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20th Anniversary Invited Article

The Future of Retail Operations

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Abstract. Retailing consists of all the activities associated with the selling of goods to the final consumer. In this article, we review the research on retail operations published in *Manufacturing & Service Operations Research* (*M&SOM*) since 1999. We then discuss the current retail landscape and the new research directions it offers, in which *M&SOM* can play a prominent role.

History: This paper has been accepted for the *Manufacturing & Service Operations Management* 20th Anniversary Special Issue.

Keywords: e-commerce • omnichannel • analytics • retail externalities

1. Introduction

In 1999, the founding year of *Manufacturing & Service Operations Research* (*M&SOM*), the retail landscape was dominated by big-box retailers such as Walmart, and leading specialists such as JCPenney, RadioShack, and the Gap. Nascent business models had started disrupting the retail world, with direct sales pioneered by Dell in personal computers, e-commerce platforms such as book e-tailer Amazon, and marketplaces such as eBay. Although e-commerce was viewed as a potential dominating force in future retail, new models showed varying degrees of success, ranging from Amazon.com, which collected a revenue of USD 2.6 billion that year, to Webvan, which raised USD 800 million in its initial public offering (IPO) in November 1999 before filing for bankruptcy in 2001. It was not clear at the time whether all incumbent retailers should set up online channels and how they should manage it. Striking examples were provided by Toys "R" Us and Borders bookstores, who outsourced their online channels to Amazon in 2001 (Vickers 2001).

Two decades ago, few people expected the development of Amazon into a giant with sales of USD 232 billion in 2018. Even less imaginable at the time was the appearance of formidable online retailers from China, such as Alibaba and Jingdong (JD). In parallel, new retail approaches such as hard discounting, pioneered by German champions Lidl and Aldi, and fast fashion, exemplified by the Spanish group Inditex, owner of Zara, became transformative of their respective segments in the brick-and-mortar space. Fast forward to 2019, we see that technological advances are once again bringing transformation opportunities, and the retail sector is perhaps among the first to grasp them, leading to innovative business practices worth studying.

Over the past 20 years, research on retail operations has developed significantly. Numerous publications have documented the best existing business practices, and influenced the evolution of the industry. Research forums such as the Consortium for Operational Excellence in Retailing (COER) at Harvard Business School and the Wharton School, and the Retail Management Institute at Santa Clara University have been influential in facilitating discussions about the latest retail research in the operations management (OM) community. *M&SOM*, together with other OM outlets, was instrumental in diffusing the most relevant research. In this article, we review the evolution of retail research through the lens of *M&SOM* and discuss current trends, new business models, and challenges for retail managers today. We believe that the latest developments in technology and business models generate considerable opportunities for future academic work.

2. 20 Years of Retail Research at *M&SOM*

Our first challenge in surveying *M&SOM* was to put boundaries on what defines retail research. Indeed, the field applies to a business activity, retailing, which is defined by *Merriam-Webster's Dictionary* as "the activities involved in the selling of goods to ultimate consumers for personal or household consumption." Retail combines elements of merchandising, customer management, supply chain and inventory planning, product distribution and logistics, pricing, and store operations. As a result, retail research sits mainly at the interface of OM and marketing, and includes diverse perspectives with multiple angles.

Our surveying exercise focused on the retail publications at *M&SOM* since it was started in 1999 until December 2018 (including Articles in Advance to that date). We examined all the published articles and looked for those whose title or abstract contained the word "retail." Out of the 652 papers surveyed, 337 mention "retail," which already suggests that the topic is strongly linked to the OM discipline. Among those, we excluded the articles that use retail as an example in passing, and those about supply chain coordination, which typically involve a manufacturer-retailer relationship, but do not examine retailing processes. This lead us to a final list of 65 articles, which we examined in more detail.

During the initial years, the retail articles from our sample were concentrated in one special issue in 2001 edited by Marshall Fisher and Ananth Raman (Fisher and Raman 2001). Strikingly, little retail work was published in the years that followed (2002–2007), but since then, publications have appeared in a more or less steady pace, with a recent peak in 2018.

2.1. Topics Covered and Methods

We classified the papers in eight categories, shown in Table 1. These topics cover the central challenges in retail management. They span questions about distribution structure and coordination, inventory planning, variety management, price positioning, and fulfillment decisions.

At a strategic level, an effective coordination between retailer and suppliers requires that channel incentives are properly aligned. For instance, the importance of shelf space allocation is explored in Wang and Gerchak (2001), and the role of assortment inclusion rules in shaping supplier prices is studied in Heese and Martínez-de-Albéniz (2018). Most of the papers in this space are based on game-theoretic modeling. As an exception to this, DeHoratius and Raman (2007) present an empirical study of the impact of store managers' incentives on store performance.

