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POM AND RETAILING

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1 Introduction

The retailing sector is an important part of the economy of both developed and developing countries. In the U.S. economy, retail businesses (excluding motor vehicles and spare parts) represented $3.6 trillion in sales in 2014, contributed 5.8% to GDP, carried $366 billion in inventory, and provided direct employment to 15.6 million workers. E-commerce sales have been steadily growing faster than sales in brick-and-mortar stores. They have increased as a fraction of total retail sales from less than 0.2% in 1998 to 6.44% in 2014. The U.S. Bureau of Labor Statistics predicts that employment in retail is projected to grow at 7% per year between 2012–2022. The inventory productivity of retailers has improved over time; aggregate inventory turnover increased from 5.15 in 1994 to 6.87 in 2014. (We compile these statistics using data from Bureau of Economic Analysis (2016), Bureau of Labor Statistics (2016), and U.S. Census Bureau (2016).)

Retailing is a dynamic sector, affected by many different types of factors, such as the growth of online and mobile retailing, supply chain innovations such as Radio Frequency Identification (RFID) technology, regulatory changes in global trade such as the Multi Fibre Arrangement, developments in the digital technology industry, as well as concerns around worker safety, product contamination, quality enforcement, and fair trade. Retailing is conducted through a wide range of platforms used in different countries. These include kirana stores and kiosks in India and nanostores in Central and South America (which are millions of very small, family-owned and-operated stores); marketplaces such as Etsy (www.etsy.com) and Amazon marketplace; rental models (www.renttherunway.com/); pop-up stores (www.shopify.com/guides/ultimate-guide-to-pop-up-shops); and virtual stores (www.wpp.com/wpp/press/2012/oct/19/ecommerce-grocer-yihaodian-opens-stores-overnight/; see also Chapter 34 in this book).

The discipline of POM has contributed to the development of many aspects of retailing, such as inventory management, supply chain coordination, warehousing and logistics, revenue management, store operations, and customer service. Current research is seeking to address challenges such as omnichannel integration, sustainability, workforce management, and many problems at the interfaces of operations with finance and marketing. In this chapter, we first describe the past history of research and development in retailing, then characterize the state of retailing research and practice today, and finally make projections for future research and practice. Since
retailing is a vast industry, it intersects with many topics in operations management, including supply chain management, services operations, operations-marketing interface, revenue management, and operations-finance interface. Our goal in this chapter is not to be comprehensive but to highlight those areas of research that have influenced the retailing industry (e.g., vendor-managed inventory) or are unique to retailing (e.g., assortment planning, shelf-space allocation, store execution). We also refer the reader to related contents in Chapter 6 on inventory management, Chapter 20 on POM and Marketing, and Chapter 34 on best practices in e-commerce supply chain management in this book.

2 A Historical Perspective of Research in Retail Operations

We classify the existing research in retail operations into inventory management, retail supply chains, customer service, pricing and clearance markdowns, shelf space management, assortment planning, and financial performance of retailing firms.

2.1 Inventory Management

Inventory management in retailing faces many challenges. One of these challenges is a proliferation in the amount of variety that retailers provide to customers. Variety makes it harder to forecast demand, plan inventory, manage shelf space and distribution centers, and manage relationships with suppliers. It also creates diseconomies of scale and scope, which increase cost and decrease profitability. Along with an increase in variety, retailers face a high incidence of stockouts and their attendant costs as shown by Corsten and Gruen (2003). These challenges have fueled research and the retailing industry has benefited from the vast advancements in inventory theory. In this section, we describe recent research on inventory management done in the context of retailing firms. The reader is referred to excellent books by Porteus (2002) and Zipkin (2000) for an in-depth treatment of inventory theory.

Inventory data in retailing at the store-SKU level is often inaccurate. Even when data is accurate, inventory gets misplaced in stores with surprising frequency. These two important problems, discovered by Raman et al. (2001), have wide-ranging implications for the usefulness of point-of-sale (POS) and inventory data for demand forecasting and inventory planning. They impose a high cost on the financial performance of retailers. They also highlight the importance of store execution and workforce management. Significantly, these problems are common across large and technologically advanced retailers. DeHoratius and Raman (2008) studied the drivers of discrepancies between system data and physical counts in stores in a retail chain and showed that inventory data inaccuracy occurs due to many factors including replenishment and sales processes in stores and distribution centers, store design, and variety. Researchers have designed new replenishment algorithms that address inaccuracy in inventory data (Kök and Shang 2007; DeHoratius et al. 2008). The management of inventory in retail stores is also exemplified by a case study on Wawa, a convenience store chain, by Krishnan and Fisher (2005). The case study shows that retail store inventory management is a complex task requiring process design, training, incentive alignment, and process discipline.

