (at least proportional to the increase in service variety). This leads to the following hypothesis:

Hypothesis 3.2b: Greater service variety leads to increased costs, but at a decreasing rate.

4.2.4 Product and Service Variety

In order to appeal to diverse customer needs, firms often provide high levels of product and service variety. Firms expect that this variety will result in increased demand and higher sales. However, if increases in demand are not as high as expected, poor demand performance with high variety decision will discourage the future variety decision. On the contrary, when high variety attracts high demand, managers will invest in research and development and further increase the variety of their products. In addition, they may also develop new ways of delivering their products to their customers; that is by increasing the variety of their service offerings. Therefore, I propose the following hypotheses:

Hypothesis 3.3a: Higher demand leads, in the future, to greater product variety.

Hypothesis 3.3b: Higher demand leads, in the future, to greater service variety.

Since the difference between revenues and costs constitute profits, higher costs reduce profits. Lower profits in the current period will reduce available funds for future investments, such as investments in new products and new services. Furthermore, if managers find largely increased costs associated with greater variety, they will be reluctant to raise the number of future product and service options. For example, firms generally review their performance by the end of a time period (such as a month, a season, and a year). In the review report, if the costs in the period with great variety are so high that profit shrinks much, or even that negative profit occurs, high variety strategy may not be proposed to the next time period. Therefore, I propose the following hypotheses:

Hypothesis 3.4a: Higher costs lead, in the future, to lower product variety.

Hypothesis 3.4b: Higher costs lead, in the future, to lower service variety.

All hypotheses are summarized in the model shown in Figure 4.1. Hypotheses 1 and 2 examine the influences of product and service variety on demand and costs, respectively, while the reverse impacts of demand and cost performance on future variety decisions are investigated by Hypotheses 3 and 4.

4.3 Research Methodology

4.3.1 Data Collection

My analysis is conducted using data from the distribution network operated by a major soft drink bottler collected on a period basis over three years (2007-2009). A period includes four weeks and there are thirteen periods in a year. Unlike a month, a period does not split a week. Thus, time tables with periods are broadly used in the industry for financial and operational purposes. Furthermore, a week may be too short to allow for the effectiveness of impacts of demand and costs on product and service variety decisions, since firms do not review their performance too frequently, such as in a weekly basis. Instead, performance reports are likely to be conduct in a longer time period. Thus, I conduct the following analysis using these four-week periods.

The distribution network of the soft drink industry provides an excellent forum for the study of the influences and the determinants of product and service variety for a number of reasons. First, firms in this industry provide a variety of both physical products and services and there is rapid new product development in the soft drink industry. In recent years, Coca-Cola Co. and PepsiCo have invested more than $3 billion each year in new product development and advertising (Fosfuri and Giarratana, 2009). Various services, such as different delivery options, are provided to facilitate the transactions of physical products. Since the provision of ancillary services is common in traditional manufacturing industries, my findings from the analysis in this industry may be generalized to other manufacturing-based industries. Second, products and services provided by distributors contribute to the business to business (B2B) transactions between distributors and retailers. The analysis extends the product and service studies that have been done from B2C (Jackson et al., 2003) to B2B markets. Third, due to the mature duopoly between Coca-Cola Co. and PepsiCo, the U.S. soft drink market is characterized by stable prices, slow demand growth, and the absence of exogenous shocks. This stable environment helps to isolate the provision of product and service variety for other environmental factors. Finally, large distributors in the soft drink industry operate nationwide distribution networks with hundreds of distribution centers. Heterogeneous product variety, service variety, demands, and costs across these distribution centers provide a good context for my study, as well as sufficient variance in key variables for an econometric analysis.

The data sample was pulled directly from the central database of the soft drink bottler. Three years of data were collected from 108 distribution centers that distribute 328 total SKUs. An SKU is defined as a unique combination of brand, flavor, weight, container material, container size, and pack-size. In order to avoid inconsistency in sales quantity measurement, data on only one major beverage container size (i.e., 12-ounce cans) are used in my analysis. Thus, the sample contains data on soft drink products sold in 12-ounce cans with 113 brands, 12 package sizes, and 328 total SKUs from 108 distribution centers over three years (2007-2009). In total, the sample contains 3,749 distribution center-period observations, after eliminating observations with missing values and mismatches between operational and financial records. The distribution center-level data consist of the number of products and services provided, distribution center demand, operational variables, and sales per period for each soft drink product.

Since all of the data are from the distribution centers of a single bottler, unobserved cross-sectional heterogeneity, such as differences in production functions across observations, are controlled in my estimations. Moreover, using data from a single firm allows for consistent measures in the analysis.

