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Review

Fashion retail supply chain management: A review of operational models☆

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ABSTRACT

Over the past decades, we have witnessed the rapid development of giant fashion brands in the retail market which inspires a lot of operational research (OR) studies in fashion retail supply chains (FRSCs). In fact, FRSCs are highly consumer-demand driven and face many operational challenges coming from high demand and supply side uncertainties. Realizing the significance of fashion retail supply chain management (FRSCM) and a lack of comprehensive review on the topic, we develop this paper which examines the operational models on FRSCM in the mainstream OR literature. We organize this review systematically with respect to the core functional areas of FRSCs, namely the manufacturer, retailer, consumer, and fashion retail supply chain system. In each functional area, insights regarding the related studies as well as the specific OR model features and assumptions are generated. Finally, we conclude the review by summarizing the major findings and proposing promising future research areas (from both OR modeling and practical perspectives).

1. Introduction

1.1. Background

With the growing power of giant retail groups, retail supply chain management, in which the retailer assumes the leadership role of the whole channel, has become an important topic in modern supply chain management in recent years (Agrawal and Smith, 2015). There is no doubt that quick and reliable supplies, proper product quality, accurate transportation and inventory control, efficient and valuable information flow, competitive pricing strategy, and high-accuracy demand forecasting are all critical elements in supply chain management (Hanne and Dornberger, 2016). Retailing, as the ultimate element of retail supply chain directly facing consumers, has special emphasis on product availability and customer satisfaction. In fact, consumers only need a limited quantity of certain types among tremendous product assortments offered by the retailer. Therefore, it is crucial but immensely challenging for retailers to learn exactly what customers want, when and where demand occurs, and provide the needed information (e.g., demand forecasting, real-time sales data, consumer return and feedback, inventory status) to other upstream members so as to improve the supply chain performance (Afshari and Benam, 2011).

In the fashion industry, fashion retailing has received growing attention with the rapid growth of global fashion industry and brands (fashion products are like fashion apparel, footwear, accessories, and fashion beauty). Statistics of Fashion United[1] show that the worldwide value of fashion apparel market reached three trillion US dollars, about 2% of global Gross Domestic Product (GDP), totally creating 115.6 million employment opportunities in the world by 2014 which had increased by 69% since 1990. Global fashion retail brands in luxury fashion (e.g., Hermes, Louis Vuitton), functional apparel (e.g., Adidas, Nike) and fast fashion (e.g., Zara, H&M) have emerged as the leading brands and consistently being ranked as top 100 brands in the world, together with retail giants like Apple Computers, Amazon, and Walmart. As a consequence, fashion retail supply chain management (FRSCM) has become prominent. According to Choi (2014), fashion retail supply chain (FRSC) is a retailer-led supply chain coupled with forward and backward flows of fashion products, information, and funds, where the decisions are driven by consumer demand in the market. The four core members of a FRSC are illustrated in Fig. 1. In this paper, for the definition of FRSCM, we adopt the one proposed by Choi (2014), arising from the definition of Supply Chain Management given by The Council of Supply Chain Management Professionals: "*FRSCM encompasses the planning and management of all activities*

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[1] https://fashionunited.com/global-fashion-industry-statistics.

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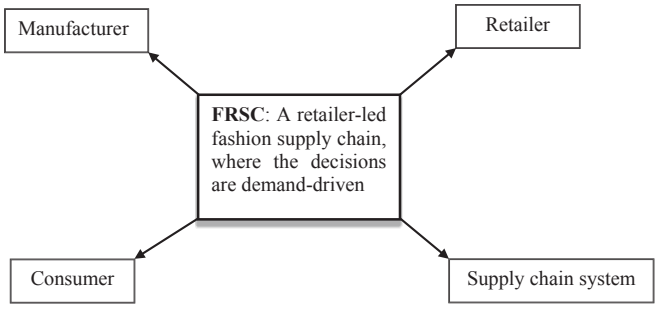

Fig. 1. Core members in a FRSC.

involved in sourcing and procurement, conversion, and all logistics management activities in the FRSC. It includes coordination and collaboration with supply chain partners. In essence, FRSCM integrates supply and demand management within and across the FRSC with a goal of satisfying the customer requirements under the leadership of the retailer."

According to Şen (2008), the fashion industry is characterized by short life cycle, huge variety in products (e.g., color, size, style), inevitable inherent uncertainties (e.g., demand, supply), lengthy and rigid supply procedures, and high impulse buying behavior. As a result, FRSCM is highly complicated and challenging. Although the significance of FRSCM has been well-realized, very few studies have been conducted to comprehensively examine FRSCM from an academic perspective. To the best of our knowledge, Şen (2008) conducts an overview about the advanced technologies and operations, including apparel manufacturing, retail operations, and trends such as quick response and e-commerce, in fashion supply chain management in the US until 2006. Choi (2014), in the introductory chapter of the book, summarizes several important topics in FRSCM, including customer service management, inventory models, channel coordination, efficient consumer response, new product selection, and information system. Shen et al. (2016a) review the literature related to fashion inventory management. However, none of them focuses on exploring the related operational models in detail.

1.2. Methodology

Motivated by the significance of FRSCM and a lack of comprehensive review on the topic, we have developed this paper which reviews 144 papers published in the recent decade (2006–2017). The review focus is on those analytical studies which apply operational research (OR) techniques in tackling the research problems. The reviewed papers apply OR techniques ranging from game theory to diverse mathematical programming methods such as dynamic programming, integer programming, and stochastic programming.

Regarding the searching and selection criteria for papers, similar to Wang et al. (2015), we concentrate on the dominant operations research and management science (OR/MS/OM) journals, including INFORMS journals (Management Science, Operations Research, Manufacturing and Service Operations Management, Interfaces, Information Systems Research, Marketing Science, Service Science, Transportation Science, Mathematics of Operations Research, and INFORMS Journal of Computing), Production and Operations Management,[2] IEEE Transaction (various),[3] IIE Transactions, European Journal of Operational Research, International Journal of Production Economics, Decision Sciences, Transportation Research (various parts),[4] Naval Research Logistics, Omega, Annals of Operations Research, International Journal of Production Research, Journal of the Operational Research Society, Computers & Operations Research, Decision Support Systems, OR Letters, and SIAM Journal on Optimization, with the keywords of "fashion", "supply chain" and "retail". In total, we have found 1295 papers. To fit our "fashion" scope well, we select three categories of publications that employ operational models to investigate fashion retail supply chain management problems: i) Those considering the fashion industry directly (like Cachon and Swinney (2011)); ii) those considering products like fashion items (like O'Neil et al. (2016)); iii) those with features of the problem or findings that are relevant or applicable to the fashion industry (like Cui et al. (2016) and Lee and Park (2016)). Therefore, 138 papers are retained. Besides, based on our knowledge and advice from reviewers, we intentionally include 5 papers (e.g., Chiu et al. (2011) and Xiao et al. (2010)) published in other reputational journals (i.e., Automatica, and Computers & Industrial Engineering) and one paper of Zhao et al. (2018) [5] that are crucial for the development of the FRSCM literature to make our findings comprehensive. Consequently, there are totally 144 papers being reviewed in this work. Table 1 illustrates the statistics of the collected 144 papers in each journal. We can see that the majority of selected papers are published in European Journal of Operational Research, International Journal of Production Economics, and IEEE transactions, while no relevant publications are found in SIAM Journal on Optimization, OR Letters, Transportation Science, Mathematics of Operations Research, and INFORMS Journal of Computing.

Fig. 2 summarizes the number of publications every two years and shows the trend in the growth of research interests in FRSCM in recent years. Specifically, the research attention steadily increases after the year of 2009. In 2016–2017[6], 36 related papers were published, which is more than a double compared to ten years ago. Therefore, it is confident that there will be more publications in the future and this research area will keep attracting researchers.

As a remark, in this paper, we vote for a comprehensive review for recently published papers in the basket of dominant OR/MS/OM journals for a number of reasons: (i) The collected papers are of a high quality, timely and relevant to FRSCM. (ii) The result from this searching can show some statistics regarding the trend of publications, and the popularity of different outlets for FRSCM research. (iii) The searching result also indicates the topics that have been widely explored as well as those under-explored, which helps with our proposal on future research opportunities.

Considering that most selected studies investigate: i) Operational strategies of upstream players (fashion manufacturer/supplier), ii) decision frameworks of downstream players (fashion retailer), iii) issues of consumers, or iv) the collaboration and coordination between these agents, this review is systematically classified with respect to the four core members of a FRSC: Manufacturer, retailer, consumer, and supply chain system. This classification strategy is easy for readers to follow and understand what each stakeholder concerns in a FRSC. Specifically, Section 2 summaries four topics mostly considered by fashion manufacturers (equivalent to "supplier" in this review), while six frequently concerned problems are reviewed for fashion retailers in Section 3. Next, we renew the knowledge about consumer behavior, consumer demand, and customer return in Section 4, in order to generate some managerial insights from the aspect of fashion customers. Then, recent developments regarding the supply chain system are examined in Section 5. Finally, we conclude this review by summarizing the major findings and proposing future research opportunities. The numbers of the selected papers investigating the respective topics for the four

[2] Notice that Journal of Operations Management is excluded because it only publishes empirical research in the recent decade.

[3] IEEE Transactions on Engineering Management; IEEE Transactions on Systems, Man, and Cybernetics: Systems; IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans.

[4] Transportation Research Part B: Methodological; Transportation Research Part E: Logistics and Transportation Review.

[5] Due to its significance and high relevance to fashion retail supply chain management, we deliberately include Zhao et al. (2018) according to the insightful suggestion of an anonymous reviewer.

[6] Zhao et al. (2018) is included in 2016–2017.

Table 1
Statistics of the papers selected in each journal.

Journal	Amount	Journal	Amount
European Journal of Operational Research	28	IIE Transactions	5
International Journal of Production Economics	19	Annals of Operations Research	4
IEEE Transactions (various)	12	Manufacturing and Service Operations Management	3
Management Science	9	Naval Research Logistics	3
Omega	8	Service Science	3
Decision Sciences	7	Computers & Operations Research	2
Production and Operations Management	7	Information Systems Research	2
Transportation Research (various parts)	7	Journal of the Operational Research Society	2
International Journal of Production Research	6	Decision Support Systems	1
Marketing Science	5	Interfaces	1
Operations Research	5	Others	5

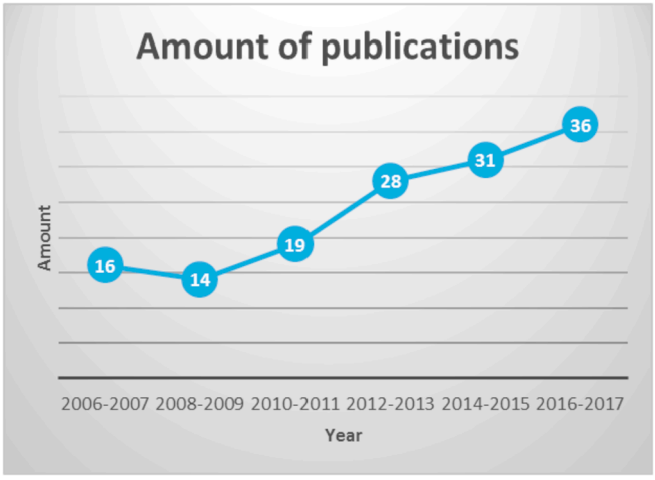

Fig. 2. Trend of publications during the last decade.

functional core members are provided in Table 2. It is revealed that the studies focusing on fashion retailers (72 papers) and consumers (39 papers) are much more than those on fashion manufacturers (25 papers). Besides, great attention has been paid to the fashion retail supply chain system (87 papers), especially with regard to the mechanism of channel coordination (62 papers).