RFID technology holds the promise of reducing inventory data inaccuracy and misplaced SKUs. It can streamline processes in supply chains, improve labor productivity, bring about supply chain transparency, and improve in-store product availability. Research articles that have explored the value of RFID include Camadereli and Swaminathan (2010), Dutta et al. (2007), Gaukler et al. (2007), Hardgrave et al. (2013), and Lee and Ozer (2007). These papers have studied the value that RFID holds for retailers and manufacturers as well as mechanisms for sharing
the costs of RFID. Gupta et al. (2009) conduct an extensive review of research on RFID and present directions for future research. They classify RFID research into two categories: research on the business value of RFID and that on the adoption and implementation of RFID. Large retail chains have experimented with the application of RFID in their supply chains. Ton et al. (2005) present a case study describing a pilot project at Metro Group, a large supermarket chain based in Germany, to implement pallet-level and case-level RFID with a subset of suppliers in some of its distribution centers.

Another topic that has received attention in the literature is store-level inventory management. Several researchers have studied decision models for the management of perishable inventory in retail stores (for example, Ketzenberg and Ferguson 2008; Ketzenberg et al. 2015; and Li et al. 2012). Akkas et al. (2016) measure the occurrence of product expiration in stores and identify its causes related to store execution, supply chain aging, and product characteristics such as case pack size and shelf life. Inventory management in vending machines has been studied by Ketzenberg et al. (2013). Van Donselaar et al. (2010) study the ordering behavior of retail store managers and discover that store managers deviate systematically from an automated replenishment system implemented in the store chain. Using inventory shipment and sales transaction data for several stores in a supermarket chain, they find that store managers prefer to change order quantities in the system to order slow-moving and large case pack items on the lean days of the week, which yields better use of labor time on lean days for replenishing shelves, so that attention can be focused on customer service on peak days. Their findings suggest gaps in the design of automated inventory replenishment systems.

Many researchers have focused attention on the inventory management of short lifecycle, seasonal, and fashion products. The length of selling season of such products typically ranges from a few weeks to less than six months. Thus, there is limited opportunity for inventory replenishment. Moreover, since the products are new, there is no historical demand information available to apply time series forecasting methods. The research on improving the profitability of such products has focused on developing new demand forecasting tools and quick response capability so that a retailer can create more accurate forecasts, update their forecasts as information is revealed, and replenish merchandise in the middle of a selling season. Murray and Silver (1966) and Hausman and Peterson (1972) were some of the early papers to study decision models for this problem, and Abernathy et al. (1999) conduct a field study of quick response capability in the apparel industry. Fisher and Raman (1996) present a multi-product model of capacitated production and inventory management for seasonal products and report results from a pilot project at a skiwear manufacturer. Key ideas in this paper are that early demand is an accurate predictor of demand in the rest of the season and that the standard deviation of forecasts issued by a panel of experts is a good measure of the demand uncertainty of an underlying product. Eppen and Iyer (1997a) present a Bayesian forecasting method that combines historical data and buyer judgment to update the demand forecast for a short lifecycle or fashion product and apply it for inventory management.

Many innovative methods for managing short lifecycle products have been studied in the literature, including backup agreements (Eppen and Iyer 1997b), reactive capacity (Raman and Kim 2002), and risk sharing and contracting with suppliers (Donohue 2000; Barnes-Schuster et al. 2002). Researchers have also conducted applied research on this topic (Fisher and Raman 1996; Caro and Gallien 2010). For example, Caro and Gallien (2010) describe work done in collaboration with the Spanish fast fashion retailer, Zara, focusing on the problem of allocating limited inventory over time from a centralized fulfillment center (or distribution center) to retail stores inventory. The authors conduct a pilot test of their algorithm at Zara. A key feature of their model is to incorporate the effect of broken sizes on demand. The problem of broken
sizes occurs when a product is in-stock in some sizes and out-of-stock in others. For instance, a style of shirts may be available in Small and Extra-Large but stocked out in Medium and Large. Retailers prefer to remove such products from display to avoid customer dissatisfaction over not finding their sizes.

Researchers have also looked at methods for modeling and forecasting demand for short life-cycle products. Agrawal and Smith (1998) show that retail demand is represented well by a negative binomial distribution. Haksöz and Seshadri (2004) develop a sequential monotone likelihood ratio property for Bayesian updating of demand distributions that are stochastically increasing in early demand observations. Gaur et al. (2007) show using sales forecast data from equity analysts that the dispersion among experts’ forecasts is useful as a metric to calibrate the uncertainty in the underlying sales. Gaur et al. (2013) show that stock market index returns contain information that can be useful for forecasting retail demand because demand for different types of retail firms is correlated with market indices to different degrees. Inventory management in retailing is also connected with supply chain coordination and pricing, which we discuss in subsequent sections.

2.2 Retail Supply Chains

There is a vast amount of literature on supply chain management that has led to improvements in the retailing industry. We briefly discuss this literature from the point of view of its impact on retailing.