4.3.2 Measures

Through a field study at the soft drink distributor's operations, and given conversations with bottling managers in both operations and sales departments, the following measures for product and service variety, demand, sales, and operational variables were derived with both practical and theoretical support (see Table 4.1):

Table 4.1 Description of Variables

Variable Name	Description
Product Variety$_{it}$	Measured by No. SKU$_{it}$.
No. SKU$_{it}$	The number of stock keeping units (SKUs) sold at distribution center i in period t.
Service Variety$_{it}$	Measured by Delivery Variety$_{it}$.
Delivery Variety$_{it}$	The number of delivery methods provided by distribution center i in period t.
Order Quantity$_{it}$	The amount of orders in cases received by distribution center i in period t.
COGS$_{it}$	Cost of Goods Sold includes costs associated with raw materials, bottling, packaging, inventory, labor, and related distribution costs at distribution center i in period t.
Cum Sales$_{it}$	Cumulative sales volume at distribution center i from the first period in 2007 until period t
No. Customer$_{it}$	The number of retail customers served by distribution center i in period t.
Sales$_{it}$	The number of cases sold from distribution center i in period t.
Onhand Inventory$_{it}$	The number of cases stocked in distribution center i at the beginning of period t.
OverForecast Error$_{it}$	The ratio of the difference between forecast demand one period in advance and actual order amount received by distribution center i in period t to the actual order amount.
Unit Price$_{it}$	The average price per case in dollars offered by distribution center i in period t.
Return Quantity$_{it}$	The number of cases returned by retailers to distribution center i in the period t.
Fill Rate$_{it}$	Measured by service level: the percentage of the number of cases filled compared to total cases ordered at distribution center i in period t.

4.3.2.1 Product Variety

The number of stock keeping units (SKUs) is a well-accepted measure of product variety (Alfaro and Corbett, 2003). Thus, product variety is measured by the number of SKUs sold by a distribution center.

4.3.2.2 Service Variety

In order to satisfy the requests from producers and demand from retailers, distributors need to provide a variety of services to facilitate product supply (Mudambi and Aggarwal, 2003). Thus, services are indispensable functions of distributors that deserve similar attention to the provision of physical products. Services offered by the distribution centers in the soft drink industry are primarily delivery options.

Variety of delivery methods includes Bulk, Dispatchable Bay, and Non-dispatchable Bay. Bulk delivery is normally offered to large retailer stores. Products are loaded onto trucks in pallets and unloaded to retail stores by pallet jacks. A bulk truck can carry up to 11 pallets on each delivery route from a distribution center. Sideload trucks are used for dispatchable and non-dispatchable bay deliveries. Products are delivered to retailers in cases and unloaded by two-wheel dollies. Pre-sold products, which are packed with the exact amount of products requested, are delivered via dispatchable bay, while non-dispatchable bay delivery allows products to be unloaded from a truck after a driver surveys each retail store on the route.

4.3.2.3 Demand

Order quantity of physical products received by distribution centers is used to measure the demands of retailers. $Order\ Quantity_{it}$ represents the order quantity received by distribution center during a period; namely the total number of cases received by distribution center i in period t in multiples of 10,000 cases. One case is defined as a pack of 24 12-ounce cans, so a 12-can pack is equal to 1/2 case in the dataset. Since the data only contain soft drink products packed in 12-ounce cans, no inconsistencies arise from cases with different container sizes.

4.3.2.4 Costs

Cost is measured by a well-known criterion: cost of goods sold (COGS), which includes costs associated with bottling, packaging, holding inventory, transportation, inbound logistics, and other distribution center operational activities. $COGS_{it}$ is calculated as the overall cost of the product cases sold at distribution center i in period t.

Table 4.2 provides descriptive statistics for the variables used in the analysis

Table 4.2 Descriptive Statistics for Variables

Variable	Min	Mean	Max	Std. Deviation
No. SKU_{it}	15	50.91	114	13.92
Delivery $Variety_{it}$	1	2.58	3	0.66
Order $Quantity_{it}$ (10,000 units)	0.01	11.16	103.36	12.02
$COGS_{it}$(10,000 dollars)	0.03	35.07	236.09	34.81
Cum $Sales_{it}$(10,000 units)	0.10	163.71	2237.29	212.65
No. $Customer_{it}$	79	6,324.49	20,908	4,690.46
$Sales_{it}$ (10,000 units)	0.02	8.31	78.62	9.12
Onhand $Inventory_{it}$ (10,000 units)	0.03	3.73	56.39	4.75
OverForecast $Error_{it}$	-1	-0.16	8.54	0.47
Return $Quantity_{it}$ (10,000 units)	0	0.37	12.64	0.49
Unit $Price_{it}$ (U.S. dollar)	5.86	7.38	20.77	1.46
Fill $Rate_{it}$	76.39	99.29	100	1.86

4.3.3 Model Development

In the literature, demand and costs are normally written as functions of product variety and/or service variety. Through these equations, researchers can capture the impact of variety. As stated in my hypotheses, however, demand and costs may also affect future decisions related to product and service variety (i.e., the reverse effect). Thus, the estimation of demand and cost equations, alone, will not capture the dynamic relationships among variety, demand, and costs. For this purpose, I model a simultaneous equation system consisting of four equations.