1.3. Contribution

This review contributes to the OR literature by examining the most recent research development with FRSCM operational models and updating the most advanced knowledge in the domain. Our focus is to examine the works investigating FRSCM decisions with operational models to generate managerial insights. Insights on the areas (from both OR modeling and practical perspectives) in which more research should be conducted are proposed. This review helps to improve the understanding towards FRSCM for both researchers and practitioners from the four functional areas. By identifying the prospects arising from current research, we hope it will attract more attention in both the industry and academy, and inspire more innovative OR studies on this important research area.

2. Manufacturer

In a FRSC, fashion manufacturers produce and supply fashion products to other downstream members which ultimately reach consumers via retailers. Traditionally, manufacturers have the flexibility to set prices to influence the market demand and further affect the profitability of the whole supply chain. With the limitation of production capacity and lead time, manufacturers decide due dates to either accept or reject orders from downstream partners. It is hence crucial for fashion manufacturers to make production schedules according to demand forecasting ahead of the selling season (Charnsirisakskul et al., 2006). In this section, we review the recent literature discussing the important aspects of manufacturers in a FRSC, as shown in Fig. 3.

2.1. Production

Production is an activity performed by manufacturers. However, it is also closely related to retailers and market demand. Considering the highly volatile demand and long lead time, it is critical and challenging to make efficient and effective production decisions, including the optimal quantity to produce, time to produce and ship, and price to sell. A good production plan can improve the profitability of both manufacturers and retailers, increase market share, raise consumer satisfaction, and reduce inventory costs. Some research works on improving the production decisions in the fashion industry are conducted in recent years. For example, Charnsirisakskul et al. (2006) investigate the optimal decisions on production scheduling, pricing, lead time flexibility, and order rejection/acceptance in an integrated model. By applying mixed integer programming and

Table 2
Statistics of the papers selected investigating the diverse research topics[a].

Functional member	Major topics	Statistics	Functional member	Major topics	Statistics
Manufacturer (25)	Production	11	Retailer (72)	Supplier, market & retail channel selections	20
	Product design	4		Inventory management	20
	Channel selection	8		Retail in-store operations	11
	Shipment	6		Pricing strategies	21
Consumer (39)	Consumer behavior	14		Selling strategies	4
	Consumer demand	13		Product operations	9
	Consumer return	17			
Supply chain system (87)	Channel coordination	62			
	Fast fashion	9			
	Information management	13			
	Risk management	34			

[a] Note that it is possible for one paper appearing in more than one topic due to the multiple aspects it primarily considers.

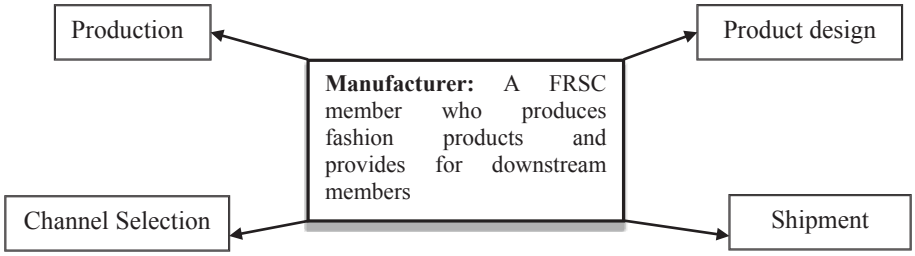

Fig. 3. Important issues considered by fashion manufacturers.

heuristic initialization methodology, the experimental results demonstrate the significance of integrating production with other decisions on improving profitability. Similar to Charnsirisakskul et al. (2006), Cao (2014) explores a decision model integrating pricing and production strategies for a dual-channel chain. In addition to manufacturing by themselves, many fashion companies outsource production to specialized third-party suppliers to gain a higher level of competitiveness and flexibility. Some research focuses on improving decision making in this area. For instance, Ni and Srinivasan (2015) propose a matching model to identify the optimal outsourcing manufacturer for fashion companies with the consideration of manufacturer's tenure and location, while Georgiadis and Rajaram (2013) investigate the selection strategies from outsourcing suppliers for private label fashion products. Besides, Choi et al. (2013) propose to assign a third-party company to collect returned fashion products for remanufacturing.

Not restricted to manufacturers, production decisions can be made by fashion retailers (Georgiadis and Rajaram, 2013). Such cases are commonly seen in fashion retail brands with private labels, such as Zara, H&M, and GAP, which benefits the companies by differentiating the products from their competitors in the market. However, the private label production strategy defines the responsibility of retailers to make decisions for the whole supply chain with a minimum cost. In the work of Georgiadis and Rajaram (2013), the retailer-led decision framework is formulated as a mixed integer programming problem and solved by Lagrangian relaxation coupled with heuristics. The authors emphasize the significance to consider inventory management decisions for upstream activities like production and distribution. Besides, the costs arising from production and inappropriate inventory are proven to constitute the major part of total supply chain cost which should be considered carefully during the planning horizon.

Remanufacturing occurs in a closed-loop supply chain where (returned or used) products flow backward to the manufacturer/remanufacturer for reproduction, the cost of which is usually lower than producing a new one with a similar quality level. The significance of remanufacturing has been recognized (Choi et al., 2013). The analysis conducted by Choi et al. (2013) illustrates that the efficiency of remanufacturing strategy is highly associated with the distance between the supply chain agents with the market.

Contract production is essentially a strategy to achieve quick response and supply chain coordination. In contract production, the fashion manufacturer produces products according to the contract signed with the retailer. For example, on one hand, the manufacturer can produce a contracted quantity of fashion products long before the season and provide the retailer with a low cost. On the other hand, the retailer can place an order to the supplier after the market demand is revealed when the season is approaching with a higher cost. An alternative is that the retailer first orders a certain number of products from the manufacturer, and requests further replenishment after the demand is known with a higher cost. Note that the work conducted by Cattani et al. (2008) considers a fashion supplier which contracts with a retailer about production. The authors identify the conditions under which the three contract production strategies proposed are efficient. Moreover, Martínez-de-Albéniz and Simchi-Levi (2009) examine a situation where the retailer reserves some production capacity of the manufacturer in the early stage and then places the final order after the consumer demand is known. However, owing to the uncertainty in demand, the retailer faces the risk of having redundant reserved capacity and inventory. Therefore, it is important for the retailer to contract with several different suppliers with unit capacity reservation fee and distribution fare considerations. However, their analysis shows that diverse suppliers tend to cluster together (that is, applying the same strategies in small groups) during the competition in order to win the retailer. In addition, Xiao et al. (2010) study a perishable-product supply chain where the manufacturer could subcontract some of the retailer's order to a subcontractor to better satisfy the retailer's demand. The authors uncover that both the manufacturer and the subcontractor would offer a lower wholesale price when the lead time increases.

Production capacity is the major restriction faced by the fashion manufacturer. However, most existing literature on FRSCM assumes infinite capacity. Only a few papers consider the capacity restrictions. For example, Huang and Su (2013) take the capacity constraint into account when designing a closed-loop supply chain. Cattani et al. (2008) identify the requirements on capacity when making the optimal contracted production decisions. Moreover, Wang et al. (2011a) make the optimal capacity allocation and order acceptance integrated decisions to achieve profit maximization. Both manufacturers and retailers suffer from the limitation of production capacity. From the perspective of fashion manufacturers, limited capacity restricts the ability to accept orders, which further influences the development of the company. For fashion retailers, the incapability of manufacturers to supply products timely to capture the ever-changing market trend leads to a loss in market share. In order to deal with these problems, some fashion retailers decide to place orders long before the selling season. However, a high inventory holding cost is incurred and the flexibility of reacting to real market demand is impaired. To deal with the capacity restrictions, Huang et al. (2014a) propose two strategies: Capacity expansion and wholesale price rebate for the fashion supplier. In the first strategy, it is straightforward to improve production capacity so as to better satisfy the retailer's demand promptly. In the second strategy, the manufacturer offers the retailer a discount wholesale price to encourage it to make an early order. Their research suggests that the capacity expansion cost, manufacturer's inventory holding cost, and retailer's inventory holding cost are three key factors affecting the choice on the optimal strategy. Particularly, the first strategy is preferred if the supplier's original capacity is low while the second is advantageous when the supplier's original capacity is relatively high.

2.2. Product design

Product design is the engine to drive the success of fashion companies considering the fast-changing fashion trend and turbulent market demand. To capture consumers, giant brands, such as Zara and H&M, have adopted the enhanced design strategy to quickly produce the most fashionable items by extensively investigating the latest customer preference and tastes (Cachon and Swinney, 2011). The improved design in fashion items benefits the companies by dealing with strategic consumers through reducing their willingness to wait for discount. Different from the enhanced design measure, Caro and Gallien (2007) propose to design during the selling season. This innovative

strategy offers the opportunity to improve the design according to the real market information collected from retail stores. Moreover, instead of designing by themselves, many fashion companies outsource the design job to professional third-party firms to keep a high level of competitiveness. According to Shen et al. (2016b), many fashion brands move from the traditional Original Equipment Manufacturing (OEM) strategy to the Original Design Manufacturing (ODM) strategy in recent years, in order to enjoy the advantages of low costs and professional design skills of the outsourcing service providers. In the OEM, the outsourcing supplier is only responsible for production according to the clients' requirements, while in the ODM, the third-party manufacturer is responsible for both product design and manufacturing. For example, famous fashion brands, Brooks Brothers and JC Penney, outsource their product design and manufacturing function to TAL group, a leading apparel manufacturer in the world (Appelbaum, 2011). Besides, a popular Hong Kong fashion supplier, Crystal Group, reports that they have transformed from a traditional OEM supplier to an ODM/OEM integrated service provider to design and produce the most fashionable garments. Additionally, JEEP, a US fashion brand, appoints a Chinese manufacturer to design and produce for it (Shen et al., 2016b).

Design for the Environment (DfE) is a growing topic in the literature (Raz et al., 2013). Nowadays, more and more companies are seeking to provide products with less resource consumption and pollution emission (Schmidheiny, 1992). Focusing on functional and innovative products (like fashion clothes), Raz et al. (2013) examine the relationship among the effort paid in DfE, variation in consumer demand, and change in total profit and cost. Exploring a newsvendor problem, the authors obtain the optimal green efforts to be put in product design and the optimal production quantity for the manufacturer. Their results illustrate that although the green efforts can always improve the environmental effect of individual product, the deviation in total environmental influence remains uncertain due to the rise in production quantity. The authors then find out the conditions where the growth in production could be balanced by the eco-design efforts and show that overproduction is critical.