The literature on the bullwhip effect identified practices in the industry that lead to poor performance of retailers and their suppliers (Lee et al. 1997). As a result, many programs have been implemented at consumer packaged goods companies and large retailers to improve supply chain coordination through methods such as forecast sharing, collaborating decision making, and vendor managed inventory. Researchers have documented these programs and their impact at Campbell Soup (Cachon and Fisher 1997), Barilla SpA (Hammond 1994), Proctor & Gamble (Sebenius and Knebel 2007), and other firms. Research in POM has also shown that information sharing in supply chains is valuable to both retailers and suppliers. For instance, Cachon and Fisher (2000) showed that sharing demand and inventory information enables a supplier to postpone the decision of allocating inventory across a network of stores, therefore enabling an improvement in the efficiency of inventory allocation. Subsequent research in this area has looked at the feasibility and implications of information sharing in different competitive settings, when a retailer is served by competing manufacturers as well as when a manufacturer supplies to competing retailers.

There are many methods that retailers can use to manage inventory in their supply networks. Researchers have studied pooling of inventory (Eppen 1979), transshipment (Robinson 1990), and fast shipments (Chen et al. 2016). DeHoratius and Raman (2007) examine the effect of store manager incentives with respect to sales performance and inventory shrinkage on the profitability of retail stores. Their study is based on data from a consumer electronics retail chain. Narayanan and Raman (2004) present a framework for aligning incentives in retail supply chains. They characterize the roles of hidden information, hidden actions, and badly designed incentives and then present methods to mitigate these problems. Finally, there is a vast amount of literature on coordination in decentralized supply chains, which has implications for retailing (Cachon 2003; Chen 2003). Researchers have also studied supply chain coordination and competition in the context of introduction of online channels (Cattani et al. 2006).

Although considerable research has been conducted in this area and there have been significant advancements in supply chain practice, supply chain coordination continues to remain a vexing problem for many retailers and their suppliers. This could be caused by the increasing...
complexity of supply chains, which requires scholars and practitioners to constantly remain one step ahead. Additionally, online retailing is transforming backend supply chains. Manufacturers that sell to Amazon.com experience different seasonality patterns of demand and information lead times than manufacturers that sell through traditional retail relationships. Coordination in the era of Amazon.com remains an exciting and open area of research.

2.3 Customer Service

Product availability and stockouts are a measure of customer service. Corsten and Gruen (2003) study the occurrence and implications of stockouts using data collected from CPG firms and supermarket chains in several countries. They show that stockouts occur frequently and are caused by reasons related to supply chain as well as retail store execution. Furthermore, customers who experience stockouts react in a variety of ways. They may substitute a different item, postpone the purchase, abandon the entire shopping cart, or even switch to a different store for their future shopping needs.

The implications of stockouts have been studied in different types of theoretical models. Balakrishnan et al. (2004) analyze a phenomenon called “stack them high, let them fly,” in which the rate of demand occurrence is a function of the amount of inventory stocked by the retailer. The higher the inventory, the higher the demand rate. Their analysis uses a generalization of the EOQ model. A different approach is to model individual consumer behavior in which consumers choose which retailer to visit based on their expectations of service level provided by the retailer. Dana and Petruzzi (2001) analyze a rational expectations equilibrium between consumers and a retailer and determine the optimal inventory level for a retailer when consumers are sensitive to product availability. Bernstein and Federgruen (2004) consider a game-theoretic model in which retailers compete in the marketplace on their service levels and customers choose which retailer to visit based on their expectations of finding the product in stock at the retailer. In many situations, customers are unaware of the service levels provided by competing retailers, and they learn over time from past experiences, which then affects their future store visits. Gaur and Park (2007) study the implications of consumer learning on market shares and stocking levels of retailers competing in the marketplace.

Stockouts also lead to spillover demand, i.e., the demand in excess of the available inventory. Netessine and Rudi (2003) study a multi-item setting in which the spillover demand for an item is allocated to the other items. They analyze both centralized and decentralized optimal stocking decisions in this setting. Bassok et al. (1999) study inventory decisions for the practice of downward substitution, in which a retailer substitutes a higher-quality and higher-price product to meet excess demand for lower quality-lower price products. Finally, stockouts play a very critical role in assortment planning models. We discuss this implication of stockouts in Section 2.6.

2.4 Pricing and Clearance Markdowns

Department store markdowns soared from less than 5% of total sales in 1970 to more than 20% of total sales in 1997 according to data collected by the National Retail Federation (Fisher and Raman 2010: chapter 1). Thus, there has been considerable research in improving the management of markdowns in retailing. Gallego and van Ryzin (1994) develop an optimal markdown policy when demand follows a price-dependent Poisson process. Smith and Achabal (1998) present a model of a seasonal product in which the demand rate is an increasing function of the amount of inventory available. They develop an optimal markdown trajectory as a function of the remaining length of season and the amount of leftover inventory and test its performance
at three major retail chains. Caro and Gallien (2012) develop a method for deciding clearance markdowns in a network of retail stores with varying demand rates and inventory availabilities and apply their method to the Spanish retail chain, Zara.

Recent researchers have also investigated the phenomenon that anticipation of markdowns can motivate consumers to behave strategically and wait for a better deal rather than purchasing immediately. Many approaches to manage strategic consumer behavior have been studied in the literature. Aviv and Pazgal (1998) show that when consumers are forward-looking, it may be optimal for a retailer to pre-commit to a price path. Cachon and Swinney (2009) show that quick response capability is more valuable to a retailer when consumers behave strategically, and Osadchiy and Vulcano (2010) analyze the implications of binding reservations.