At a more operational level, inventory has been the most active area of study. Models have included distinct retail elements, such as substitution (Chen and Plambeck 2008), record inaccuracy (Kök and Fisher 2007, DeHoratius et al. 2008), and clearance pricing, as well as more general supply chain considerations such as transportation costs (Cachon 2001) and reorders with returns (Fisher et al. 2001). Most of the work in this area is based on stochastic inventory modeling. Inventory has also been examined from an empirical standpoint. The impact of inventory metrics on stock-market performance has been determined in Chen et al. (2007), and the impact of variety and demand volatility on inventory decisions in Kesavan et al. (2016). In these empirical studies, the most common challenge is identifying and dealing with endogeneity issues in the data.

Assortment optimization has been a popular area of research specific to retail, dealing with the critical question of which products to offer to customers. Combined with pricing and inventory decisions, the problem quickly becomes intractable. The models and methodology are highly dependent on the specifics of the customer choice model. One of the earlier papers, Chong et al. (2001), provides a marketing perspective to develop a decision support model for brand/size decisions for traditional logit-based models. More recently, nonparametric choice models (Honhon et al. 2012), customer search (Cachon et al. 2005), and prospect theory (Wang 2018) have been incorporated into assortment optimization.

Pricing is another central question in retailing, and hence an active area of research. Some of the papers have applications for retailers, as well as for manufacturers and service providers. One area of interest is the coordination of prices of substitute products. Dong et al. (2009) focus on substitute products with an analytical characterization under a special customer choice model. Ferreira et al. (2015) is an important paper that includes an application at an online retailer. Another area of interest is markdown pricing and discounts with limited inventory, typically solving dynamic programs as in Smith and Agrawal (2017). When customers strategically determine the time to make a purchase, a rational expectations equilibrium framework can be used, as in Cachon and Feldman (2015).

Table 1. Topics of Retail Research Published in *M&SOM*

Topic	Number of papers	Average of Google Scholar citations
Inventory	13	78
Pricing	12	62
Assortment	10	52
Incentives, channel issues	9	152
Online retail	7	43
Industry studies	6	53
Returns	4	123
Other	4	43
Total	65	77

Note. Citations are until November 2017.

In addition, practical questions related to price matching, promotional products, and cross-selling have been studied.

Finally, fulfillment is a relevant and growing topic, especially because it is a key concern in online retailing. Important papers in this area are Xu et al. (2009) and Acimovic and Graves (2014), who develop decision support models for real-time order fulfillment decisions.

It is worth highlighting that research in retail has used a variety of methodologies. The most widely used is traditional operations research modeling, in about half of the selected papers. In other words, the majority of papers develop a decision model where the different variables in the retail process are described, constraints are defined, and a mathematical optimization problem is formulated. A typical example is assortment planning, which looks at the impact of including or excluding a product from the retailer's offer (Cachon et al. 2005, Sauré and Zeevi 2013, Bernstein et al. 2015). After modeling, game theory and empirical methods are popular methodologies, both appearing in a fifth of the papers. Game-theoretical methods consider the equilibrium strategies of different players in a supply chain, typically a manufacturer and a retailer (Wang and Gerchak 2001, Kurtuluş and Nakkas 2011), several retailers competing with each other (Tsay and Agrawal 2000, Caro and Martínez-de-Albéniz 2010), or a retailer and consumers (Su 2009, Altug and Aydinliyim 2016). Empirical methods use real data from a retail context and document insights important for retailers that could be the basis for future modeling efforts. Some papers use publicly available information (Chen et al. 2007, Kesavan and Mani 2013, Kesavan et al. 2016) whereas others build on proprietary data from a particular retailer (Perdikaki et al. 2012, Craig et al. 2016). In some cases, the empirical model is validated by a field experiment (Gallino and Moreno 2018). Finally, a few remaining papers provide an applied perspective, in the sense that they combine a predictive model built from real data, with optimization to prescribe concrete retail strategies, and possibly a field validation (Xu et al. 2009, Craig and Raman 2015, Ferreira et al. 2015, Lee et al. 2015).

2.2. Impact

In addition to classifying the research topics covered, we have analyzed the impact that *M&SOM* has had in the OM community. One common metric of impact is citations. For simplicity, we focus on citations reported by Google Scholar.[1] According to this metric, the sample of *M&SOM* retail operations papers gather a total of 4,405 citations, which gives an average of 77 citations per paper.[2] This means that the work on retail operations has had slightly more impact than the average *M&SOM* paper, which gathered an average of 63 citations per paper in the same period.