2.3. Channel selection

In a FRSC, fashion manufacturers can distribute products to the end consumers either through the traditional retailer channel or online direct channel. Therefore, there are two main streams of distribution channel for suppliers being studied in the literature: Retailer (offline) channel and dual-channel (an integration of the retailer channel with an online direct channel). It should be noted that a fashion retailer can also play as an online seller, which will be discussed in Section 3.1.

Retailer channel: Most of the existing research works consider the manufacturers distributing fashion products through retailers at a wholesale price (Cattani et al., 2008; Chen and Chen, 2007; Huang and Su, 2013; Hung et al., 2013; Shao et al., 2013). For example, Chen and Chen (2007) consider a multi-echelon supply chain for short life cycle products (like fashion items), where the retailer makes replenishment decisions according to the Economic Ordering Quantity (EOQ) model and the behavior of the manufacturer follows a lot-for-lot discipline. A profit-sharing channel coordination contract is proposed for Pareto improvement. Besides, Shao et al. (2013) consider a manufacturer distributing its fashion products through several competing retailers, where the decisions on inventory and retailing price for individual retailers are shown to be different from the global optimal solutions.

Dual channel: It is commonly seen in the current fashion retail industry that manufacturers sell fashion products directly to end customers through online stores, rather than depending solely on the traditional retailer channel, owing to the immense development of internet technology and rapid growth in the logistics industry. According to Chen et al. (2012), the online direct sales help achieve cost reduction, sales increase, and market expansion. Taleizadeh et al. (2016) point out that the dual-channel strategy can not only reduce costs, but also decrease time and energy consumption by selling online. Besides, it is convenient for customers to make comparisons on prices among various websites and select the most preferred one. However, the authors comment that online stores cannot replace the traditional retail stores because there are many customers who like to see, touch, and evaluate the products in person before making a purchase. As a result, an increasing number of giant brands (e.g., Nike) are adopting the dual-channel supply chain strategy. For example, Cao (2014) examines a dual channel supply chain coordination problem by a revenue sharing scheme for fashion companies, with the objective to maximize the profit of the whole supply chain. Then, the effect of demand disruptions on profitability and coordination contrasts is considered, and the value of knowledge of disruption in management is quantified. His results show that for both the normal and disrupted situations, price adjustment and production modification are the optimal decisions for the dual-channel supply chain. He concludes that if the information concerning disruption is known by the decision-makers, the entire dual-channel supply chain will benefit from it. A related work is found in Shang and Yang (2015), where a profit-sharing contract is developed to coordinate a dual-channel supply chain and the optimal contract parameters are identified to achieve Pareto-improvement. More importantly, they prove that the three-player FRSC coordination contract negotiation is totally different from the two-player FRSC.

2.4. Shipment

Fashion products flow in a FRSC, which highlights the importance of shipping decisions (Caro et al., 2010). Decisions about product shipment is important to both the fashion manufacturers and retailers, because they affect costs, flexibility, and inventory management. For example, to deal with the problem of stock out, Chen et al. (2013) develop a fast shipment strategy between the fashion apparel retailer and the supplier ensuring that once the inventory level of the retailer decreases below a contracted level, the supplier would help expedite the shipment of replenishment without an extra cost. Three categories of fast shipment strategies are proposed. In the first strategy, the retailer determines the amount of initial shipment and the subsequent fast shipment with an upper quantity limit imposed by the manufacturer. Next, in strategy 2, the initial shipment is infinite to cover the retailer's demand, but there is a limit on the amount in the stage of fast shipment. Differently, strategy 3 allows the supplier to decide the quantity limit after the order from the retailer is observed. Their mathematical analysis shows that the manufacturers always choose strategy 1 when compared with strategy 2. Besides, the manufacturers and the retailers always have opposite preferences regarding strategy 2 and strategy 3.

Beside the fast shipment strategy, suppliers offer a multi-shipment contract to help retailers optimize their inventory control policy and better satisfy the market demand, in which the retailer determines the ordering quantity for each shipment (Chen et al., 2016). From the perspective of fashion manufacturers, the multi-shipment contract enables small batch productions to ease the peak season pressure. For the fashion retailers, they can enjoy a reduction in the inventory holding cost while maintaining a high level of customer service. Furthermore, green shipment, as discussed in Konur and Schaefer (2014), relates to the optimal transportation policies under the carbon emission scheme. Konur and Schaefer (2014) point out that truck emission is the major part of transportation pollution in the world, which should be carefully studied in order to improve the sustainability of supply chains. It is proven that the cost of shipment is not the only reason for the optimal selection of transportation strategies, because the emission of freight is also crucial for the choice. Besides, outsourcing logistics is commonly seen in the fashion industry. However, there is little research studying the outsourcing logistics decisions faced by the fashion industry. Huang and Su (2013) is the only related literature we found. Huang and Su (2013) investigate the conditions to apply an outsourcing shipment strategy, assuming that the shipment of returned products could be operated by either third-party logistics companies such as UPS or FedEx

or in-house transportation departments. Their results show that the number of products is crucial for the selection of third-party logistics service provider.

In addition to shipping vertically in a FRSC, lateral transshipment is also considered in the literature. For example, Özdemir et al. (2013) formulate a transshipment problem within the same echelon as a network flow problem, in which the impact of supply capacity of the fashion manufacturer on the FRSC performance is analyzed. Besides, Huang and Sošić (2010) consider a transshipment problem in which the unsold inventory of a fashion retailer is transported to other retailers so as to satisfy the unsatisfied demand. However, the authors mention that an independent third-party organization is necessary to monitor the inventory and sales status to ensure the efficiency of the optimal transshipment strategy.

3. Retailer

This section discusses the issues related to fashion retailers. Fig. 4 shows the brief definition of the fashion retailer and the related topics to be reviewed.

3.1. Supplier, market & retail channel selections

In this part, we discuss various selection problems faced by a fashion retailer. Specifically, a retailer needs to choose a reliable supplier, a market to enter, and a channel to sell its products.

Supplier selection: Fashion retailers are facing with the risks from supply side, including the uncertainties in supplier responsibility, lead time, supply quality, and supply quantity. Consequently, the selection of a qualified and reliable supplier remains a challenge for fashion retailers. To deal with these risks, Choi (2013b) develops a two-stage supplier selection strategy in which the fashion retailer can filter poor suppliers in the first stage and then choose the optimal one from the remained suppliers in the second stage by stochastic dynamic programming. Besides, Martínez-de-Albéniz and Simchi-Levi (2009) select from several suppliers with different capacity reservation costs and wholesale prices, while Bandyopadhyay and Paul (2010) make decisions between two competitive suppliers who offer unsold product return contracts to the fashion retailer. Georgiadis and Rajaram (2013) highlight the importance to integrate the consideration of manufacturer selection into the decisions on production scheduling, distribution strategy, and inventory management. This is because a manufacturer who is optimal for any individual decision might not be optimal for the whole FRSC. Besides, Choi (2013a) studies a dual sourcing problem where the local suppliers are proposed to replace the offshore manufacturers, with the objective to improve the environmental sustainability of the FRSC under a carbon emission taxation policy. His result shows that a high-quality carbon emission taxation policy can not only encourage the retailer to select a local supplier, but also reduce the risk level faced by the retailer. Other studies related to dual sourcing problem could be found in Huang et al. (2017a), Oberlaender (2011), and Serel (2015).

Market selection: For fashion retailers, the decisions on market selection is critical for its survival and profitability. For example, Huang et al. (2014b) propose a secondary market strategy to deal with the problem of returned and leftover inventory. Consumers return fashion products in the primary market. Then, retailers trade the returned and unsold inventory in an internal market to determine the optimal quantity of products to be salvaged in the secondary market. Their discussions show that the secondary market plays a critical role in the profitability of the fashion retailer. However, the authors mention that this strategy might lead to serious conflict between the retailer and the supplier regarding the optimal decisions on inventory level. Abdel-Aal et al. (2017) integrate the market selection problem with the product selection problem for a fashion retailer who sells multiple products in several markets. They propose three market entry strategies: Full entry, flexible entry, and partial entry. In the first strategy, all products are sold in the selected market with a single introduction cost per period, while in the second strategy, the retailer has the flexibility to decide what and how many products to sell in the market with an introduction cost for each product per period. Last for the third strategy, the retailer needs to pay an initial cost in order to enter the market, then pay an introduction cost for each particular product sold in that market. In the work of Abdel-Aal et al. (2017), the retail price, market entry cost, and consumer demand are dependent on the market selected. The authors claim that the constraint on service level and retail price affect the optimal decisions on market selection significantly. Gray market, referring to the sales through unauthorized channels, has attracted researchers' interest in recent years. For example, Zhang and Feng (2017) point out that the existence of gray market could impair the brand owner's profit. The authors propose a pricing strategy to ease the impact of gray market sales on the authorized channel. Besides, Autrey et al. (2014) investigate whether the centralized or decentralized decisions benefit a brand owner with the existence of gray market. They conclude that decentralization is preferred if the competition against gray market is based on quantity. Besides, the research interests in market segmentation are emerging in the literature. For instance, Raza et al. (2016) investigate the impact of market segmentation led by the price differentiation among environmental-friendly products and standard items on the FRSC decisions. They build an integrated revenue management model to identify the optimal decisions on pricing, green efforts, and ordering quantity. Moreover, they suggest that the market segmentation possibly leads to demand leakage.

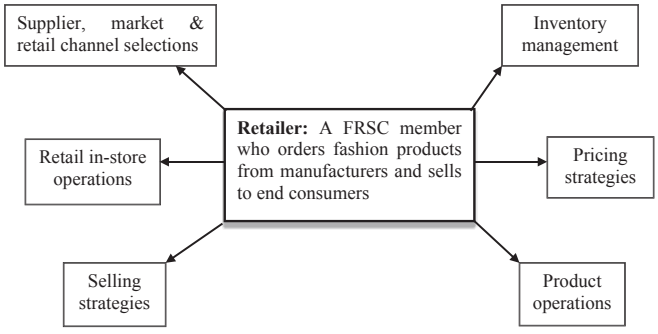

Fig. 4. Important topics for the fashion retailer.