### 2.5 Shelf Space Management

The productivity of shelf space is important for the profitability of a retailer. According to the 2007 U.S. Economic Census, there were 1,122,703 retail establishments in the United States and a total of 14.2 billion square feet of retail space. As reported by Farfan (2014), the amount of shelf space availability varies across countries: There was approximately 46.6 square feet of retail space per capita in the U.S. in 2007, two square feet per capita in India, 1.5 square feet per capita in Mexico, 23 square feet per capita in the United Kingdom, 13 square feet per capita in Canada, and 6.5 square feet per capita in Australia. Thus, retailers make large investment in shelf space, and a key decision is to allocate available shelf space among products.

The shelf-space allocation problem has a long history of research. One of the seminal papers in this area comes from Corstjens and Doyle (1981), who present a model in which products compete for limited shelf space but their demand is sensitive to the amount of shelf space allocated to each product. Cachon (2001) analyzes a model of joint optimization of retail shelf space, inventory, and transportation. Kök and Fisher (2007) incorporate shelf space constraints in an assortment planning problem. Competition for shelf space among manufacturers has also been studied in the literature. Martinez-de-Albeniz and Roels (2011) examine competition among manufacturers for retail shelf space. In their model, a retailer makes shelf space allocation decisions, and competing manufacturers make pricing decisions. They find that the incentives of retailers and manufacturers are misaligned, leading to suboptimal prices and shelf space allocations.

Shelf space allocation not only has demand implications, but it also has cost implications because the amount of shelf space allocated to a product limits the inventory of that product that the store can carry. For a slow-moving item with ample shelf space, this can increase inventory holding costs and product expiration. For a fast-moving product with limited shelf space, it can lead to stockouts and increased transportation cost. Van Donselaar et al. (2010) show that shelf space allocation has implications for the type of ordering policy followed by a retail store. Akkas et al. (2016) show that shelf space availability is related to the amount of product expiration. The cost implications of shelf space have not been fully studied in the literature and provide opportunities for future research.

### 2.6 Assortment Planning

Assortment planning can be defined as the decision of selecting which items to stock in a product category from a given set of possibilities and what product categories to carry in a retail store in order to maximize expected profit. Items within a category are typically substitutes, whereas items across categories are complements, e.g., chips and salsa or bread and jam. There has been a vast amount of theoretical and applied research on assortment planning in the past two decades.
Most of the papers in this area focus on assortment planning within a category. Researchers have also studied the problem of category management, although to a lesser degree. Kök et al. (2009) conduct a comprehensive review of the literature on assortment planning. We provide a brief summary of the main topics of research in this area.

Researchers have developed methods to decide the assortment for different types of customer choice behavior. Van Ryzin and Mahajan (1999) focus on the multinomial logit choice model, Smith and Agrawal (2000) use a model in which substitution rates are specified for different pairs of products, Gaur and Honhon (2006) focus on an attribute-based locational choice model, Cachon et al. (2005) incorporate consumer search in assortment planning, and Hopp and Xu (2005) study joint pricing and assortment planning decisions. Researchers have also extensively studied models of stockout-based substitution in assortment planning and developed heuristics and algorithms for different formulations of this problem. Work done in this area includes Mahajan and van Ryzin (2001), Kök and Fisher (2007), Goyal et al. (2016), and Honhon et al. (2010) as well as many other papers. An innovative problem studied by many researchers is that of dynamic assortment planning, in which a retailer changes the assortment over time and uses realized sales to learn about consumer demand. Research papers on this problem include Bernstein et al. (2015), Caro and Gallien (2007), Chen and Plambeck (2008), and Ulu et al. (2012).

Research in assortment planning has had a significant impact on practice. Such application involves the related problems of estimating demand and optimizing the product assortment. Anupindi et al. (1998) present a method to estimate demand rates and substitution parameters from censored demand data. This problem is complex because stockouts induce substitution, which changes demand rates of products over time. Musalem et al. (2010) also utilize similar data, and develop a method to estimate the parameters of a random utility model. The advantage of this approach is that the utility model is more parsimonious. Kök and Fisher (2007) estimate a multinomial logit choice model using data from a supermarket chain and conduct a pilot test of assortment planning. Fisher and Vaidyanathan (2012) study an interesting problem of localization of assortment. Using demand data for different subsets of products stocked in different stores, they estimate an attribute-based choice model and present a method to localize assortments to the demand characteristics in each store. Lee et al. (2016) apply choice estimation to data from a bookstore and conduct a controlled field experiment to evaluate the resulting improvement in stocking decisions and realized profit.