Equations (1) and (2) investigate the impact of product and service variety on demand and costs respectively. In both equations, independent variables include

No.SKU$_{it}$, *DeliveryVariety*$_{it}$, and their quadratic terms. Dummy variables are included for distribution centers (*LocDum*$_{ij}$ = 1 if i=j; 0 otherwise) to control for other unobserved variations in performance between distribution center locations (e.g., due to variances in areas served, distribution routes, and managerial ability), and for time differences across seasons and years (*YrSnDum*$_{kt}$ = 1 if period t belongs to the year-season k; 0 otherwise).

In addition, two control variable matrices U_{it} and V_{it} are included in Equations (1) and (2) respectively. U_{it} includes *UnitPrice*$_{it}$ (average price per unit), the fill rate from the previous period (*FillRate*$_{it-1}$), and the number of retail customers served by a distribution center (*No.Customer*$_{it}$), which is a proxy for the the size of the distribution center. V_{it} includes sales quantity at a distribution center (*Sales*$_{it}$), the on-hand inventory at the beginning of the period at a given distribution center (*OnhandInventory*$_{it}$), and the quantity of returns to the distribution center, *ReturnQuantity*$_{it}$. Furthermore, a variable that measures the over-forecast error one period in advance (*OverForecastError*$_{it}$), (negative values indicate demand was under-forecast) is included. This forecasting variable is able to capture exogenous factors, such as changes in the industry over time, competition between this firm and its competitors, and the life cycles of products, since all these factors are considered when demand planners forecast demand.

Equations (1) and (2) are provided below:

$$\begin{aligned} OrderQuantity_{it} = \alpha_0 &+ \alpha_1 No.SKU_{it} + \alpha_2 No.SKU_{it}^2 \\ &+ \alpha_3 DeliveryVariety_{it} + \alpha_4 DeliveryVariety_{it}^2 \\ &+ \sum_{j=1}^{107} \alpha_{5j} LocDum_{ij} + \sum_{k=1}^{11} \alpha_{6k} YrSnDum_{kt} + U_{it} A + \xi_{it} \end{aligned} \tag{1}$$

$$
\begin{aligned}
COGS_{it} = \beta_0 + \beta_1 No.SKU_{it} + \beta_2 No.SKU_{it}^2 \\
+ \beta_3 DeliveryVariety_{it} + \beta_4 DeliveryVariety_{it}^2 \\
+ \sum_{j=1}^{107} \beta_{5j} LocDum_{ij} + \sum_{k=1}^{11} \beta_{6k} YrSnDum_{kt} + V_{it}B + \upsilon_{it}
\end{aligned}
\tag{2}
$$

Equations (3) and (4) are used to capture the reverse influences of demand and costs on future variety decisions. The equations regress current product variety and service variety on current demand (*$OrderQuantity_{it}$*), as well as on costs and demand from the previous period and from one year (13 periods) previous (*$OrderQuantity_{it-1}$, $OrderQuantity_{it-13}$, $COGS_{it-1}$, $COGS_{it-13}$*). Since costs are only calculated at the end of a period, it is unlikely that current period costs will affect current variety decisions. Therefore, current costs are not included in the equations.

As I hypothesized, demand and costs may affect future product and service variety decisions. However, these influences may not be effective immediately, but may occur after a certain time lags. Since the company observed conducts performance reviews by the end of a period and a year, costs and demand in previous period and one year (13 periods) previous are included on the right hand side in both Equations (3) and (4). Equations (3) and (4) are outlined below:

$$
\begin{aligned}
No.SKU_{it} = \gamma_0 + \gamma_1 OrderQuantity_{it} + \gamma_2 OrderQuantity_{it-1} + \gamma_3 OrderQuantity_{it-13} \\
+ \gamma_4 COGS_{it-1} + \gamma_5 COGS_{it-13} \\
+ \sum_{j=1}^{107} \gamma_{6j} LocDum_{ij} + \sum_{k=1}^{11} \gamma_{7k} YrSnDum_{kt} + W_{it}C + \delta_{it}
\end{aligned}
\tag{3}
$$

$$
\begin{aligned}
DeliveryVariety_{it} = \theta_0 + \theta_1 OrderQuantity_{it} + \theta_2 OrderQuantity_{it-1} + \theta_3 OrderQuantity_{it-13} \\
+ \theta_4 COGS_{it-1} + \theta_5 COGS_{it-13} \\
+ \sum_{j=1}^{107} \theta_{6j} LocDum_{ij} + \sum_{k=1}^{11} \theta_{7k} YrSnDum_{kt} + Z_{it}D + \varepsilon_{it}
\end{aligned}
\tag{4}
$$