Retail channel selection: In recent years, e-business has grown intensively all over the world, especially in the fashion retail industry. For example, an AIP survey[7] illustrates that the target products for 58% of the online purchasers are fashion items in China. With the development of online business, both the traditional offline physical stores and online stores are available for fashion retailers. Through online channel, customers can buy products via internet directly without walking into a store. In the literature, several studies explore online-offline integrated FRSCM decisions. For instance, Chen et al. (2011) consider two fashion retailers (retailer A and retailer B) with physical stores that can also accept the online orders from an e-tailer. Retailer A is of higher priority for the e-tailer to select. However, considering that a part of revenue is required to be shared with the e-tailer when accepting the online orders, retailer A always satisfies its own in-store demands with priority. A related work can be found in Chen et al. (2015b), where the fashion retailer operates two channels: An on-site physical store and a long distance online store. Different from the physical store where the consumer demand should be fulfilled immediately, the orders from the online store could be delayed for a period. Besides, these two channels share an inventory pool. On the other hand, some studies focus on the online fashion retailers. For example, Hua et al. (2016) investigate the optimal shipping strategy (whether to ship the products to consumers for free) and product return charging scheme for an online fashion retailer. The insights derived from their research explain why some

[7] https://marketingtochina.com/fashion-market-china-gets-next-level/.

online retailers provide free shipping and return strategies in the real world. Furthermore, Shen et al. (2017) build an analytical model to explore the impact of the variation in consumer demand on the performance of a luxury fashion retailer with the consideration of social influence. More online fashion retailing examples are illustrated in Altug and Aydinliyim (2016), Aydinliyim et al. (2017), and Xiao and Chen (2014).

3.2. Inventory management

Inventory management is critical for the success of a fashion retailer. A high-performance inventory management system can improve the competitiveness and profitability of retailers in the highly unpredictable and fast-changing fashion market, by providing superior customer service with minimum inventory related costs. The inventory replenishment strategy decides the time to place an order and the quantity to be ordered. Efficient utilization of the information collected from the market is crucial to make high-quality inventory decisions. In the fashion industry, retailers place orders to the suppliers for inventory replenishment either before or during the season (Şen and Zhang, 2009). Plenty of studies relate to inventory management, like Archibald et al. (2007), Choi (2007), de Brito and van der Laan (2009), McCardle et al. (2007), and Wu et al. (2015). For example, Choi (2007) concentrates on the pre-season inventory problem for a fashion retailer, while Archibald et al. (2007) evaluate several inventory management models for the survival of start-up companies.

RFID technology is an efficient inventory management and information collection tool, which is of great value for the fashion retail industry (Wong et al., 2012). RFID technology is based on radio frequency and the RFID tags attached to the inventory items, with which tracking, control, and replenishment become easier. However, the RFID readings sometimes lead to inaccuracy because the radio waves are absorbed, and the RFID tags are detuned, which is known as the "false-negative" impact that should be carefully considered in the RFID-based inventory management systems (Metzger et al., 2013). Besides, Chan et al. (2012) and Chan et al. (2015) investigate whether the RFID technology outperforms the traditional bar-coding approach based on the health care apparel industry. To be specific, Chan et al. (2012) explore the conditions under which the RFID technology achieves better performance than the bar-coding approach with the consideration of safety stock. Later, Chan et al. (2015) introduce the RFID system into a quick response supply chain and analyze the value of the information updated.

Inventory operations: Due to the highly volatile consumer demand and short selling season, leftover inventory (both the returned and unsold items) is commonly seen in the fashion industry. Frequent approaches to dealing with leftover inventory are: Sharing with other retailers (Huang and Sošić, 2010), clearing at a discount price (Caro and Gallien, 2012; Huang et al., 2014b; Lee, 2007; Lee and Rhee, 2007), and returning to the suppliers (Lee and Rhee, 2007; Li et al., 2014a; Yue and Raghunathan, 2007). An innovative research topic arising with the development of online fashion business is inventory disclosure (Aydinliyim et al., 2017). Online fashion retailers can show either the exact number of inventory items or just "in stock" to consumers, to imply the risk of stock out. Aydinliyim et al. (2017) firstly analyze the impact of inventory disclosure strategy on the profitability of an online fashion retailer. They obtain an inventory threshold, above which the retailer prefers to hide the exact inventory availability while below which it is better to reveal the real inventory level. Therefore, they conclude that it is not always the optimal decision to disclose the actual inventory. Besides, fashion retailers should identify the optimal inventory allocation strategies when they have multiple retail stores, in order to decide the optimal quantity of inventory items to be allocated to each store. Chen et al. (2015a) show that the multi-store inventory allocation problem is NP-hard when the decisions of markdown pricing strategy are integrated, even if the consumer demand is deterministic. They develop a rolling horizon approach coupled with Lagrangian relaxation technology to solve the complicated problem and demonstrate that the proposed solution algorithm outperforms the benchmark approach. Another important issue regarding retail inventory is the low inventory assortment effect which usually appears in the late selling season when the inventory level declines and there is a lack of non-homogenous products in the stores (Khouja, 2016). In such a case, the fashion consumers might not buy the products on the shelf that fail to satisfy their secondary expectations (like color, condition, size). Motivated by the significance of the low inventory assortment effect on the decisions of fashion retailers, Khouja (2016) investigates the optimal ordering quantity for a newsvendor retailer with the consideration of the low inventory assortment effect. His results show that the low inventory assortment effect decreases the optimal ordering quantity and this impact is significantly affected by the standard deviation of consumer demand. Besides, a discount strategy before the end of selling season is proposed to improve the retailer's profitability in this research. Moreover, Lee and Park (2016) examine the inventory decisions of two retailers who could implement transshipment between them to achieve cooperation. However, the two considered retailers may inflate their orders in order to compete for the supplier's capacity. The Nash equilibrium solutions of Lee and Park (2016) show that the carefully selected transshipment prices could mitigate the order inflation behavior.

3.3. Retail in-store operations

Retail capacity, retail assortment, shelf allocation, labor planning, and service quality management are fashion retailers' major considerations in terms of in-store operations.

Retail capacity: In addition to the production capacity of fashion manufacturers discussed in section 2.1, the retail capacity is another constraint to be considered in FRSCM decisions. The capacity of fashion retailers refers to the limitation of shelf space, budget, and long lead time. However, the giant fashion retailer, Zara, regards the retail capacity constraint as a strategy to sell products at a higher price (Liu and Van Ryzin, 2008). According to Liu and Van Ryzin (2008), Zara rationalizes its retail capacity strategy to ease the impact of strategic consumers on sales by creating rationing understock. They explain the trade-off between the lost and holding sales which is commonly observed in the fashion industry. However, the authors point out that this capacity rationalization strategy is not always advantageous especially when the consumers are risk neutral. Besides, it also fails even if the consumers are risk averse, but the proportion of high-valuation consumers is low.

Retail assortment: Fashion retailing is featured with huge product variety. However, what a consumer expects from a fashion retailer is just a limited quantity of certain types from the tremendous product assortment. Therefore, the retail assortment strategy is crucial for the performance of a fashion retailer. Maddah et al. (2014) investigate the optimal retail assortment decisions for the most popular products in a fashion store while Vaagen et al. (2011) explore to improve the robustness of retail assortment plans. Besides, considering the dynamic consumer demand of seasonal apparel products, Caro and Gallien (2007) improve the company's profit by dynamically optimizing the retail assortment strategy according to the real demand during the season. Moreover, Li et al. (2015) integrate the optimal retail assortment plan into the procurement strategy through a screening mechanism, while Caro et al. (2014) seek for trade-offs among the preference weights, profit margin, and short life cycle through a retail assortment packing strategy in the fashion industry.

Shelf allocation: Shelf allocation is critical for the retailers' performance, especially for the fashion retailers selling products with short shelf life. According to Hübner and Schaal (2017), shelf allocation even influences consumer demand. Although most of the related literature considers deterministic models, Hübner and Schaal (2017) apply stochastic demand into the shelf allocation problem for fashion apparel goods in order to maximize the retailer's profit. A new modeling approach is proposed to obtain the optimal solutions within short running times. Besides, they consider the impact of space elasticity on the

optimal shelf allocation strategy. In a related study, Abbott and Palekar (2008) explore space elasticity by considering a retail replenishment problem where the consumer demand is a linear function of the shelf space assigned to the product.

Labor planning: As fashion retail sales largely depend on the performance of in-store first-line sales staff, highly trained and skilled sales assistants significantly help enhance the consumers' purchasing intention and vice versa. Besides, labor cost is one of the largest compositions of a fashion retailer's total operational costs (Chuang et al., 2016). Therefore, the research interests in the fashion retail labor planning problem are emerging in recent years. For example, Chuang et al. (2016) investigate the effect of sales assistant on the sales performance based on a US women fashion apparel retailer, and construct a planning model to help the firm arrange labor source efficiently. They claim that the consumers' buying behavior is dependent on the ratio of the number of sales assistants to consumer traffic. Their numerical study demonstrates the efficiency of the proposed heuristic based solution algorithm. Moreover, Sainathuni et al. (2014) focus on the problem of staff congestion which affects the labor productivity of a US fashion clothing supply chain. An efficient local search based heuristic algorithm is proposed to ease the impact of manpower variation.

Service quality management: It is known that service operations management has become a popular research topic in recent years (Wang et al., 2015). In the fashion retail industry, the service quality of fashion boutiques is critical for the customer experiences which affects purchase intentions. One could expect that the level of service offered by the fashion boutiques should be high and the gap between consumer expectation with the actual perceived level of service should be small. Based on this knowledge, Choi et al. (2017) examine the service quality management issues through a revised retail quality scale model. The closed-form analytical results reveal that the equilibrium demands only rely on the service gap enhancement efficiency and the profit margin. Besides, Choi et al. (2017) prove that the demand sensitivity which is dependent on the relative problem-solving service gap is especially crucial for the fashion retailers.

Tables 3 and 4 in the appendix provide a structured review of the operational models in the literature examined in this part.

3.4. *Pricing strategies*

Fashion retail pricing is a high-risk game involving the guesses of competitors' decisions, consumer valuation, and the consideration of retailer's own operational cost. Nowadays, many pricing optimization software based on the analysis of enormous historical data help fashion retailers make pricing decisions more intelligently and dynamically, in order to deal with the fast-changing market (Elmaghraby et al., 2008). Besides, Charnsirisakskul et al. (2006), Huang et al. (2014c), and Şen and Zhang (2009) even utilize pricing strategies to control consumer demand. Large body of the literature has investigated the fashion retail pricing strategies, like Jadidi et al. (2017), Li et al. (2012), Liu et al. (2012), Shao et al. (2013), Webster and Weng (2008), Wu et al. (2012), and Xiao et al. (2015). For instance, Jadidi et al. (2017) study the pricing problem of a fashionable-product retailer where the supplier offers an all-unit quantity discount scheme. Their results demonstrate that the quantity discount scheme would benefit the supplier and retailer by increasing the profit pool. Moreover, the end consumers could also benefit from this policy.

A special pricing strategy, the preannounced markdown pricing strategy, is introduced by Elmaghraby et al. (2008) to deal with strategic consumers. In this scheme, the fashion retailer first sets a high price and preannounces to the consumers that there will be several markdown periods in the future. This pricing strategy is essentially a game between the retailer and the various sets of customers holding different product valuations. If only a few customers bid for the high price, then the purchasing intention of the high-valuation consumers will increase owing to the concern of stock out considering that more customers would buy the product at a low price. Oppositely, to hedge against demand uncertainty, the postponed pricing strategy does not determine the prices of fashion products until the real consumer demand is known (Chernonog and Kogan, 2014). Besides, Aloysius et al. (2013) propose the sequential pricing strategy to deal with demand uncertainty, where the price of one product is determined after the consumer preference for another product is observed through online shopping cart. On the other hand, the responsive pricing strategy, as proposed by Tang and Yin (2007), is a flexible pricing strategy to manage supply uncertainty with deterministic consumer demand, which enables the fashion retailer to determine the prices after knowing the actual supply yield. Compared with the traditional strategy where the ordering and pricing decisions are made before the real supply is observed, the responsive pricing strategy shows higher profitability.