While all of the above papers deal with assortment planning for a category of substitutable products, a few research papers have studied the problem of planning assortments across several related product categories. A challenge in this problem is that the choice models for basket shopping consumers across a category of products are fairly complex. Cachon and Kök (2007) and Chong et al. (2001) are two research papers that propose choice models and analyze assortment planning for this problem. Category management has also been studied from the perspective of coordination between retailers and manufacturers, who may serve as category captains (Kurtuluş and Nakkas 2011). Assortment planning remains an area of vigorous research in different methods and applications. Recent research in assortment planning has looked at consumer behavior across brick-and-mortar and online channels (Dzyabura and Jagabathula 2016).

### 2.7 Financial Performance of Retailing Firms

Research in retailing is exciting, not only for the large variety of operational challenges faced by retailers, but also because data for retailers is readily available to assess their financial performance. Stock market investors and analysts closely watch many types of performance metrics used by retailers. These include inventory levels and write-downs, opening and closing of new stores,
store traffic, comparable stores sales growth rate, profit margins, use of markdowns, and lifecycles of retail brands from growth to maturity and potential decline. In turn, retail managers can quickly assess the financial implications of their decisions by observing these same variables at a more detailed level across product categories, stores, or buyers.

Considerable research has been done on the inventory productivity of retailers. Inventory is linked to the financial performance of retailers because it provides signals for future performance and can be a source of information asymmetry between retailers and their investors regarding past performance (Gaur et al. 2014). Thus, research has addressed questions such as (i) what are the drivers of inventory productivity in retailing, (ii) how does inventory productivity of retail firms impact their earnings and stock returns, and (iii) do high- and low-inventory turnover retailers differ in the ways in which they manage demand uncertainty.

Specifically, Gaur et al. (2005) show that inventory turnover of retailing firms varies widely over time as well as across firms within retail business categories or segments. They propose a metric, adjusted inventory turnover, to measure performance changes by adjusting inventory turnover for correlations with contemporaneous gross margin, capital intensity, and sales surprise (i.e., the ratio of actual sales to forecast). For instance, a retailer that increases its inventory turnover while improving its gross margin or achieving a positive sales surprise would have performed better than another retailer that increases its inventory turnover with a deterioration in gross margin. Kesavan et al. (2010) devise a method to include historical inventory and gross margin data in time-series sales forecasting methods. Their work discovers that stock market analysts are biased because they do not pay adequate attention to abnormal inventory. Alan et al. (2014) and Kesavan and Mani (2013) take the next step in this research and show that inventory productivity and abnormal inventory of retailers are predictors of future stock returns and earnings. Finally, Kesavan et al. (2015) analyze the ability of high- and low-inventory turnover retailers (HIT and LIT, respectively) to manage demand uncertainty. They show that these two types of retailers respond differently to uncertainty; HIT retailers predominantly respond by adjusting their inventory levels (quantity response), whereas LIT retailers respond mainly by adjusting their prices (price response). Moreover, LIT retailers take longer lead time to incorporate new demand information in their inventory planning and are forced to make larger adjustments. As a result, the financial performance of LIT retailers is much more sensitive to abnormal inventory than that of HIT retailers.

Retailers can open and close stores at a rapid rate. An interesting problem created by store closings is that of liquidating inventory and managing a going-out-of-business sale. Craig et al. (2014) document the industry practice of inventory-based lending or asset-based lending, in which a retailer obtains a low-cost bank loan by using its inventory as collateral. Craig and Raman (2016) show that store liquidation has unique characteristics compared to end-of-season markdowns. They analyze data from a retailing firm and an inventory liquidation firm to assess the drivers of profitability in a store liquidation and develop an algorithm to optimize markdowns and transshipment of inventory across stores in order to maximize the total revenue generated from the sale.

3 Present Situation

The retailing industry is rapidly experiencing a transformation through several forces. In recent years, new research has emerged in retailing in store execution and workforce management as well as in online and omnichannel retailing. We discuss ongoing research in these developing areas as below.
3.1 Store Execution and Workforce Management

Fisher (2004) noted that a retail store performs both factory and sales functions. Several research articles and case studies have focused on problems in store execution and workforce management. Access to in-store data has encouraged research in this area. This research has led to an impact on practice as well as the discovery of new problems. One of these problems is that of assessing the impact of labor staffing on sales in retail stores (Fisher and Raman 2010: chapter 6). On the one hand, an increase in staffing is beneficial for better customer service, increased sales, and higher market share. On the other hand, staffing is expensive and requires the retailer to consider many factors, such as projections of store traffic and the mix of labor between full-time, part-time, and temporary workers. Perdikaki et al. (2012) use store traffic, labor staffing, and point-of-sale data from a retail chain to study the effect of traffic and staffing on characteristics of sales performance, such as customer conversion and basket value. Kesavan et al. (2014) use similar data to study the effect of labor mix, i.e., number of full-time, part-time, and temporary workers, on sales and profit. Mani et al. (2015) apply hourly data on store traffic, sales, and staffing in a mathematical model to identify time periods when retail stores are understaffed and measure the resulting impact on retail sales.