Within the retail operations sample there are eight papers that have more than 150 Google Scholar citations. These papers are shown in Table 2, sorted by total number of citations. It is noteworthy that the two most cited papers extend the ideas of supply chain coordination, which was a popular area of research at the turn of the century, to allow for retail considerations such as service level and shelf space. It should also be noted that all of the papers listed in Table 2 are modeling papers, that is, they do not directly work with real data. The top three are based on game theory, which indicates that citations might be contingent on the methodology.

An interesting comparison can be made by looking at inbound citations, that is, other references that cite a paper in the retail operations sample, versus outbound citations, that is, the references cited by the papers in the sample. The 65 papers in the retail operations sample have 2,260 references in total (this is the overall count so we allow for repetitions). Hence, these papers generated 1.95 (= 4,405/2,260) inbound citations for each outbound reference. This suggests that the retail papers in *M&SOM* are "net importers" of citations.[3]

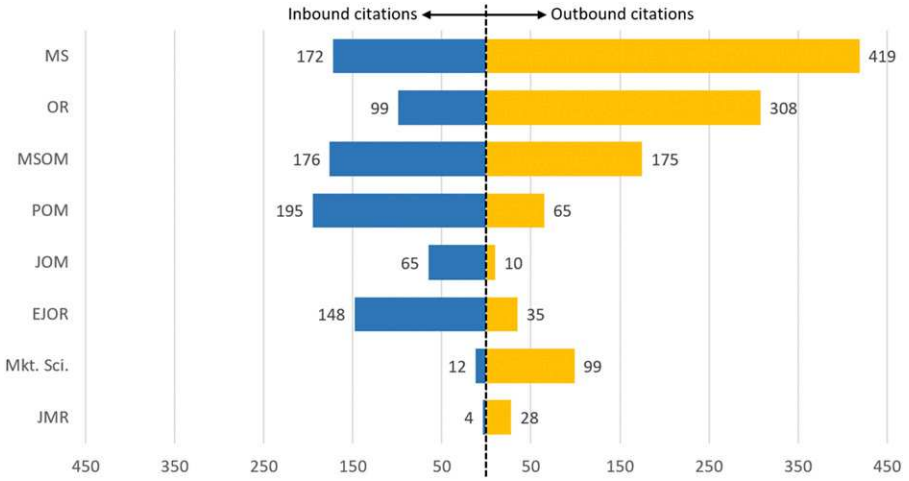
To get a better sense of *M&SOM*'s positioning in the academic retail operations space, we refined the inbound/outbound analysis at the journal level.[4] Figure 1 shows this comparison for the main journals that are considered for OM promotion cases in top business schools. *M&SOM* is remarkably balanced when compared with itself: there are 176 inbound citations from *M&SOM* papers to the sample, and 175 outbound

Table 2. *M&SOM* Papers in Retail Operations Sample with More Than 150 Google Scholar Citations

Reference	Title	Cites	Cites/year
Tsay and Agrawal (2000)	Channel dynamics under price and service competition	611	33.9
Wang and Gerchak (2001)	Supply chain coordination when demand is shelf-space dependent	279	16.4
Su (2009)	Consumer returns policies and supply chain performance	204	22.7
Cachon et al. (2005)	Retail assortment planning in the presence of consumer search	166	12.8
Kök and Shang (2007)	Inspection and replenishment policies with inventory record inaccuracy	165	15.0
Webster and Weng (2000)	A risk-free perishable item returns policy	164	9.1
Dong et al. (2009)	Dynamic pricing and inventory control of substitute products	162	18.0
DeHoratius et al. (2008)	Retail inventory management when records are inaccurate	157	15.7

Note. Citations are as of November 16, 2018.

Figure 1. (Color online) *M&SOM* Retail Operations Inbound and Outbound Citations



citations from the sample to papers in *M&SOM*. In contrast, when compared with *Management Science* (*MS*) and *Operations Research* (*OR*), there are more outbound references than inbound citations. If we correct for yearly number of papers published by each journal, as shown in Figure 2, one can see that papers in the sample have actually attracted significant attention from *MS*, *OR*, and other major OM journals, and it shows that in just two decades *M&SOM* has become an influential source in retail operations. However, there is room for improvement when we look at the comparison with the main journals in quantitative marketing (*Marketing Science* and *Journal of Marketing Research*). Figures 1 and 2 show that the *M&SOM* papers in retail operations pay attention to research published in marketing outlets, but the reverse does not seem to hold true, suggesting that *M&SOM* retail papers lack visibility in the marketing field.