As was the case with Equations (1) and (2), dummy variables are included in Equation (3) and (4) to control for differences between distribution centers and over time. The control variable matrix in Equation (3), W_{it} , includes the cumulative sales volume at distribution center i from the first period in 2007 until period t ($CumSales_{it}$), which is used as a proxy for operational experience (Lapre and Tsikriktsis, 2006). In Equation (4), Z_{it} includes the experience index ($CumSales_{it}$) and the distribution center size index ($No.Customer_{it}$).

4.3.4 Model Estimation

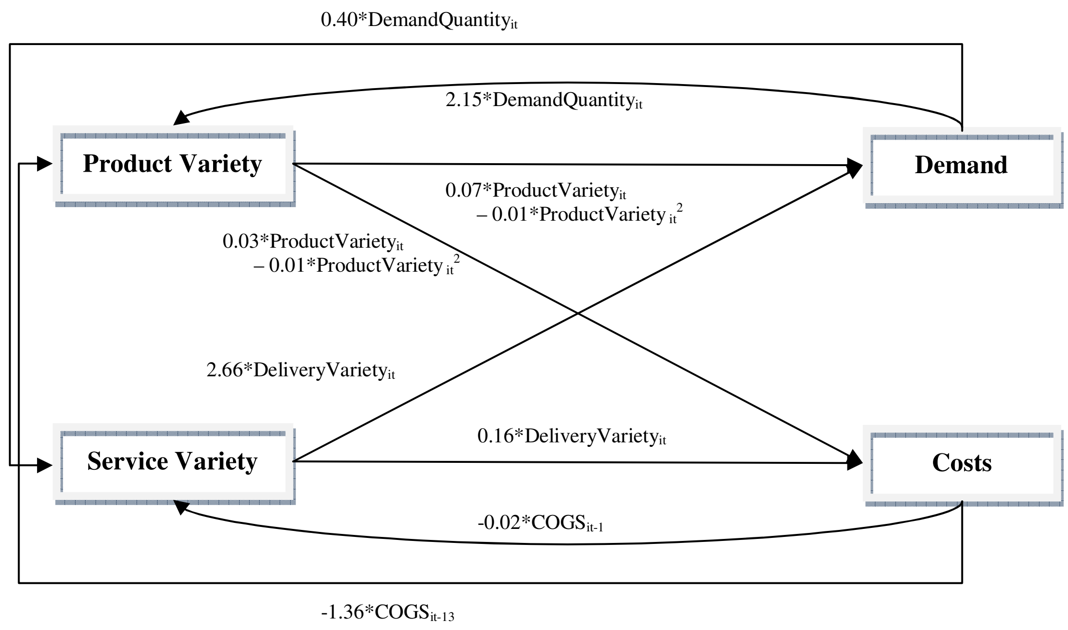
Each equation in our model includes fixed effects to address unobservable heterogeneity (operationalized by dummy variables) (Kalaignanam et al., 2007, Shane et al., 2006). Fixed effects for each period capture the impact of unobserved factors which change over time, such as average income, population, and events. In addition, they control factors, such as seasonality, economic conditions, and company policies. Fixed effects for distribution centers control time-invariant characteristics for the distribution centers, such as location and available storage space. Accounting for distribution center and time fixed effects helps control for unobserved heterogeneity across facilities and periods, which might otherwise affect stockouts and sales, and lead to biased estimates.

My model system includes four simultaneous equations for the following dependent variables: demand, cost, product variety and service variety. Since these four variables affect each other as stated in my hypotheses, correlations cross four equations may exist (Barry et al., 2006). I use a standard Breusch-Pagan Lagrange Multiplier (LM) method to test the null hypothesis of independent residuals across the equations (Barry, Kemerer and Slaughter, 2006, Kalaignanam, Shankar and Varadarajan, 2007). The result rejects the null hypothesis of independence across equations (χ^2=100.98, p<0.01). Thus, Three Stage Least Square (3SLS) is used to estimate the model.

Variance inflation factors (VIF) are calculated for each of the variables in order to determine if multicollinearity may be present. The VIFs are all found to be less than 7, thus implying that multicollinearity may not be a concern in my analysis.

Causal paths proposed by my hypotheses are summarized in Figure 4.2. Estimated coefficients and hypotheses test results are indicated on the corresponding paths.