Solving a staffing problem also requires a retailer to estimate the elasticity of sales to additional staffing. This estimation problem is challenging due to endogeneity (i.e., staffing is planned in anticipation of sales) and data aggregation (i.e., retail store data are often too aggregated to observe cause and effect). Technology is coming to the rescue of POM researchers wanting to overcome this challenge. A wide variety of data from store traffic counters, video recordings, location sensing technology, and heat mapping are now available to measure how customers experience a retail store and interact with store employees. Researchers can employ these data to construct decision-support tools for retail store managers. For instance, Lu et al. (2013) combine video recognition data from retail stores with point-of-sale data to study the effect of waiting in queue on purchases. Digital snapshots were collected at the deli section of a supermarket and were analyzed by image recognition technology to track the number of customers waiting in line and the number of sales associates staffing the deli. This area offers rich opportunities for future research.

3.2 Online and Omnichannel Retailing

Online retailing is an important part of the retailing industry today. Between 2005 to 2015, online retail sales grew at a compounded annual growth rate of 14.1% whereas total retail sales (excluding motor vehicles and spare parts) grew at 2.9% per year. Thus, about one-third of the total growth in retail sales in the U.S. over the past ten years has occurred online. Amazon.com, a purely online retailer, is now among the ten largest companies in the U.S. by market capitalization. Brick-and-mortar retailers have also invested aggressively in expanding their online channels and in omnichannel retailing, i.e., a seamless integration of online and brick-and-mortar retail channels.

It is helpful to classify new research in this area into three types of topics: (i) supply chain fulfillment for online and omnichannel retailing, (ii) customer experience, and (iii) merchandising. We are beginning to see research on supply chain fulfillment. Whereas in a brick-and-mortar store, a customer visits a store to purchase a product, an online retailer has a network of fulfillment centers and can choose where to ship a product from to fulfill a customer’s order. This decision can be based on several considerations, such as the transportation costs from the fulfillment centers to the customer, available inventory at the fulfillment centers, and whether
it is a multi-item or a single-item order. Acimovic and Graves (2015) devise a heuristic to make fulfillment decisions by minimizing the sum of immediate and expected future fulfillment costs, and conduct a pilot test for an online retailer. Gallino and Moreno (2014) study the effect of supply chain fulfillment choices on the occurrence of demand. They consider the capability of buy-online-pickup-in-store (called BOPS or BOPUS) in the brick-and-mortar stores of a large retail chain. Using an interesting data set consisting of point-of-sale transactions from retail stores and the online channel of the chain, they apply a difference-in-difference method to compare the effect of introducing BOPS on sales in both channels. Interestingly, they find that introduction of this feature led to a reduction in online sales but an increase in store sales and traffic. Gao and Su (2016) conduct a theoretical analysis of the impact of BOPS on store operations. They show that although BOPS expands the market size for a retailer, not all products are well suited for BOPS.

The topic of customer experience has also been studied in a few recent papers. One aspect of customer experience is the practice of showroming, in which customers receive information from stores and fulfillment takes place online. The concept of showroming is illustrated by Warby Parker, an online eyewear retailer that opened brick-and-mortar showrooms in select markets to allow consumers to select products before placing their orders online. Warby Parker’s showrooms carry only display inventory, and merchandise is stored in online fulfillment centers and shipped directly to customers’ homes. Bell et al. (2014) study the effect of showroming on the sales and profits of Warby Parker. They find that showroming enabled the retailer to better match its channels with customer needs, thus reducing the occurrence of product returns, and increasing sales. Balakrishnan et al. (2014) analyze the implications of showroming in a mathematical model of competition between a brick-and-mortar retailer and an internet retailer in which customers are heterogeneous and have uncertain valuations of the product.

The topic of online merchandising has been relatively less well studied. Dzyabura and Jagabathula (2016) propose a new consumer choice and assortment planning model that incorporates differences in choice behavior in stores and online. They test their model in controlled laboratory experiments and determine the optimal assortment of products that a retailer should carry online and in store to maximize its profits. This research is a promising start. New modeling and empirical research is needed in this area to help guide retailers in their merchandising decisions.

Online retailing provides opportunities to design new business models and to apply optimization and machine learning approaches to solve problems faced by retailers. Belavina et al. (2016) study the implications of revenue models for online groceries retailing for total sales, delivery cost, and food waste. They show that per-order payment model and subscription-based payment model fit different types of retailing depending on profit margins and geographic and demographic patterns. Ferreira et al. (2016) apply machine learning to historical sales data at an online retailer, Rue La La, in order to predict demand and set prices for products that the retailer has never sold before. They implement their algorithm as a decision support tool for the retailer and conduct field experiments to assess its performance. Acimovic and Graves (2015), discussed earlier in this section, is also an example of real-time optimization applied to online order fulfillment processes.

## 4 Directions for Future Research

Retailing is rich with opportunities for future POM research and application. In this section, we make five projections of important research directions in this industry.