Finally, citations mostly focus on academic impact. An alternative is to look at impact on practice. In that regard, the 2016 special issue on practice-based research (Gallien and Scheller-Wolf 2016) featured three "pure" retail articles, and two other papers with a strong retail component. Hence, five out of nine papers published in that issue were related to retail operations. This suggests that, in addition to contributing to academia, *M&SOM* research in retail operations has also been linked to industry and its impact spans theory and practice.

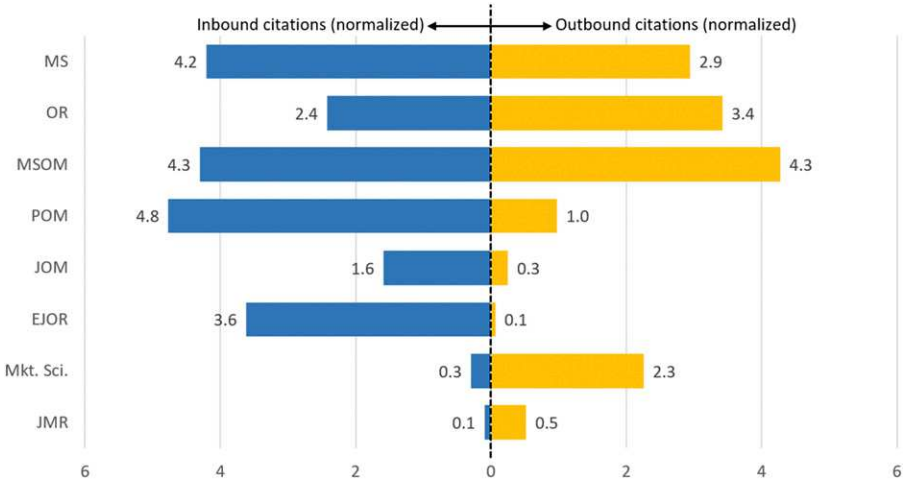
3. Future Research Topics

Our review of past research on retail provides an indication that there are many opportunities to continue making an impact on both academia and industry. We provide in this section a discussion of emerging topics, grouped in three categories: distribution approach, analytics capabilities, and broader relationships to societal issues.

3.1. Distribution Approach: E-Commerce and Omnichannel

Traditional retail models were built around the store, which grew in prominence since the 1950s. Many of

Figure 2. (Color online) *M&SOM* Retail Operations Inbound and Outbound Citations, Normalized by Yearly Volume



these were located in shopping malls, which became cathedrals of consumption (Kowinski 1985). Stores were where consumers would make purchase decisions, and thus creating the perfect store experience became an obsession for retailers. This translated into important one-time decisions, such as choosing the right store location or designing an engaging layout; and a pressure to sustain store performance through assortment planning, visual merchandizing, inventory management, and pricing.

In this perspective, the store was used both as a product fulfillment channel and an information provision channel. The majority of operational decisions in the store were made based on point-of-sales data. Demand forecasts were generated (Graves et al. 1986, Heath and Jackson 1994, Fisher and Raman 1996, and many others) and served as input for inventory planning, where base stock policies were a common practice (Zipkin 2000). Assortment plans were optimized after estimating substitution patterns (Kök and Fisher 2007). In this framework, the store was the center of operations and served as the interface between demand and supply. Customer interactions were typically managed in an artistic fashion, through qualitative assessments made by visual merchandizers (except in grocery retailing, where planograms were determined with quantitative decision support tools); and the supply chain was intended to support sales by properly planning purchases to external suppliers, and ensuring a smooth supply of goods through logistics.

Things started to change in the 1990s, with the early direct sales model pioneered by Dell in electronics. The leading e-commerce players Amazon, JD, and Alibaba were founded in 1994, 1998, and 1999, respectively. Online retailing completely changed the game. By freeing themselves from the tyranny of space constraints, retailers could now expand the operational scope of their activities. Assortments became unlimited, for example, 562 million different products sold by Amazon in the United States in January 2018 (ScrapeHero 2018), and the way they are displayed on the online platform can be updated immediately, as demand trends change. Inventory management is simplified by centralizing or virtually pooling stock-keeping into large distribution centers managed as a network (Acimovic and Graves 2014). However, the price to pay for this more flexible structure is twofold. First, the retailer now faces more expensive fulfillment and return costs. Second, the retailer may lose the physical interaction with the customer. As a consequence, supply chain management has become a strategic competence for online retailers, which is directly managed, as opposed to some brick-and-mortar retailers who outsourced it to third-party logistics providers. Online retailers not only focus on optimizing their internal supply chain processes (Xu et al. 2009), but they have also invested heavily in distribution centers and owned delivery fleets (Webb 2017). They have also used the investments to develop their marketplace program (Fulfillment by Amazon or TMall by Alibaba), and have been extremely aggressive with same-day delivery programs like Amazon Prime, which offers fulfillment within one or two hours in major cities for the bestselling products (Fiegerman 2018). Although these promises increase fulfillment costs enormously, they also improve the customer service experience and result in higher loyalty and spending, and create barriers to entry in the industry. As a matter of fact, most retailers are now matching Amazon's logistics conditions even when they do not have the capabilities or the scale, which implies that the online channel of traditional brick-and-mortar retailers lose money (Kaplan 2017).