Figure 4.2 Estimated Impacts of Variety on Demand and Costs and Their Reverse Influence on Variety Decisions



4.4 Results

4.4.1 Demand

The estimated results of the four-equation system are summarized in Table 4.3. In the demand equation, both the linear and quadratic terms for product variety are significant ($p<0.05$), and the coefficient is negative for the linear term and positive for the quadratic term. This result suggests that increases in product variety lead to increases in order quantity at a decreasing rate. Hypothesis 3.1a, hence, is supported.

The impact of service variety on demand is represented by the coefficients of linear and quadratic terms for delivery variety in the demand equation. The linear term for delivery variety has a positive and significant coefficient ($p<0.01$), while the coefficient for its quadratic term is not significant. Thus, Hypothesis 3.1b is partially supported. Service variety increases demand, but not necessarily at a decreasing rate.

In addition, the estimated price elasticity in this log-log demand equation is significant ($p<0.1$) and negative (-0.35). This is consistent with previous empirical research (Bayus and Putsis, 1999). Moreover, the absolute value of the price elasticity is less than 1. This result indicates that demand is inelastic to changes in price. The number of retail customers served by a distribution center is positively associated with its demand. The fill rate in the previous period does not affect retail order quantity.

Table 4.3 Estimated Results for Determinants and Influences of Product and Service Variety

Variable	Demand Equation	Cost Equation	Product Variety Equation	Service Variety Equation
No. SKU_{it}	0.07 ***	0.03 ***		
	(0.03)	(0.01)		
No. SKU_{it}^2	-0.01 **	-0.01 ***		
	(0.00)	(0.00)		
Delivery $Variety_{it}$	2.66 ***	0.16 ***		
	(0.25)	(0.06)		
Delivery $Variety_{it}^2$	0.42	-2.45		
	(0.62)	(2.08)		
Order $Quantity_{it}$			2.15 ***	0.40 ***
			(0.31)	(0.03)
Order $Quantity_{it-1}$			0.89	0.01
			(0.77)	(0.02)
Order $Quantity_{it-13}$			-0.46	0.01
			(0.72)	(0.02)
$Cogs_{it-1}$			-0.29	-0.02 ***
			(0.40)	(0.01)
$Cogs_{it-13}$			-1.36 **	-0.01
			(0.67)	(0.01)
Unit $Price_{it}$	-0.35 *			
	(0.18)			
Fill $Rate_{it-1}$	0.01			
	(0.01)			
No. $Customer_{it}$	0.17 **			0.11 ***
	(0.08)			(0.03)
Sales $Quantity_{it}$		0.90 ***		
		(0.02)		
Onhand $Inventory_{it}$		0.01 **		
		(0.00)		
OverForecast $Error_{it}$		-0.11 ***		
		(0.02)		
Return $Quantity_{it}$		0.01		
		(0.01)		
$CumSales_{it}$			17.23 ***	0.18 ***
			(1.94)	(0.05)
Constant	47.57 ***	32.23 ***	25.86 ***	-4.50
	(2.09)	(8. 57)	(3.41)	(3.22)
Distribution Center Dummies	Included in the model but not shown			
Year-Season Dummies	Included in the model but not shown			
R^2	0.81	0.78	0.93	0.85
χ^2 test statistic	10,681***	27,885***	20,788***	5,755***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Standard errors are reported in parenthesis.
Chi-Square test statistic indicates the rejection of the null hypothesis that all model coefficients are zero.

4.4.2 Costs

As the results of cost equation in Table 4.3 show, the estimation fully supports Hypothesis 3.2a and partially supports Hypothesis 3.2b. Both the linear and quadratic terms for the number of SKUs are significant ($p<0.01$), and the coefficient is positive for the linear term and negative for the quadratic term. Thus, product variety leads to increased costs at a decreasing rate. Service variety also increases costs ($p<0.01$). However, the nonlinear pattern of service variety's impact is not supported by the results. This may be due to the limited range in service variety in my data sample.

Other factors that affect costs are identified. The coefficient for overforecast error is significant ($p<0.01$) and negative. This result indicates that stockout costs due to less-than-forecasted demand are higher than holding costs due to over-forecasted demand. In addition, sales quantity, not surprisingly, increases costs ($p<0.01$), while Onhand inventory, also not surprisingly, raises costs ($p<0.05$). However, return quantity does not significantly increase costs. Since soft drink distributors use delivery vehicles to collect returned products after unloading new products, the logistics cost in the reverse supply chain may not be significantly affected by the quantity of returned products.

4.4.3 Variety Determinants

The results from the estimation of the product variety and service variety equations, as shown in Table 4.3, provide insight into the determinants of variety decisions. Particularly, my findings reveal the roles of demand and costs in the product and service variety decisions.