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4.1 Availability of Individual Customer-Level High-Frequency Data Will Drive Research in New Decision Models and Experiments

There are many kinds of data available in retailing: in-store data regarding point-of-sale transactions, customer behavior, store and workforce characteristics, fulfillment, and marketing and promotions; online shopping and clickstream data; public data about retailers; and macroeconomic, weather, and competitive data. Often, these data sets can be combined with each other to create informative decision models. These types of data are enabling researchers to apply analytical methods to retail decisions in new and innovative ways, as shown by Ferreira et al. (2016) in applying machine learning for demand forecasting and pricing at an online retailer, Kesavan et al. (2014) and Lu et al. (2013) for workforce management in a retail store, and Archak et al. (2011) for the analysis of online customer reviews.

The ready availability of data and the ability to make frequent changes also makes it possible to conduct field experiments in retail firms. Retailers frequently conduct experiments in their stores to test new merchandise, assess the design of store layouts, and test prices. However, these experiments used to be costly and often unreliable (Fisher et al. 2000). The design of experiments can be improved through detailed and high frequency data, the cost of experimentation can be brought down by the ability to isolate decisions across time, customers, and products, and the scope of application of experiments can be expanded to include targeted promotions, visual layout of websites and mobile displays, and inventory availability information. In the past, research has been done in brick-and-mortar retailing as a way to improve the design of experiments and test the reliability of their results (Fisher and Rajaram 2000; Gaur and Fisher 2005). Examples of the increasing use of field experiments in online retailing include Bell et al. (2014) and Gallino and Moreno (2014) and those in brick-and-mortar retailing include Caro and Gallien (2012) and Lee et al. (2016).

4.2 New In-Store Technologies Will Transform Retail Stores, Making Bricks and Clicks a Reality and Changing the Customer Experience

The type of retail technologies that have seen the most remarkable growth since 2010 is in-store traffic counting, scanning, and surveillance. There are several new startup ventures providing different kinds of technologies in this space. They are creating new kinds of structured and unstructured data that can be used to improve efficiency and quality in retail stores and are introducing new research problems in POM. They are also making it easier to use data and analytics to solve problems in innovative ways. Following are some examples:

- Axis Communications uses networked cameras in stores to count customers, measure traffic, and conversions. Information is available in real time, so that it can be used to conduct experiments in stores.
- Euclid Analytics collects and models customer location data to measure customer frequency and duration of visit and intensity of interaction.
- Hointer.com provides technology for effective and efficient operation of fitting rooms.
- LocationGenius collects location data from customer smartphones and integrates it with social media and customer demographics.
- Prism Skylabs uses heat-sensing technology in stores to provide analytics for planning store layout and pricing shelf space.
- RetailNext uses sensors to measure the effectiveness of displays and windows in retail stores.
- ShopKick is an app that customers can download on their smartphones and earn points when they walk into a store, scan merchandise, or make a purchase.
• Shopperception uses 3D sensor technology to detect how customers interact with products on retail shelves.
• ShopperTrak provides technology for traffic counting in stores, which can then be combined with POS data for optimizing staffing, conducting A/B tests, and measuring conversion.

Previously, brick-and-mortar retailers faced a data disadvantage compared to online retailers. They could only observe customer purchases, whereas online retailers could capture and archive the entire customer engagement with their online stores for those making a purchase as well as those who were just browsing. These technologies are plugging this data gap between brick-and-mortar and online retailers. They are also enabling customers to have a seamless engagement with retailers across multiple channels. Thus, brick-and-mortar retailers can adopt pricing, promotions, and store design tools in the same way as online retailers.

4.3 Emerging Retail Formats, Warehouse Logistics, and Package Delivery Methods Will Create More Opportunities for Research

The retailing industry has periodically seen the evolution of new formats. Formats evolved over the past century include supermarket stores, department stores, discount stores, category killers, warehouse clubs, and online retailers. New retail formats emerging in the recent years include mobile retailing, consumer-to-consumer marketplaces such as Etsy, pop-up stores, virtual stores by Yihaodian in China (Chapter 34 in this book), and a hyper-retail model in India. Retail formats have been an overlooked research opportunity in the past. There is need for new research on the lifecycles, economic viability, and social and market implications of these new formats. One research paper in this area is work by Blanco and Fransoo (2013) on nanostores in Latin American countries.

Similar to new retail formats, there has also been considerable development in the design of warehouses and order fulfillment processes consisting of picking, packing, and shipping. The growth of online retailing has particularly fueled innovations in this area. Warehouses can be designed for case-picking, or unit-picking, and for manual picking, conveyors, or robotic devices. Smart warehouses integrate with retailers’ inventory management and demand forecasting systems to push product based on predictions of excess inventory and outages. Delivery to a customer’s doorstep can be assisted by drones. Research can contribute to the design of algorithms for employing these technologies for order fulfillment.