In parallel with this online disruption, new business models have appeared to enrich the retailing experience. Brick-and-mortar retailers have started to offer home delivery together with the possibility of in-store pick-up (Gallino and Moreno 2014). They have also invested more in flagship stores to further emphasize the value of the store experience (Dennis 2018). Similarly, native online retailers are opening physical stores, as in Amazon Go, Hema by Alibaba, or 7Fresh by JD (Saiidi 2018), where new technologies such as the Internet of Things (IoT) and robots are being tested to reduce staffing or offer complementary services such as in-store food preparation. Alternatively, Apple successfully demonstrated that stores can serve as an environment for customers to experience the products and the brand rather than serve in a fulfillment role (Carrick and Sosa 2018). Even e-retailers like Warby Parker or Bonobo's have opened physical showrooms to allow customers to test their products, which results in higher engagement (Bell et al. 2018), and technologies for virtual product fitting are being deployed to decrease return rates (Gallino and Moreno 2018). Furthermore, distribution platforms such as Farfetch have entered the market to help customers search for their desired products, by virtually integrating products that are geographically scattered in small stores. The revenue model has also evolved from a per-transaction fee into a combination of per-use and subscription-based fees, available for digital content (Netflix or Spotify), for logistics (Amazon Prime), or even for products (Stitch Fix). Finally, customer interactions can be further monitored and managed, which results in an active dynamic assortment strategy (Caro and Gallien 2007, Caro et al. 2014, Bernstein and Martínez-de-Albéniz 2017) that promotes the customer's emotional attachment to the retailer. Brick-and-mortar and online retailing are thus melting into the new retail paradigm of omnichannel. These new developments raise

many interesting questions that provide a rich research agenda for our community.

First, in this state of affairs, the role of the physical store is not clear anymore. It serves as fulfillment and information provider (Bell et al. 2014), but how should one measure the contribution of the store to a retailer? Specifically, it has been observed that when a store opens in a new location, online sales grow due to increased brand awareness. One can foresee future work being carried out to measure the impact of a store through the multiple demand drivers such as brand exposure (similar to measurement of social media impact), product experience (Bell et al. 2018), or reduced fulfillment times (Fisher et al. 2016). This mainly empirical research should be complemented by optimization-based prescriptions determining optimal store expansion plans, possibly including recommendations about what size stores should be (e.g., flagship versus regular store versus corners in department stores), which features they should include (e.g., carry all categories and assortment versus a reduced set), and how they should operate together by actively managing substitution options (e.g., transshipments of products or referrals to other stores). One company that seems to have figured out the complementary role of stores and e-commerce is Home Depot, which will spend USD 5.4 billion in the next three years in an aggressive omnichannel strategy (Melton 2017).

Second, given that last-mile logistics are responsible for a high portion of fulfillment costs, the optimization of distribution strategies seems a prerequisite for the sustainability of online retailing. This includes the study of the "uberization" of logistics services, by considering two-sided markets where orders and delivery units are matched; and the role of new technologies such as additive manufacturing or robotics, and ensuring that the customer is at home so that the package can be delivered in one stop and is not returned. The last issue is especially prevalent when cash on delivery is involved (Bandi et al. 2018) or in countries with stringent consumer legislation such as Germany.

Third, the back-end of the retail chain must also be rethought. One can no longer assume a tree-like distribution system, because an order placed by a customer can be fulfilled from a distribution center, from a store, or even from an external channel such as a competitor. In the omnichannel perspective, demand must be forecast taking the new complexities that arise into consideration. The sensitivity of customers for different fulfillment options must be included in these considerations, too, as there is ample evidence that customers are highly sensitive to lead times (Cui et al. 2018). Fulfillment also becomes a decision where the retailer must decide which stock position fulfills which order (Xu et al. 2009, Acimovic and Graves 2014). Although fulfillment from a distribution center minimizes shipment costs and double manipulations, fulfillment from the store is able to offer shorter lead times and can help companies get rid of unsold inventory faster (Martínez-de-Albéniz 2019), so there does not seem to be a silver bullet for this problem. Finally, inventory prepositioning is a key input to the fulfillment problem and must be optimized in this setting. In a way, with omnichannel fulfillment, inventory becomes a virtual stock pool (Svoronos and Zipkin 1988), yet stock locations still have a large impact on logistics costs and customer choices (Mahajan and van Ryzin 2001). Hence, how to coordinate inventory levels in the distribution network remains an open and difficult question for future work.