4.4.3.1 Product Variety

In the product variety equation, order quantity in the current period has a significant and positive ($p<0.01$) impact on product variety, while order quantity in the previous period and in from the period one year in the past do not significantly affect product variety. On the other hand, the coefficient of the cost variable in the previous period is not significant, but the costs from one year in the past have a negative and significant ($p<0.05$) impact on product variety.

The results suggest that both demand and cost have significant, but opposite influences on product variety decisions. In addition, their impact lead times are different. Only current period demand leads to increases in current product variety. The impact of cost results in product variety decisions one year later (Further explanation of this result is conducted in the Discussion section). Thus, Hypothesis 3.4a is supported, but Hypothesis 3.3a is not. The product variety decision at the distribution centers is a tradeoff between current demand and past costs.

Finally, the operational experience at a distribution center, as measured by cumulative sales quantity, positively ($p<0.01$) contributes to product variety ($p<0.01$). This result indicates that distribution centers with greater operational experience tend to be assigned higher product variety.

4.4.3.2 Service Variety

With regard to service variety decisions, current period demand has a significant and positive ($p<0.01$) impact on current service variety decision, while cost in the previous period has a downward ($p<0.01$) effect on service variety. Hence, Hypothesis 3.4b is supported, but Hypothesis 3.4a is not. Similar to product variety, the service variety decision is affected by both demand and cost in opposite directions and with different influence lead times. Demand affects service variety more immediately than do costs. Furthermore, the downward response of service variety to increase in costs appears to be quicker than for product variety decisions.

In addition to demand and cost, other service variety determinants are recognized. The experience of a distribution center and the number of retailers it serves are both positively ($p<0.01$) associated with service variety. In other word, distribution centers with more experience or those serving more customers tend to provide higher service variety than do other centers.

4.5 Discussion

4.5.1 Impact of Variety on Demand and Costs

Increases in product variety result in increases in demand (order quantity) at a decreasing rate. This result suggests that increased product variety likely results in variety-seeking behavior among customers leading to higher demand, but the positive impact of product variety on demand has a diminishing marginal increment. An increase in product variety, when variety is already high does not raise demand as much as an increase in product variety when it is at a low level. The decreasing rate may result from the cannibalization of existing products within the product space (Bayus and Putsis, 1999, Xia and Rajagopalan, 2009).

Similarly, increases in product variety lead to increases in costs but at a decreasing rate. The decreasing rate may result from economies of scope (Panzar and Willig, 1981). New products may be produced, stored, and transported based on common and recurrent uses of practices and physical assets. For example, when a new product is introduced at a soft drink bottler, the bottler does not need to completely replace its bottling process lines, warehouses, and logistics facilities, such as trucks, forklifts, and pallets). Thus, an increase in product variety increases variable costs but may not proportionately increase fixed costs.

Increases in service variety increase demand and costs as well. However, these relationships are linear. A potential reason for the insignificant quadratic terms for service variety may be the limited range of service variety in the soft drink industry (or at least in my dataset). Service variety is limited with a minimum value of 1 and a maximum value of 3. Thus, nonlinear impacts of service variety on demand and costs are not demonstrated in my results.

4.5.2 Impacts of Demand and Costs on Variety Decisions

Demand (order quantity) in the current period affects product and service variety, while the impact of costs on variety is delayed over a certain time. Furthermore, these impact time lags are different between product variety and service variety. These different lead times in the impacts of demand and costs on variety decisions may be explained by the operations at the distribution centers. Products are delivered to retailers usually two or three days after demand (orders) arrives. This time lag allows the distribution centers to make corresponding adjustments to product and service variety decisions. However, the cost information is only collected after products are delivered, and is not reviewed on a daily or weekly basis. Thus, the feedback impact of cost on variety decisions is slower than for demand. Moreover, the delivery decision for the next day is made at a distribution center every afternoon, while product variety decisions (included in orders placed by distribution centers with syrup producers) are made several weeks in advance. Thus, the impact lead time of costs on product variety is longer than it is for service variety.

4.6 Conclusions

In this essay, I propose a four-equation simultaneous model that considers variety decisions, demand, and costs to be jointly determined. By estimating this model, I capture dynamic relationships among the variables.

Major findings from this essay suggest that product and service variety is associated with high demand and high costs. The impacts on demand and costs from product variety are positive, but at a decreasing rate, while those from service variety are linearly positive. Furthermore, demand and cost outcomes both affect product variety and service variety decisions. Higher demand in the current time period leads to the provision of higher variety in products and services. However, the impacts of costs on product and service variety have time lags of one year and one period, respectively.