Instead of static pricing, an increasing number of fashion retailers are adopting the dynamic pricing strategy to deal with the fast-changing market. Lin (2006) points out that demand forecasting is the key for the performance of dynamic pricing strategy. Plenty of research has investigated the related decisions. For instance, Lin (2006) modifies the retail prices dynamically according to the consumer traffic prediction which is corrected by real-time sales data to maximize revenue. Liu and Zhang (2013) consider a dynamic pricing problem where two competing fashion retailers and strategic consumers exist, while Chen et al. (2017) incorporate a menu cost into the dynamic price setting framework. Other literature considering dynamic pricing includes Akçay et al. (2013), Aloysius et al. (2013), Chen et al. (2015b), Elmaghraby et al. (2008), Huang et al. (2014c), Liu and Van Ryzin (2008), Şen and Zhang (2009), and Wu et al. (2015). Tables 5 and 6 in the appendix give a structured overview of the operational models in the literature introduced in this part.

3.5. *Selling strategies*

Bundling selling, advance selling, probabilistic selling, and open-box selling are commonly used selling strategies in the fashion industry. Firstly, the bundling selling strategy is to bundle several products and sell them together, which could be found in many industries such as fashion apparel, food industry, entertainment retailing, electronics, and cosmetics. The reasons for bundling selling include logistics cost reduction, market share and profit improvement, and packaging issues. McCardle et al. (2007) investigate the impact of bundling sales on the performance of a fashion retailer. They identify the optimal decisions on ordering quantity and bundling price to optimize total profit. Finally, they suggest that the profitability of the bundling selling strategy is determined by the demands for individual products, the relationships among these demands, and the bundling cost. Secondly, the advance selling strategy is studied by Li et al. (2014b), encouraging customers to pre-buy the fashion products before the start of season. However, the retailers may face a high level of product returns due to the uncertain consumer valuation. Therefore, Li et al. (2014b) point out that the fashion retailers should consider the price and refund policy carefully to maintain profitability. Next, the probabilistic selling strategy, as mentioned in Xiao and Chen (2014), is to provide an online consumer with another product which is convenient for the fashion retailer to supply, rather than the original selected one (e.g., different color), with a discount price. In fact, the probabilistic selling strategy targets the consumer group who is sensitive to price. Besides, the fashion retailer benefits from inventory pooling through this strategy. However, if the future demand is predicted to be high while the inventory is limited, the retailer may face a loss of revenue because many products are sold with a discount. Lastly, the open-box selling strategy, emerging with consumer returns, is introduced by Akçay et al. (2013), in which the returned fashion products are resold to consumers at a discount price with the boxes being opened. Not limited to salvaging the returned inventory, the open-box selling strategy helps capture late demand and further avoid lost sales.

3.6. Product operations

Fashion product operations include product variety, product substitution, and new product introduction.

Product variety: As discussed, fashion retailing is challenged by huge variety of products with unique demands. Therefore, it is crucial for fashion retailers to determine the level of product variety in retail stores. It is obvious that a high level of product variety contributes to high consumer satisfaction, consumer demand stimulation, and brand image development. Besides, product variety and portfolio alleviate the risk of demand uncertainties of individual products (Vaagen and Wallace, 2008). Furthermore, Choi (2016b) comments that a contract on product variety could coordinate a quick response FRSC. However, a high product variety level does not necessarily lead to high profit margin due to the increase in the costs of design, manufacturing, logistics, and inventory management. For example, Huang and Su (2013) claim that enormous product variety affects both directions of a reverse supply chain. Besides, Xiao et al. (2015) build two models with different channel leadership to study the decisions of pricing and product variety in the fashion apparel industry. They reveal that it is preferred to offer a higher level of product variety than just satisfying the market under a centralized retailer-led supply chain, while for a decentralized scenario, it is wise to keep a level exactly satisfying the market. Furthermore, in the other model with the supplier being the leader, the optimal level of product variety increases due to economies of scope.

Product substitution: When the needed fashion product is out of stock, consumers usually turn to a similar product for substitution (e.g., similar color, style). According to Vaagen et al. (2011), like product variety, product substitution is beneficial for fashion retailers to ease the impact of demand uncertainty. Several studies explore the impact of product substitution on FRSCs. For instance, Maddah et al. (2014) investigate the optimal retail assortment, inventory management, and pricing strategies when the product line contains substitutable fashion merchandise, while Stavrulaki (2011) considers the inventory management problem of two fashion products that can substitute each other, and suggests that under some conditions, product substitution helps increase total profit significantly.

New product introduction: For a fashion retailer, it is important to keep consumers interested in the products on the shelf. Launching new products frequently is an efficient approach to enhancing retailer's presence, maintaining existing customers, attracting new ones, and improving market share. Besides, initial sales, as pointed out by Gallien et al. (2015), play a pivotal role in the overall performance for the whole selling season, because the stock out in the initial stage brings huge negative impact on the later market. On the other hand, excessive initial inventory leads to a high inventory holding cost and a waste of leftover inventory. Consequently, the decisions on new product introduction are significant for the success of FRSCs. Gallien et al. (2015) develop a new data-driven system for the fast fashion retailer Zara to improve the decision quality on initial shipment. They build a heuristic based algorithm to obtain acceptable solutions with slight computational efforts. Their experimental results show that the system helps Zara achieve 2% growth in seasonal sales and 4% decline in leftover inventory. Additionally, Chiu et al. (2015b) determine the optimal launch time for fashion products with unknown demand, by formulating the decision framework as a stock loan problem that is commonly seen in the financial area. Besides, in the work of Caro et al. (2014), the optimal new product introduction strategies are studied with the retail assortment problem.

4. Consumer

As discussed, FRSC decisions are driven by consumer demand with diverse uncertainties. Therefore, studying consumer behavior, improving demand forecasting, and dealing with consumer returns are significant to the success of a FRSC. This section presents the publications in terms of fashion consumers from three aspects: Consumer behavior, consumer demand, and consumer return, as depicted in Fig. 5.

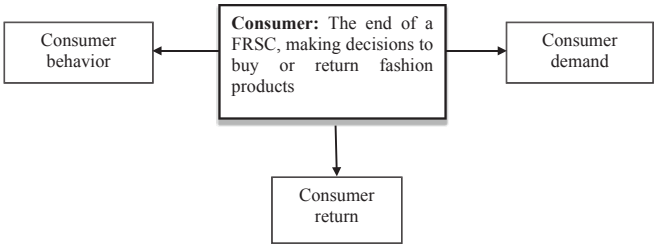

Fig. 5. Important topics related to fashion consumers.

4.1. Consumer behavior

Consumer behavior concerns about the experience, knowledge, intellectuality, and psychological characteristics of the customers. Consumers decide what to purchase, the quantity to purchase, and when/where to purchase. Owing to the importance of consumer behavior on the profitability of a FRSC, much research has been conducted to improve the efficiency of FRSC decisions by considering consumer behavior.

One research stream investigates the impact of consumer behavior on FRSC decisions (Altug and Aydinliyim, 2016; Chua et al., 2017; Taleizadeh et al., 2016). For instance, Chua et al. (2017) study how customer behavior affects the optimal discount and inventory replenishment decisions of a retailer who sells perishable products like fast fashion items. Besides, Taleizadeh et al. (2016) consider the influence of customer preference on a fashion manufacturer's selection between a direct online channel and a traditional retailer channel. They find that it is preferred for the supplier to select the online channel if consumers enjoy purchasing online rather than offline. Besides, the online channel contributes to lowering the product prices so as to enhance the consumer welfare. However, the supplier needs to invest in marketing and advertising itself through the online channel. On the other hand, if consumers prefer shopping in a physical retail store, the traditional retailer channel is hence selected. The manufacturer is responsible for marketing and advertising if the retailer is unwilling to make investments. Undoubtedly, the retail prices increase, and the consumer welfare is impaired through this channel.

Another research stream believes that the decisions made by fashion retailers influence the behavior of consumers (Aydinliyim et al., 2017; Chen and Chen, 2016; Xu et al., 2015; Yan and Cao, 2017; Yoo et al., 2015). For example, online fashion retailers can enhance the buying intention of consumers by strategically disclosing the inventory level, signaling the risk of stock out by intentionally hiding or showing the exact inventory (Aydinliyim et al., 2017). Besides, Xu et al. (2015) impose deadlines for returning fashion products to influence the customer return behavior. They suggest that customers decide whether to return or keep the product based on their valuation which is affected by the return deadline regulated by the retailers. Longer return deadline helps improve the consumer valuation for the product. Moreover, they suggest that the return policy should consider product life cycle and historical return rate. Based on these ideas, Xu et al. (2015) identify the optimal decisions on consumer return deadline, refund amount, pricing, and inventory level for a fashion retailer. Besides, Yan and Cao (2017) study the impact of payment method, ordering quantity, and assortment strategy on consumer behavior regarding returning products for a B2C US fashion retailer while Chen and Chen (2016) and Yoo et al. (2015) show that the product return policy influences consumers' buying behavior.

In the third research stream, the consumers who learn from experience, predict future discount, and adjust their purchasing behavior

are called strategic consumers. When consumers become strategic, the fashion retailer's profit is impaired and the efficiency of a FRSC is hurt (Li and Yu, 2017). Wu et al. (2015) point out that strategic consumers will deliberately postpone the purchase with the expectation for lower prices according to the historical pricing data while facing the risk of stock out. They call the estimated lower price expected by strategic consumers as the reference price. To relieve the impact of strategic consumers, Liu and Van Ryzin (2008) propose that the fashion retailers can intentionally cause understock to motivate consumers to buy at a higher price. Besides, Altug and Aydinliyim (2016) study how to utilize a product return policy to deal with strategic purchase postponement of online customers. They suggest that high-price sales increase with a lenient return policy because it is not too expensive for consumers to regret. Similar work is found in Elmaghraby et al. (2008), where a markdown policy is applied to affect strategic consumers. Additionally, Cachon and Swinney (2011) and Swinney (2011) believe that the efficiency of quick response strategies could be impaired by strategic consumers. Tables 7 and 8 in the appendix summarize the operational models in the literature introduced in this part.

4.2. Consumer demand

In the fashion industry, consumer demand is highly turbulent and unpredictable. Demand uncertainty is the major challenge considered by both researchers and practitioners. Stock-out caused by poor demand forecasting leads to a consumer loss and huge damage to brand image. On the other hand, the unnecessary inventory holding cost incurred by over-stock should be avoided. However, the fast-changing fashion trend, short selling season, and unpredictable consumer preference make the demand highly challenging to forecast. Besides, Sun and Debo (2014) insist that it is difficult for supply chain members to keep long-term partnership under turbulent environment. Therefore, much research has been conducted to improve the quality of demand forecasting (Lin, 2006; Swinney, 2011).