3.2. Analytics: Predicting and Influencing Customer Experience

With the advance of omnichannel offerings by retailers and e-commerce platforms globally, customers have access to nearly unlimited products and services across channels (stores, online sites, social media) and across competitors, complemented by information from a variety of sources provided by retailers, manufacturers, customer reviews, third-party information providers, and social information sharing. When customers use these services, they leave a digital trail of their activities. Companies have invested heavily in technologies that enable tracking and recording of these digital trails, making available information about people's physical movements and their consumption of services (including news and entertainment). Even private communications (content of emails) are tracked by bots and used for commercial services without storing and sharing the content with other parties.

These developments, for the first time in history, present an opportunity to understand and predict customer behavior at a much more granular level than before, potentially tracking every click and every step of each individual at all places. The data collected includes information about consumers' purchases, interests, needs, intent of purchases, plans, social network interactions, decision processes, and so on. Similar developments also allow tracking of competition (prices, offers, campaigns) at a high level of granularity.

Demand forecasting in the past used aggregate demand or panel data to predict future aggregate sales for inventory. Nowadays, it can use much broader sources of information. For long-term demand forecasting, companies like Fab.com use crowd voting and customer interest to predict potential best-seller designs. Some retailers use early online customer response (purchases or clicks) to predict total season demand. Two recent papers by Huang and Van Mieghem (2014)

and Martínez-de-Albéniz et al. (2017) use clickstream data to predict offline orders of a retailer, and to forecast short-term demand within a flash sales campaign. Furthermore, IoT is creating a huge amount of data about what is happening inside the stores or shopping malls (Caro and Sadr 2019). Where are customers and salespeople in the store? What are they doing? Where are the products? How long are the interactions? Mani et al. (2015) demonstrate the impact of total store labor on total store sales. Kesavan et al. (2014) show through a field experiment that managing store congestion can lift sales significantly. We expect to see more granular examples of such papers using new data sources.

In the past, product choice and price sensitivity of customers were also estimated with models that used sales or panel data. Optimization of offers (assortment, pricing, or promotion) were done at store level, day or week level for promotions and pricing, and month or season level for assortment. Today, assortment decisions are made for each person and every minute at online retailers. Some new business models are founded around the premise of personalized dynamic assortment offers to customers with free shipping and returns, for example, StitchFix for clothes, Birchbox for beauty supplies, and Pawpost for dog food. The success of these companies is heavily dependent on their predictive algorithms for styles, customer taste, sizing, and quantity needed.

In fact, all online display decisions (which products or services to show to customers on the first page and in which order) are in some ways similar to assortment decisions. However, traditional customer choice models as well as optimization models fall short of representing the steps toward a purchase event (clicks, views, past visits, and purchases of similar products). Thus, new choice models are needed. In a recent example, Aouad and Segev (2015) represent products that are displayed more prominently as vertically differentiated products by a choice model in which customers randomly construct consideration sets consisting of the top n products on the web page. Farias et al. (2017) develop a nonparametric customer choice model using the customer-level choice history based on an idea similar to collaborative filtering (à la Netflix), that allows them to predict demand for new products. Bertsimas et al. (2018) present a data-driven assortment optimization focusing on average performance. They show that the added flexibility of their model outperforms traditional logit-based models in estimation and convergence to a good solution. Hence, there are opportunities to build new optimization models that capture the flexibility to dynamically change the offer for each customer.

Inventory modeling for some of the new business models no longer focuses only on the retailer's stocking points. Indeed, it now extends to the household level. Subscription models by Amazon Family currently send an agreed-upon quantity every month. Amazon is working on an anticipatory shipping system designed to cut delivery times by predicting what buyers are going to buy before they buy it—and shipping products in their general direction, or even right to their door, before the sales click even (or ever) happens. With the advance of platforms and sharing economy, firms can also track sellers' behavior on platforms such as Fullfilment by Amazon and AliBaba's Tmall, and they can activate supplier management policies that go beyond simple inventory ordering.