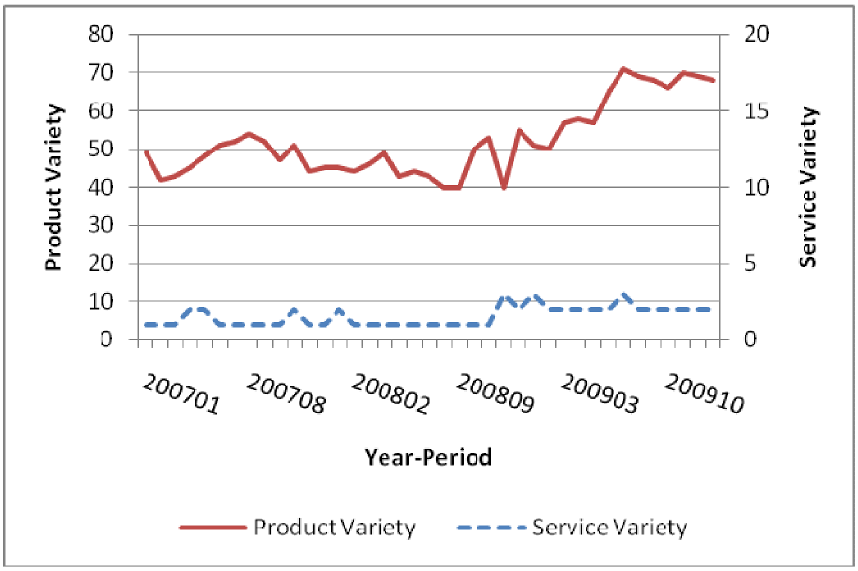
This research makes several major contributions to the literature. First, I extend the study in variety decisions from manufacturers and retailers to other intermediaries in the supply chain, namely distributers. It has been found that increased product variety (product lines) for manufacturers in the personal computer industry raises costs at an increasing rate (Bayus and Putsis, 1999). My empirical results suggest that their finding does not necessarily hold for distributors in the soft drink industry. This result indicates that the impact of costs from product variety may vary cross different firms at various levels in a supply chain. The difference may result from differences in cost structures. Product variety costs for manufacturers mainly arise from added complexity in product design and production, while product variety costs for distributors arise from inventory operations and logistics. This finding highlights the importance of studying logistics operations, which differs from traditional manufacturing operations.

Second, my finding indicates a positive incentive loop from adopting a variety strategy; that is, high variety leads to higher demand, which in turn leads to greater variety in the future. On the other hand, a negative influence loop is found: higher costs that result from variety discourage future variety decisions. These results paint a relatively more complete picture of variety influence than does existing research.

Third, a better understanding of impacts of variety decisions on demand and cost outcomes is provided by my empirical results. In addition to product variety, service variety is investigated in this essay in order to extend research in service operations. This work follows the suggestions of previous researchers to provide a new perspective in the consideration of service strategy (Boyer, Swink and Rosenzweig, 2005, Roth and Menor, 2003). I identify curvilinear effects from product variety and linear influences of service variety on demand and costs. Variety decisions for products are recognized as tradeoffs between demand and supply (cost) factors.

Fourth, my empirical results decode the tradeoffs between demand and costs in decisions concerning product and service variety. The impact time lags on variety decisions not only are different between demand and costs, but also vary across decision types: products and services. Furthermore, the impact of demand on variety is greater than the impact of costs over time. For example, Figure 4.3 demonstrates changes in product and service variety over time at a distribution center in Florida. The increasing pattern of the graph indicates that the upward impact on variety decisions from demand dominates the downward impact on variety from costs over time.

Figure 4.3 Product and Service Variety over Time in A Single Distribution Center



The results advance our understanding of the dynamic system that includes product variety, service variety, demand, and costs. The findings provide a number of implications for industrial practitioners: 1) Managers need a dynamic system-wide view to make product and service variety decisions. Considering the impact of variety on performance only, but ignoring the feedback impacts of performance on variety is incomplete. 2) It is necessary for managers to consider the feedback effects of demand and costs on variety decisions over different time frames. Regarding variety decisions, demand effects are faster than cost effects. Thus, managers may see the benefits from variety on demand before noticing the negative consequences from higher costs. I suggest that managers need to evaluate the outcomes of variety decisions on a relative long time basis, such as over a year. 3) My results suggest that product and service variety can be double-edged strategies. Higher variety not only attracts more demand but also results in higher costs. Thus, some production and operational approaches that increase variety at a relative low cost are recommended to practitioners, such as modularization, component sharing, and assembly postponement (Fisher, Ramdas and Ulrich, 1999, Heese and Swaminathan, 2006).

Chapter 5 Conclusions and Future Research

5.1 Main Results and Conclusions

In this dissertation, product and service variety and their impacts on distributors is studied through a series of empirical analyses. I build a framework that connects product variety, service variety, and performance (demand, sales, and costs) of distributor locations. Product and service variety simultaneously affect both demand and costs. The firm's demand and cost performance that results from product and service variety influences a firm's future variety decision. This dissertation models a dynamic system of product variety, service variety, demand, and costs for a distributor.