Fashion companies always conduct demand forecasting long before the selling season due to the concerns of production, capacity, transportation, cost, or contract, which leads to inaccuracy in the predicted demand. An efficient information updating mechanism contributes to improving the quality of demand forecasting by updating the latest market information that is close to the coming season. Besides, early sales data at the beginning of the season can be applied to update later demand information to ease the impact of demand uncertainty (Şen and Zhang, 2009). Bayesian information updating approach is widely used in the fashion industry. For example, Agrawal and Smith (2013) propose a Bayesian model to update demand forecasting for a FRSC with multiple retail stores, and further determine the optimal ordering and inventory allocation strategies. Choi et al. (2006) utilize the Bayesian approach to update fashion products' demand distribution using the sales data near the beginning of the season. Two updating models, one with unknown mean and variance, and another with unknown mean and pre-known variance, are compared. Their results show that the fashion retailer always benefits from the quick response policy under the second model. Other applications of the Bayesian information updating approach are observed in Berk et al. (2007), Caro and Gallien (2007), Chan et al. (2015), Choi (2007), Huang et al. (2017b), and Şen and Zhang (2009). Furthermore, O'Neil et al. (2016) utilize machine learning to predict the unknown demand without knowing the type of distribution, variance, and mean. Their proposed method only requires information regarding the upper and lower bounds on demand.

Demand nowcasting: With the development of online business and social media, the big data technology has seen great potential in improving fashion demand forecasting. Big data moves the traditional historical data-based demand forecasting to the advantageous big data-based demand nowcasting. An analytical example of the application is reported in Choi (2016a), where the fashion retailer adjusts its attitude towards future demand through analyzing the enormous consumer comments collected from various social media platforms. The author finds that the penetration of social media enables fashion brands to better identify consumer needs, complaints, and expectations, and further reduce the bullwhip effect that widely exists in a FRSC due to information distortion.

4.3. Consumer return

Due to the uncertain product valuation, fashion companies always face the challenge of consumer returns. Guide et al. (2006) report an over 100 billion US dollars of returned products (within ninety days for any reason) every year in the US. However, only a small part of value of the returned products are extracted by suppliers due to the long supply chains. As discussed in Taleizadeh et al. (2016), the suppliers selling directly to customers through the online channel facilitate high utility of the returned fashion products for reproduction, so as to improve environmental sustainability, while the traditional retail store channel decreases the rate of reproduction unless the manufacturer contracts with the retailer. Moreover, Reimann (2016) proposes to utilize the refurbished returned products collected in the early sales stage, to fulfill the later demand.

Motivated by the significance of consumer returns on the performance of a FRSC, many researchers pay attention to the decisions regarding consumer return policies, such as Chen and Bell (2011), Choi (2013c), Huang et al. (2014b), Li et al. (2014b), Yan and Cao (2017), and Yoo et al. (2015). For example, Chen and Bell (2013) examine two forms of product returns and their influence on the profits for both retailers and suppliers. Their results show that the retailers always prefer a manufacturer-led supply chain when the return rate is high. Finally, they demonstrate that the supply chain profit would be greatly impaired if the customer return is ignored. Moreover, Akçay et al. (2013) study a fashion retailer who applies a partial return policy and a full return policy. In the first policy, only a part of value of the returned product is refunded to the customer, while the second policy provides a 100% money-back guarantee. Then, the returned products are either salvaged or resold at a discount price. An operational model is constructed to decide the optimal ordering quantity, new product price, refund money, and discount price to resell the returned items. In a related work, Su (2009) makes comparisons between these two return policies. He suggests that the full return policy is not helpful to improve the FRSC performance while the optimal refund value should be lower than the original selling price. This idea is supported by Xu et al. (2015) which insists that the optimal refund money is equal to the salvage value of the returned product. However, a different finding is reported in Hsiao and Chen (2014), suggesting that the full return policy is more profitable when the high-valuation customers experience a low hassle cost. Besides, Heydari et al. (2017) comment that a money-back guarantee FRSC could be coordinated with a dual-buyback contract. Additionally, as the returned fashion products flow from customers to suppliers, there has been increasing attention paid to the reverse fashion supply chain or closed-loop fashion supply chain issues (e.g., de Brito and van der Laan, 2009; Guide et al., 2006; Huang and Su, 2013; Karakayali et al., 2013; Reimann, 2016).

5. Supply chain system

This section concludes the recent studies from the view of supply chain system in terms of channel coordination, fast fashion, information management, and risk management (see Fig. 6).

5.1. Channel coordination

With individual different objectives of members in a FRSC as well as the presence of double marginalization effect, the entire supply chain is usually unable to achieve optimality automatically. Both in the literature and practice, contracts are widely used to provide incentives for the FRSC members to achieve channel coordination. According to

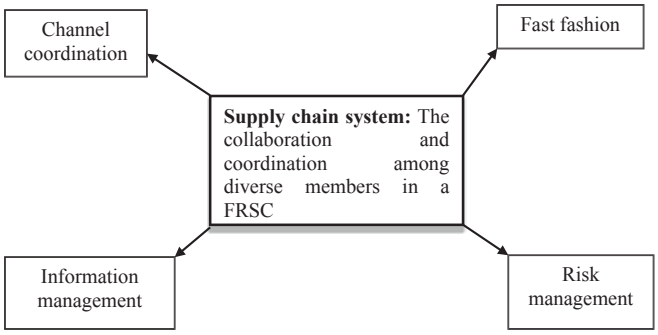

Fig. 6. Important topics in the supply chain system.

Cachon (2003), the supply chain is coordinated when the actions taken by the players facilitate a Nash equilibrium. Besides, a supply chain achieves Pareto optimality if at least one member is strictly better off, and no one is worse off after the contract is applied (or realizes the win-win situation where all members are strictly better off). For instance, in the problem of Yang et al. (2011), the retailer could firstly place an order to a long-lead-time supplier. After the demand information is updated through market observation, the retailer could cancel part of the order placed to the long-lead-time supplier and place a new order to a short-lead-time supplier. In this case, the long-lead-time supplier may suffer a loss from the order cancelation, despite that the retailer benefits from demand updating. Therefore, Yang et al. (2011) propose a return policy contract by charging an order-cancelation penalty to the retailer to coordinate the supply chain, which benefits the supplier. They show that it is easier to achieve coordination when the future market demand is observed to be sufficiently large. For the comprehensive review on supply chain coordination, we refer to Arshinder et al. (2011) and Cachon (2003). Table 9 in the appendix lists the 10 coordination contracts most frequently applied in the selected literature and the corresponding example references. Table 10 (appendix) summarizes the major assumptions and extensions of the operational models in the example literature. Particularly, the buyback contract and wholesale pricing contract are the two most popular coordination strategies. Other coordination contracts are like quantity compensation contract (Lee et al., 2013), two-part price contract (Yan and Cao, 2017), advance-purchase contract (Deng and Yano, 2016), inventory subsidizing contract (Chen et al., 2016), supply contract (Wang et al., 2012), gain/loss sharing contract (Wang and Webster, 2007), linear margin contract (Xiao et al., 2015), cost sharing contract (Wang et al., 2011b), and supply option contract (Zhao et al., 2018). For example, Wang et al. (2011b) build optimal cooperative advertising policies and a cost-sharing contract to solve a cooperative advertising problem between a supplier with competing retailers. Besides, Zhao et al. (2018) propose a novel supply option contract to coordinate a two-echelon apparel supply chain by developing a two-stage model where a stochastic spot market exists. The authors evaluate the expected benefits gained per unit of the option under different market situations. Zhao et al. (2018) greatly contribute to the literature through the analytical characterization of the option contract and deriving original managerial insights for the application of the supply option contract.

5.2. *Fast fashion*

Considering the long lead time and volatile consumer demand of the fashion industry, the quick response (QR) strategy is developed to reduce lead time and improve demand forecasting. QR helps the FRSC react to the change in market rapidly, which contributes to the development of fast fashion. According to Mehrjoo and Pasek (2016), fast fashion is to provide customers with the most fashionable products within the shortest time, which requires flexible and responsive FRSC structures, even if high costs are resulted. Giant fast fashion brands, such as H&M and Zara, have shortened the lead time from several months to only a few weeks. The postponement product differentiation strategy, postponing the final product design (e.g., color) near the season when the market information collected is more accurate, is applied to reduce lead time (Choi, 2016c; Zhang et al., 2013). However, even though the retailers benefit from the fast fashion strategy through more precise demand information and a lower inventory level, the manufacturers usually suffer from the reduction in ordering quantity and the high investment cost in constructing a flexible supply chain. In order to achieve fast fashion supply chain coordination, strategic contracts must be developed. Such contracts could be inventory service level commitment (Chan et al., 2015; Choi and Chow, 2008), minimum ordering quantity commitment (Chow et al., 2012), price commitment (Choi and Chow, 2008; Chow et al., 2012), minimum quantity with price commitment (Chan et al., 2015), buyback contract (Choi and Chow, 2008), or surplus-sharing and tariff contract (Choi, 2016a). Many works investigate the fast fashion strategies from different perspectives, like Cachon and Swinney (2011) (enhanced design and strategic consumers), Li et al. (2014a) (the impact of product return strategy), Choi and Chow (2008) (mean-variance analysis), and Mehrjoo and Pasek (2016) (risk management). For a detailed review about fast fashion, the readers are referred to Caro and Martínez-de-Albéniz (2015).

5.3. *Information management*

A high-quality information management system is of great significance to the success of a FRSC. For a fashion company in the current highly competitive market, information refers to not only the historical data, but also the real-time operations data (e.g., inventory level, customer traffic, product return, and consumer feedback), future trend, and knowledge of competitors. The importance of efficiently managing information flows within the fashion companies and across the FRSC are emphasized in Anand and Goyal (2009). It is crucial for a fashion firm to manage what it knows, what other FRSC members know, and what the competitors know. Moreover, Anand and Goyal (2009) highlight the significance of balancing information flows with material flows in a FRSC on maximizing total profit. Many studies explore the impact of information management on the performance of FRSCs. For instance, de Brito and van der Laan (2009) demonstrate that the unreliable and inaccurate historical product return information imposes great negative impacts on the decisions of fashion retailers and suppliers. Besides, information updating plays an important role in improving demand forecasting (as discussed in section 4.2).

Information asymmetry refers to a situation where the members in a FRSC possess their own private information which is not observable by others. Fashion manufacturers generally have inferior information regarding consumers than fashion retailers. Information asymmetry affects the supply chain coordination strategies significantly. For example, Li et al. (2014a) and Yue and Raghunathan (2007) study whether a return contract could coordinate a FRSC with information asymmetry, while Chiu et al. (2016) investigate the influence of information asymmetry on the FRSC coordination decisions under different channel leadership. Moreover, Burnetas et al. (2007) design a quantity discount contract for a fashion manufacturer with worse knowledge of consumer demand, in order to affect the retailer's inventory decisions.