Retail pricing is also becoming more dynamic and more personalized. Caro and Gallien (2012) developed and tested a state-of-the-art clearance price optimization methodology at Zara for weekly, country-level markdowns. Chen et al. (2015) develop real-time dynamic pricing policies with limited price changes that yield near-optimal performance. Customer price sensitivity can be estimated using the most recent history for similar products. Ferreira et al. (2015) develop an estimation methodology for demand and price sensitivity of products with no sales history at Rue La La, an online flash sales apparel retailer, and show significant margin improvement in a field application. Similar to learning about customers, one can also track competitors' actions in real time and respond with price changes. Fisher et al. (2017) provide a methodology example of learning own- and cross-price sensitivities, leading to a dynamic competitive pricing algorithm that was tested at a Chinese e-tailer. Finally, the long-term effects of dynamic pricing are another key dimension that needs to be considered. Zhang et al. (2017) test the impact of promotions of products that are already in the checkout carts of more than 100 million customers and report the long-term behavioral changes on the customers.

Solutions to these new challenges require advanced analytics for building predictive and prescriptive models. Generally, machine learning algorithms are becoming more popular both in applications and academic studies. With the high volume of data and the need to continuously learn and make decisions as more data becomes available, we are seeing more examples of online algorithms that combine learning and optimization, such as reinforcement learning. Examples include Bertsimas and Kallus (2014) proposing a method of prescriptive analytics based on stochastic optimization conditional on environmental variables in the context of inventory management, and Ferreira et al. (2018) for learning elasticities and optimization of prices at the same time using Thompson sampling. Application of these may have great practical impact in large-scale dynamic decision making.

3.3. Externalities: Social Aspects

Retail moves the economy and its supply chains. In the postwar United States, mass consumption became a way of life and a symbol of prosperity (Cohen 2004). The same occurred to some extent in all other developed countries, and for developing economies, reaching a developed-level of consumption has become a major goal. This mass consumption has fueled the growth of a strong retail sector, which is fed by ever-expanding global supply chains. As with any massive trend, the retail wave is associated with many externalities that affect societies, markets, and the planet. For starters, the culture of hyper-consumption has been criticized for its superficiality and individualism, where isolated consumers are finding it harder to cope with the uncertainties of everyday life, leading to a paradoxical emptiness despite having it all (Lipovetsky 2006). Other significant externalities include the impact on jobs, waste, and market concentration.

First, consider jobs. The retail sector has been a major employer for decades. In the United States, retail is the largest private-sector employer, driving the economy and creating jobs in communities around the country (National Retail Federation 2014). In the past, retailing was a place to have a first job and move up. Nowadays, it attracts workers without college degrees for positions that are *last-mile jobs*, which are characterized as the jobs that remain when most of a task has been automated (Autor and Salomons 2018). That includes delivery services, picking packages in e-commerce warehouses, and store associates in showrooms.

Second, mass consumptions creates enormous amounts of waste, which is becoming a problem. A well-known example is planned obsolescence (Bulow 1982, 1986), especially prevalent in electronics (Poole 2017, Warren and Statt 2017). In the case of apparel, 30% of manufactured clothes is never sold; another one-third leaves the shops with a discount. The cost of inventory distortion in the global fashion industry is estimated at USD 210 billion, which shows the disconnect between what consumers want and what retailers have in stores. The average closet of a UK citizen contains 152 items and more than a half is never worn. Hence, the value of unworn clothes in the United Kingdom equals USD 45 billion (Barrie 2018).

Third, from an industry standpoint, the retail sector has also experienced important changes. Historically, retail has been a fragmented business. Walmart is the main player in the brick-and-mortar space, but its market share has not surpassed 20%. In contrast, Amazon accounts for almost 50% of e-commerce sales (Lunden 2018). The inherent network effects of online platforms favor this level of market concentration where the winner takes all. The downside is that high levels of market power can create distortions in quality, innovation, and local economies. In developing countries, where online penetration is still low, traditional retail channels remain preponderant and very fragmented, which has led to the emergence of nanostores (Blanco and Fransoo 2013) and idiosyncratic retail clusters (Zhao et al. 2019).

There are a plethora of new business models that try to create value by addressing some of the externalities mentioned previously. There has not been a major breakthrough yet as the financial viability is still unclear, but even if there is no disruption, some startups might be able to complement the existing retail formats. For instance, companies such as Yerdle, Thredup, and Loopster are trying to build recommerce platforms. The goal is to facilitate extending the lifetime of a product that is reusable as a way to tackle the waste issue. The recommerce platform might provide this as a service to the original brand or it can act as an independent secondary market. Rental models, such as Rent the Runaway, provide another approach for increasing the use of a product. They build on the idea of *servicitization*, in which the consumer only pays for the service (i.e., the use) and not the ownership of the product. On the sourcing end, process simplification and technology is being leveraged to build supply chains that are as close as possible to a pure pull model. ShareCloth and The/Studio are examples of these on-demand manufacturing platforms that only produce what is needed, when it is needed.