Chapter 2 investigates the direct and indirect impacts of product variety on sales. The results indicate that ignoring the indirect effect of product variety will result in a biased estimation of the overall impact of product variety on sales. In order to provide better suggestions to industrial practitioners, I not only analyze product variety at the SKU dimension, but also at the brand and pack-size dimensions. The results indicate that the impacts of product variety vary across different dimensions.

Service variety is introduced in Chapter 3 with a mediating model. The empirical findings contribute to the emerging service operations management research. Results suggest that service variety has direct impacts on service quality and sales performance and that these impacts vary across different types of services: order and delivery. Delivery variety is found to have a positive, direct relationship with service quality and market performance, while order variety has a positive direct impact on market performance, but not on service quality. Consistent with the literature, the findings indicate a significant and positive relationship between service quality and market performance. In addition, increased delivery variety is found to have an indirect effect on market performance. Service quality acts as a mediator between delivery service variety and market performance. Furthermore, this indirect effect is positively conditional on order variety. On the other hand, order variety does not have an indirect effect on market performance. The findings in this study draw attention to service variety in academic research and industrial practice.

A dynamic system consisting of product and service variety, demand, and costs is studied in Chapter 4. A four-equation simultaneous model is proposed to consider the joint determination of variety, demand, and costs. By estimating the model, I capture dynamic relationships including both the influence and determinants of product and service variety. Major findings in this essay suggest that product and service variety is associated with high demand and high costs. The impacts on demand and costs from product variety are positive at a decreasing rate, while those from service variety are linearly positive. Furthermore, demand and cost outcomes both affect product variety and service variety decisions. Higher demand in the current time period leads to higher variety in products and variety in the future. However, the impacts of costs on product and service variety have time lags of one year and one period, respectively.

5.2 Methodology Summary

In order to analyze various research questions, three different estimation methodologies are used in three essays, respectively. I study the direct and indirect impacts of product variety on sales performance in essay one (Chapter 2). These two impacts are proposed in opposite signs and the total impact is unclear. Furthermore, endogeneity issues need to be considered in the sales equation. Thus, two stage regressions are employed. Total impacts of product variety in three dimensions are calculated using estimated results of the two stage regression model.

The research in essay two (Chapter 3) is similar to that in essay one (Chapter 2). Both direct and indirect effects of service variety on market performance are investigated. However, these two effects both are positive in theory. Thus, I use a mediation model with three equations to test the mediating role of service level in the relationship between service variety and market performance. Two stage regressions are used in equations 2 and 3 to consider the endogeneity as well.

Four correlated relationships are examined in essay three (Chapter 4). They are the impacts of product and service variety on costs and demand performance, as well as the influences of current costs and demand performance on future variety decisions in products and services. Since the statistic test does not reject the null hypotheses of independence cross the four equations in the model, it is not proper to estimate these four impacts (in four equations) respectively. Thus, Three Stage Least Square (3SLS) are used to estimate this correlated model system.

5.3 Future Research

In this dissertation, I contribute to the literature by analyzing product and service variety and their impacts on a distributor in the soft drink industry. Future research may be extended to other industries or multiple product categories.

It is interesting to extend the focus on variety from distributors to retailers. Retailers may face much more product variety than distributors. Products in retailers may include multiple categories and industries, such as foods, stationary, and electronics. Furthermore, demand responses to product variety for retailers are more sensitive than for distributors, because retailers face individual demand whereas distributors receive aggregate demand. Thus, the impacts of variety on retailer performance are expected to be different from those found in this study on distributors.

Quality management associated with product variety may be an interesting follow-up study. Product quality has been well studied as a key factor to balance costs and sales. In the existing literature, quality is normally analyzed under a single product framework. Introducing product variety to the quality management decision may extend existing research using a single product framework to a multiple product system.

Product variety is a result of the balance between new product introductions and the removal of non-performing products from the market. For example, in the soft drink industry, a producer increases the number of products by continuously introducing new products. However, retailers and distributors remove products with low sales performance from their shelves. Future research can be conducted to jointly consider the dynamic balance between product innovation and product removal, through which researchers and industry practitioners can obtain insight into product variety management.

Another promising field is the consideration of product and service variety management from a supply chain perspective. A supply chain consists of producers, distributors, retailers, and customers, each of which plays a different role in the determination of variety. A producer is normally the executor of variety decisions, but it is not necessarily the initiator. The pressure on producers for introducing high product variety may be from any member in a supply chain, such as retailers, consumers, and distributors. A joint analysis of the impact of variety on multiple entities in a supply chain can provide a better understanding of the motivation, implementation, and dynamic adjustment of product and service variety decisions in a supply chain.

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