Information sharing helps improve the quality of FRSC decisions. The research interests in information sharing are emerging in recent years. For instance, Liu and Özer (2010) highlight the importance of demand information sharing on improving supply chain performance, and propose a buyback contract to achieve information sharing between the supplier and the retailer. Besides, Chen and Bell (2013) show that the consumer return information sharing helps avoid the revenue loss caused by information distortion. Moreover, Chen (2011) shows that with a buyback contract, the fashion retailer prefers to share the

consumer return information if the supplier overestimates the information. A similar study is found in Yan and Cao (2017), where a two-part pricing contract is proposed to motivate the fashion apparel retailer to share the consumer return information with its supplier. Moreover, the information regarding inventory status and consumer demand is shared in a FRSC, which is demonstrated to positively influence the supply chain coordination strategies and improve total profit (Huang et al., 2017b). Instead of passively receiving the information shared by retailers, fashion suppliers could also share the information they collect from the market to affect the behavior of retailers (Guo and Iyer, 2010; He et al., 2008; Liu and Özer, 2010). In addition to the information sharing along a FRSC, the sharing within the same echelon is studied. For example, Chen et al. (2011) investigate the optimal online order acceptance decisions for two fashion retailers who share inventory information with each other.

5.4. Risk management

A FRSC encounters inherent diverse uncertainties, which leads to challenges and risk. On the consumer side, apart from demand, uncertainties in consumer valuation (Akçay et al., 2013; Chen and Chen, 2016; Li et al., 2014b; Swinney, 2011; Xu et al., 2015), consumer preference (Aloysius et al., 2013; Xiao et al., 2015), consumer population (Swinney, 2011), consumer reservation price (Huang et al., 2014c; Lin, 2006), consumer return (de Brito and van der Laan, 2009; Liu et al., 2012), and consumer arrival (Lin, 2006; Xiao et al., 2016) are frequently studied in the literature. Besides, a FRSC also faces various uncertainties arising from the supply side (e.g., supply yield, supplier responsibility, and lead time). For example, Tang and Yin (2007) deal with the uncertain supply yield using a responsive pricing strategy for a fashion retailer. Facing the supply quality uncertainty, Lee et al. (2013) show that the traditional buyback and revenue sharing contract fail to coordinate the FRSC. Instead, they propose a new coordination scheme, named the quality-compensation contract, to realize FRSC coordination. Besides, to deal with the supplier responsibility risk, Chen and Lee (2016) propose three common approaches: Supplier certification, contingency payment, and process audit. Furthermore, the supply lead time uncertainty is studied in Wu et al. (2012). Other uncertainties in a FRSC are like market condition switch time (Chiu et al., 2015b) and market size (Li and Yu, 2017; Wu et al., 2015).

It is critical for all the members in a FRSC to consider the various types of uncertainties and risks carefully, so as to improve the efficiency of decision making. Therefore, the research interests in FRSCM risk management have grown rapidly in recent years. For example, based on the fashion industry, Chow et al. (2015) study risk management with the consideration of minimum profit share. Their results imply that when the ratio of minimum profit share grows, the risk level of the manufacturer declines while that of the retailer increases. Besides, Zhao et al. (2014) investigate the impact of consumer demand uncertainty on the applicability of a buyback contract in the fashion industry. They conclude that it is crucial to consider the demand uncertainty risk when constructing contracts. Furthermore, mean-variance analysis, a risk analysis tool widely used in the financial industry, has seen great potential for the application in FRSCM (e.g., Chiu et al., 2011; Chiu et al., 2015a; Choi, 2016c; Choi and Chow, 2008; Choi et al., 2008; Cui et al., 2016; Li et al., 2014a; Shen et al., 2013; Wei and Choi, 2010). For instance, Cui et al. (2016) investigate the optimal store brand introduction strategies using the mean-variance formulation for a risk-averse retailer, and prove that the substitution factor and the risk deducted surplus of the store brand product are crucial for the decision making. Besides, based on the classic Markowitz portfolio theory in finance, Chiu et al. (2011) utilize the mean-variance approach to analyze the effect of the target sales rebate contracts on supply chain coordination when the retailer is risk-averse. We refer to Chiu and Choi (2016) as a comprehensive review of the application of mean-variance analysis in FRSCM. Besides, Mehrjoo and Pasek (2016) utilize the Conditional Value at Risk (CVaR) measure to assess FRSC risks.

Several risk management strategies are found in the recent literature. Firstly, the risk sharing strategy is widely applied both in the industry and academia. For example, the supply and inventory risks arising from consumer demand uncertainty are proposed to be shared among several FRSCs when the vacant reserved lead-time capacity is regarded as options on futures or futures for trading (Hung et al., 2013). Besides, Chen et al. (2016) develop a risk sharing based contract and an inventory subsidizing strategy to achieve FRSC coordination. Moreover, the return policy between fashion suppliers with retailers is to share the risk of leftover inventory (Archibald et al., 2007; Lee and Rhee, 2007). Next, the mentioned postponement strategies, like the postponed pricing strategy in Section 3.4 and the postponement product differentiation strategy in Section 5.2, substantially help minimize FRSC risks by postponing decision making nearer to the season. Similarly, mass customization, a strategy to postpone final product design and assembly just before passing the products to consumers, is actually a risk pooling strategy which greatly eases the impact of demand uncertainty by satisfying individual consumer's specific preferences with a lower inventory level (Liu et al., 2012). We refer readers to Fogliatto et al. (2012) for a thorough review of mass customization. Besides, the information updating strategy to improve the accuracy of demand forecasting is a method to reduce the risk from demand side (as discussed in Section 4.2).

6. Conclusion and future research agenda

The decisions in FRSCM are highly retailer-led and consumer demand driven. Owing to the diverse inherent uncertainties from both the demand and supply sides, FRSCM has become an important and challenging aspect in the domain of operations research and management science. A high level of research interests in FRSCM is confirmed by the trend of publications in the recent decade. However, there is a lack of comprehensive review of analytical modeling studies in FRSCM in the existing literature. Motivated by the significance to update the most recent knowledge in this research area, we review 144 papers selected from the mainstream OR/MS/OM journals published in the recent decade (2016–2017). It should be noted that the main contribution of this review is to investigate those analytical studies which utilize OR techniques and models to explore FRSCM problems.

Considering that most FRSCM studies investigate problems arising from the different functional areas of a FRSC, we systematically structure this review according to the four core members, namely the manufacturer, retailer, consumer, and supply chain system. In each section, the related studies and research development are examined. In particular, fashion manufacturers are concerned with the problems of production, product design, channel selection (retailer channel or dual channel), and shipment most. Besides, we highlight that there are several critical issues involved in the consideration of fashion retailers: Retailer selection (supplier, market, and retail channel), inventory management, retailer in-store operations (retail capacity, retail assortment, shelf allocation, and labor planning), pricing strategies, selling strategies, and product operations (product variety, product substitution, and new product introduction). Then, regarding fashion customers, we identify that consumer behavior, consumer demand, and consumer return concern the FRSCM decision makers most. Finally, the supply chain system is investigated from the perspectives of crucial areas such as channel coordination, fast fashion, information management, and risk management. As a concluding remark, we have the following findings from the reviews:

1. Most popular problem setting: Regarding problem setting, the newsvendor model is employed much frequently in the selected FRSCM literature (76 times in total). In fact, the newsvendor problem refers to a situation where the decision maker should decide the optimal inventory level of a product with uncertain demand that will be obsolete at the end of a short selling season, in order to

Table 11
Future exploration areas in the analytical OR models.

	Analytical Models	Retail in-store operations	Pricing strategies	Consumer behavior	Channel coordination
Approach	Computational-based analysis		✓	✓	✓
Real world relevance	Real case		✓	✓	✓
	Real data	✓	✓	✓	✓
Model features	Multi-period			✓	✓
	Multi-product		✓	✓	✓
Objective	Minimize cost	✓	✓	✓	✓

achieve profit maximization (Petruzzi and Dada, 1999). Therefore, it is extensively applied in OR modeling research in FRSCM where the products are featured with short lifecycles and highly uncertain demands.

2. Multi-echelon nature: Most of the FRSCM decisions are multi-member involved in order to yield the supply chain system-wide optimal decisions. For example, fashion manufacturers make production schedules according to the orders from retailers, while the ordering strategies of retailers are based on consumer demand. On the other hand, the inventory decisions of fashion retailers could be influenced by manufacturers through FRSC coordination contracts, while retailers could affect consumer demand through strategic pricing, selling, and return policies.
3. Downstream oriented: The review results clearly show that there is more research concentrating on downstream FRSC members (retailers and customers) than upstream agents (manufacturers). This finding is as expected as the definition of FRSCM which implies that the focus of FRSCM study is on the retailer and customer sides. However, operations of fashion manufacturers are still worthy of investigation because they relate to downstream members closely and significantly affect the performance of the whole FRSC. For example, as the start of a FRSC, fashion manufacturers should work smoothly with retailers to provide sufficient and accurate inventory to avoid stock out or overstock, so as to better satisfy the market. Besides, designing products that capture the latest fashion trend and transporting the products to the right place at the right time are profit engine of a FRSC.
4. Uncertainties: Diverse sources of uncertainties are the major challenges faced by the FRSCM decision makers. As shown in the operational model summary tables, demand uncertainty is the primary risk source considered by researchers, which is consistent with the nature of a FRSC. Therefore, risk management has become a central part of FRSCM studies. Widely used risk management strategies include updating demand forecasting close to the season, postponing the pricing, product differentiation, and product design decisions, and sharing risks with other stakeholders. All of these mechanisms are reactive actions. However, more studies are needed to investigate the effect of proactive strategies like stimulating demand, setting or influencing fashion trend.
5. Analysis approach: The summarized characteristics of the operational models from Table 3 to Table 10 show that most works employ the “close-form” analysis approach, while a few studies conduct the computational-based analysis. For the close form analysis, game theory is widely applied. In the computational-based analysis, (mixed) integer programming, stochastic programming, Lagrangian relaxation, and heuristics are frequently used. Additionally, more research considers stochastic demand instead of deterministic, which is consistent with the essence of the fashion industry. Besides, most studies pursue exact solutions rather than approximate outputs. It is also interesting to notice that the majority of models seek for profit (revenue) maximization rather than cost minimization.
6. Future model extensions: By analyzing the review results of the analytical models in four research topics, namely retail in-store operations, pricing strategies, consumer behavior, and channel coordination (Tables 3–10), we have identified several future probable extensions of the analytical modeling FRSCM research according to the number of selected papers applying the model features. For example, regarding the model objectives, nearly all the selected papers are dedicated to maximizing profits/revenues, instead of minimizing costs. Besides, except retail in-store operations, all the other three research topics utilize the close-form analysis approach much more frequently than the computational-based analysis approach. Therefore, we summarize the potential future model extensions in Table 11. Specifically, more computational-based analysis, real case research, and multi-product studies are needed for pricing strategies, consumer behavior, and channel coordination. In terms of real data and cost minimization studies, there is a large open space left for future research in all the four areas. For consumer behavior and channel coordination related research, most existing works examine the single-period problems; therefore, more attention should be paid on the multi-period cases. Finally, implementation of the OR models and techniques is critically important, and future research should pay attention to it.