The retail externalities and new business models pose many interesting research questions. Since many of these business models are based on online platforms, a basic question is whether online strategies really solve the externality problems. The answer is not straightforward, as shown by Mayers et al. (2015) for video games distribution and Wiese et al. (2012) for clothing retailing. At a more tactical level, the new business models (in particular, the sharing economy) require solving many complicated operational problems to remain profitable. For instance, a typical rental business model in apparel requires 1.9 rentals of the inventory to roughly break even (Vow to Be Chic 2017). Slaugh et al. (2016) provide heuristics for this inventory problem and show that it can increase profits by 7% and service level by six percentage points. Even in the rental models, products eventually have to be disposed of, so what to do with unsold inventories remains a valid question. There has been some initial work on the circular economy, but definitely more is needed. An immediate step would be extending models on product renewal or release to incorporate the tradeoff between sales and waste.

The effect of retail practices on employment is also ripe for more research. For instance, the effect of automation on retail jobs is yet to be understood. And for those jobs that survive, it remains to be seen how employee engagement can be maintained. Ton and

Table 3. Future of Retail Operations: Research Topics

Distribution approach	Analytics	Social aspects
Role of stores	Demand modeling	Consumerism
Last-mile logistics	Assortment optimization	Jobs and labor relations
Omnichannel fulfillment	Online display optimization	Market concentration
Inventory positioning	Personalization	Waste
	Pricing	Supplier visibility/compliance

Kalloch (2017) claim that today's bad jobs can be transformed into tomorrow's good jobs. Training is usually presented as a solution, but does it always work? Fisher et al. (2018) study this question in the context of online training and found that the sales rate increased by 1.8% for every online module taken, which is a much higher benefit than the direct or indirect costs associated with the training. Retail jobs usually involve low pay and are rather unstable. Kesavan and Kuhnen (2017) show that lower or more volatile incomes lead to higher employee turnover. Moreover, they argue that this effect is not driven by employee ability and does not improve retailer revenues, which raises questions on whether current labor agreements should be revised.

The connection with supply chain management is another clear direction of research. At the core, there is the tradeoff between the stability of long-term relationships with suppliers versus the flexibility of short term procurement. Then there is the role of retailers in increasing supply chain visibility and enforcing better supply chain practices. But given the complexity of today's supply chains, can retailers really know what is happening upstream? In other words, can they really know who is making their products? And if they do know, should they disclose it? Initial research for the former question is provided by Caro et al. (2018), and Kalkanci and Plambeck (2017) study the latter, but the OM community certainly has more to say about these topics.

Finally, an open question that pertains to retail operations and marketing is the impact of corporate social responsibility initiatives on customer choices. Hampl and Loock (2013) find that sustainability is more than a soft topic and has a hard impact on customers' store choice. Young et al. (2018) show that retailers can influence the proenvironmental behavior of customers using conventional communication channels; however, repeat messages are needed for long-term impact. Despite this preliminary evidence, additional studies are needed to understand how to nudge consumers into a more sustainable shopping behavior.

4. Conclusion

The future of retail is very exciting. As the forces of technology, competition, and new business models shape the retail landscape, pivotal questions are on the minds of all participants in the industry, including investors, entrepreneurs, business professionals, and academics. Will giants like Amazon and Alibaba take over? Will consumers delegate their day-to-day shopping to bots and automated delivery services? Will brick-and-mortar stores be reduced to mere showrooms? Will the industry reinvent stores and supply chains to deliver a unique value proposition to customers? As the retail industry goes through this evolution, interesting and challenging research questions emerge.

In this article, we have reviewed the role of *M&SOM* in retail operations during its first 20 years of existence and we have discussed what we believe are the most promising topics for future research in this area. Table 3 provides a quick summary. These past two decades show that *M&SOM* is in a unique position to become a top outlet for research on retail operations while it increases its impact on practice and its visibility in sister fields such as marketing.

Endnotes

[1] The citation counts are up to November 16, 2017.

[2] The eight papers published in 2018 are excluded from this average calculation, so 4,405/57 = 77.

[3] The counts on Google Scholar include many nonacademic reports or documents that would rarely be cited by academic papers and could tilt the inbound/outbound ratio in favor of the latter. However, we also considered Scopus citations and the results are similar.

[4] The inbound citations from a specific journal were obtained using the feature "search within citing articles" of Google Scholar.

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