4.4 Environmental Sustainability Will Grow as a Research Area in Retailing

Global warming and climate change are bringing an urgent focus to environmental sustainability in retailing. Different types of retail formats vary in their environmental implications. For instance, Cachon (2014) studies the carbon footprint implications of the design of a retail store network. Manufacturers and retailers need to coordinate with each other to reduce the cost and environmental implications of product expiration (Akkas et al. 2016). Some retailers, such as Wal-Mart and Whole Foods, are encouraging their suppliers to use environmentally friendly product and packaging designs as well as measure their carbon footprint. The design and effectiveness of these initiatives needs to be studied by POM researchers. Finally, online retail models can influence the frequency of customer shopping, and thus, there are environmental consequences of the design of such models (Belavina et al. 2016).
4.5 Merchandising and Sourcing Functions Will See Research in New Models

As we noted in Section 3, the digital revolution occurring in the retailing industry has influenced supply chain fulfillment and customer experience, but merchandising and sourcing functions have been largely left out. Merchandising in seasonal or short lifecycle products is done through a process called “open to buy” in which a retail buyer or merchant evaluates potential product offerings and makes procurement decisions over time given available cash. There has not been much research into the optimization of this process in the past. As retailers exploit data and technological tools in their customer engagement, there is need for research in improving the merchandising and sourcing functions.

5 Implications for Practitioners

POM research has had significant impact on practice through applied modeling-based and econometrics-based work. Some areas of practical impact discussed in this chapter are assortment planning, inventory management for short lifecycle products, supply chain coordination, field experiments in brick-and-mortar and online retailing, and clearance markdowns. In the past, retailing was characterized by long lead times and inaccurate and inaccessible data (Fisher et al. 2000). However, this is no longer the case. Retailers have shortened their lead times through making their supply chains more responsive and have become more data savvy. These changes have opened up the opportunity to apply analytical models for real-time decision making on pricing, assortments, and inventory management. In this section, we describe how the practitioner impact of POM has been measured in the literature.

One way to measure practical impact is to relate operational performance of retailers with their stock returns. Alan et al. (2014) show that higher inventory turnover is a predictor of higher stock returns, Kesavan et al. (2015) show that higher inventory turnover retailers have better ability to manage demand uncertainty than lower inventory turnover retailers, and Fisher et al. (1999) show that retailers with higher return on assets and lower standard deviation of return on assets achieve higher long-term average stock returns across a cross-section of firms. Hendricks and Singhal (2005) show the effect of supply chain disruptions on stock returns and equity risk.

Practical impact is also measured through the effect on profitability. Operational improvements have large financial benefits for retailers because net profits are a small fraction of sales for retailing firms and small improvements in gross margin or sales revenue translate into large increases in net profits. For instance, consider a retailer with a sales revenue of $100, cost of goods sold of $60, and fixed cost of $35. The fixed cost may include selling, real estate, marketing, depreciation and amortization, and corporate overhead expenses. Thus, the retailer has a 40% gross margin and a 5% net profit before tax. Suppose that the retailer implements a new tool for pricing or inventory management, which results in an increase in sales from $100 to $105 with an increase in cost of goods sold from $60 to $62, and no change in fixed cost. Then, the sales revenue increases by 5%, gross margin increases from 40% to 40.95% (given by $43/$105), and net profit increases from $5 to $8, an increase of 60%.

Another benefit of operational improvements is in improving the liquidity of a retailer. Cash is important for a retailer to manage its inventory and accounts payables. Consider an example of a retailer that has $100 in annual sales revenue, $60 in annual cost of goods sold, and $20 in average inventory. Thus, the annual inventory turnover of this retailer is 3.0. Suppose that the retailer improves its inventory turnover to 4.0 by reducing its required inventory from the
average of $20 to an average of $15. This implies that the retailer’s cash flow from operations increases immediately by $5 (= $20 − $15). This can be a substantial increase when compared to the cash flow impact of net profits of the retailer. Thus, operational improvements can have large benefits for a retailer in its profitability, cash flows, and stock returns.

6 Conclusions

The goal of this chapter has been to describe existing POM research on topics relevant to the retailing industry, identify present trends in research, and make a few projections for promising future directions of research. We have described theoretical modeling-based research, applied research, econometrics-based work, field experiments, as well as some important case studies.

The retailing industry has seen significant developments through POM research during the previous 20–25 years. These developments have occurred in inventory management, retail supply chains, pricing and markdown management, assortment planning, shelf space allocation, and financial management of retailers. Despite these developments, this industry continues to see explosive growth in research opportunities. Research areas that have gained importance in recent years include store execution, workforce management, and online and omnichannel retailing. In the future, there are new business models emerging in retailing, technology is enabling the capture of more data and more precise decision making, environmental sustainability is becoming an important consideration, and retailing is developing rapidly in emerging markets. At the same time, there continues to be a need for research on topics that have been hitherto under-studied, such as category management, merchandising, and coordination between online retailers and suppliers. In each of these areas, the retailing industry presents opportunities for doing theoretical modeling, data-based modeling, and empirical research, experimentation, as well as applied research.

Retailing is connected with many sectors of the economy, manufacturing, services, banking, technology, and transportation logistics. Consumer behavior observed in retail stores is often a signal of economic growth and a harbinger of macroeconomic news. Thus, POM research in retailing presents exciting opportunities that can be impactful not only in this industry but also in the rest of the economy.

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References and Bibliography


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