Lastly, as we can see from the findings derived from our literature review, despite that plenty of research studies have already been devoted to FRSCM, there still exist some under-explored topics which call for future research. We propose some most important ones as follows.

a) **Outsourcing logistics:** With the advantages of third-party firms' professional knowledge and skills, outsourcing (e.g., product design, manufacturing, logistics) is commonly seen in the fashion industry. According to the review results, product design and manufacturing decisions in outsourcing have been widely investigated. However, the issues on outsourcing logistics are underexplored, e.g., transportation scheduling in FRSCs, as well as the role of third party logistics service providers in the “buy online pick up in store” retail operations (e.g., in companies like Uniqlo). Therefore, more attention should be paid to build practical models and efficient algorithms to generate better outsourcing logistics solutions.
b) **Cross selling/up selling:** According to Wong et al. (2012), the cross selling strategy helps improve profit on the existing consumers by selling them additional items that are associated with the product they originally purchase, while the up selling strategy is to persuade consumers to buy an upgraded version of the original intended product, which is usually achieved by a sales assistant. These selling strategies are beneficial for fashion retailers and commonly seen in practice. However, there is no analytical literature considering fashion products cross selling or up selling. Future studies can develop applicable models and efficient solution methods to generate valuable insights regarding cross/up selling strategy, which will benefit the fashion retailers a lot.
c) **Horizontal collaboration:** Collaboration within the same FRSC echelon is commonly seen in the fashion industry. For example, the fashion retailers under the same brand umbrella usually share consumer information and conduct promotions together. Besides, different fashion retailers may work with the department store to have an accumulated point system during some promotion periods. Moreover, small fashion manufacturers usually collaborate to take up big orders from giant retailers. However, the horizontal

collaboration in FRSCs is underexplored. Consequently, future research can fill this gap by studying the decision frameworks and identifying the optimal strategies for the horizontally collaborative FRSC members.

d) **Social and environmental responsibility:** Lee and Tang (2017) propose that researchers are going beyond the traditional supply chain management research areas such as production, quality, inventory, and scheduling. Social and environmental responsibility of the companies that operate in developing economies has attracted increasing research interests. Our review shows that green product design and green shipment have been integrated into FRSCM decisions. However, this area is still underexplored and deserves more research. Issues such as social and economic well-being, non-profit activities, and environmental sustainability of FRSCs should be investigated. More analytical and operational models and solution methodologies with high efficiency should be developed to improve the firms' social and environmental responsibility.

e) **Proactive risk management:** Due to the diverse inherent uncertainties of the fashion industry, risk management is crucial for the success of FRSCs. As discussed, most of the existing risk management strategies applied in the literature are reactive mechanisms, which leaves open space for researchers to investigate more efficient strategies, develop novel models, and construct high-performance solution approaches from the perspective of proactive risk management.

To summarize, this paper examines the most recent literature that applies OR techniques and models to improve FRSCM decisions and updates the most advanced knowledge for the four FRSC core members. Future research opportunities are proposed. We hope this paper will lay the foundation for the topic and help inspire more future research to address many challenging issues in FRSCM.

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Appendix

Table 3
Major features of the OR models on retail in-store operations in FRSCM.

Reference	Real case	Real data	Newsvendor model	Single-period	Multi-period	Single-product	Multi-product
Abbott and Palekar (2008)					✓	✓	✓
Caro and Gallien (2007)	✓				✓		✓
Caro et al. (2014)	✓	✓		✓	✓	✓	✓
Choi et al. (2017)	✓	✓				✓	
Chuang et al. (2016)	✓	✓			✓		
Hübner and Schaal (2017)			✓	✓			✓
Maddah et al. (2014)			✓	✓			✓
Li et al. (2015)			✓	✓			✓
Liu and Van Ryzin (2008)					✓	✓	
Sainathuni et al. (2014)	✓	✓			✓		✓
Vaagen et al. (2011)	✓	✓	✓	✓			✓

Reference	Analysis approach		Analysis tool	Objective			Solution type	
	Close form analysis	Computational-based analysis		Maximize profit/revenue	Minimize cost	Others	Exact solutions	Approximate solutions
Abbott and Palekar (2008)	✓		Lambert W function, Taylor series expansion of matrix exponential	✓			✓	✓
Caro and Gallien (2007)	✓	✓	Gamma-Poisson Bayesian learning mechanism, Dynamic programming, Lagrangian decomposition, Multiarmed Bandit Model, Nelder-Mead simplex method	✓				✓
Caro et al. (2014)	✓	✓	Continuous relaxation, Fractional programming, Heuristics	✓			✓	✓
Choi et al. (2017)	✓		Multimethodological approach	✓			✓	
Chuang et al. (2016)	✓	✓	Lambert W function, Data-driven staffing heuristic	✓		Minimize optimality gap	✓	✓
Hübner and Schaal (2017)		✓	Mixed integer programming, Heuristic	✓			✓	✓
Maddah et al. (2014)	✓		Poisson decomposition, Taylor series-based approximation, Multinomial Logit Choice model	✓		Minimize the sum of squared deviations	✓	✓
Li et al. (2015)	✓		Multinomial logit model	✓	✓		✓	
Liu and Van Ryzin (2008)	✓		Game theory, Power utility function	✓			✓	
Sainathuni et al. (2014)		✓	Non-linear integer programming, Heuristic		✓			✓
Vaagen et al. (2011)		✓	Stochastic mixed integer programming, Simulation-based optimization approach, Heuristic	✓				✓

Table 4
Major assumptions and proposed extensions of the OR models on retail in-store operations in FRSCM.

Reference	Major assumptions						Major extensions or future directions
	Uncertainty		Demand feature			Others	
	Demand	Others	Deterministic	Random	Function		
Abbott and Palekar (2008)			✓		A linear function of the basic sales rate and shelf space	1. A proportional space allocation principle; 2. A known initial space allocation plan; 3. A unit of product occupying a unit of shelf space	Matrix exponential method error bounds
Caro and Gallien (2007)	✓			✓	Gamma distribution	1. Dependent demands on substitutable products; 2. No assortment plan changing costs; 3. No decision implementation lead time	1. Assortment plan changing costs; 2. Decision implementation lead time; 3. Impact of substitution
Caro et al. (2014)			✓		Attraction demand model	1. An open-loop strategy; 2. No shelf-space limitations; 3. Homogeneous products	1. Shelf-space limitations and budgets; 2. Product removals
Choi et al. (2017)			✓		A decreasing linear function	1. The cost function is demand-dependent which is modeled as an increasing convex quadratic function	1. Stochastic version of the model
Chuang et al. (2016)			✓		A sales response function related to labor and traffic	1. A declining-rate growing relationship between the retailer revenue and sales labor; 2. Experienced and cookies labor; 3. A variable substitution elasticity between consumer traffic and store labor	1. Other labor-service industries; 2. Labor turnover, workforce experience, and inventory levels; 3. Full-time and part-time labor differentiation
Hübner and Schaal (2017)	✓			✓	Random demand dependent on the shelf space allocated	1. Limited shelf space; 2. A goodwill cost; 3. A direct replenishment strategy without backroom storage	1. Category planning; 2. Shelf refilling; 3. Multi-store and multi-period cases
Maddah et al. (2014)	✓	Consumer utility		✓	Normal distribution	1. Multinomial Logit Choice model based utility; 2. No salvage value	1. A fixed assortment size; 2. An exogenous price
Li et al. (2015)	✓			✓	Multiplicative demand model	1. A linear assortment planning cost dependent on the variants quantity; 2. Full knowledge of cost information for the retailer; 3. No salvage value; 4. A goodwill cost; 5. Exogenous retail prices	1. Endogenous retail prices; 2. Multiple retailers; 3. A normally distributed demand
Liu and Van Ryzin (2008)		Consumer valuation	✓		Deterministic aggregate demand	1. Heterogeneous consumer valuations and unit demand; 2. Identical consumer risk preferences; 3. Full knowledge of future prices and fill rate for consumers; 4. A preannounced pricing strategy; 5. Risk averse consumers and risk neutral retailers; 6. No disutility of unmet demands	1. Application of the optimal prices; 2. Discounting utilities and profits; 3. Normally or log-normally distributed consumer valuations; 4. Demand uncertainty; 5. Symmetry competition; 6. Other utility functions
Sainathuni et al. (2014)			✓		Given fixed demand	1. No backorders; 2. Sufficient supply; 3. Known warehouse strategic decisions	1. Multiple warehouses; 2. Technology decisions; 3. Labor cross-training
Vaagen et al. (2011)	✓			✓	Exogenous demand model	1. Substitutable products; 2. Independent consumer decisions on the substitutable products	A full description of substitution

Table 5
Major features of the OR models on pricing strategies in FRSCM.

Reference	Real case	Real data	Supply chain feature		Model setting		Single-period	Multi-period
			Decentralized	Centralized	Newsvendor model	Stackelberg model		
Akçay et al. (2013)					✓		✓	
Aloysius et al. (2013)								✓
Charnsirisakskul et al. (2006)					✓			✓
Chen et al. (2017)								✓
Chen et al. (2015b)								✓
Chernonog and Kogan (2014)			✓	✓	✓	✓		✓
Elmaghraby et al. (2008)							✓	
Huang et al. (2014c)								✓
Jadidi et al. (2017)					✓		✓	

Li et al. (2012)			✓	✓		✓	✓	
Lin (2006)							✓	
Liu and Van Ryzin (2008)								✓
Liu and Zhang (2013)								✓
Liu et al. (2012)							✓	
Şen and Zhang (2009)	✓	✓						✓
Shao et al. (2013)	✓		✓				✓	
Tang and Yin (2007)								✓
Webster and Weng (2008)	✓			✓			✓	
Wu et al. (2012)	✓				✓			✓
Wu et al. (2015)					✓			✓
Xiao et al. (2015)	✓		✓	✓		✓	✓	

Reference	Single-product	Multi-product	Analysis approach			Analysis tool	Objective		Exact solutions
			Close form analysis	Computational-based analysis	Game theory	Others	Maximize profit/revenue	Others	
Akçay et al. (2013)	✓		✓			Stochastic fluid model	✓		✓
Aloysius et al. (2013)		✓	✓		✓		✓		✓
Charnsirisakskul et al. (2006)		✓		✓		Mixed integer programming, Heuristics	✓		✓
Chen et al. (2017)	✓		✓			Dynamic programming	✓		✓
Chen et al. (2015b)	✓		✓			Dynamic programming	✓		✓
Chernonog and Kogan (2014)	✓		✓		✓	Dynamic programming	✓		✓
Elmaghraby et al. (2008)	✓		✓		✓		✓		✓
Huang et al. (2014c)	✓			✓		Nonlinear Programming, EOQ model	✓		✓
Jadidi et al. (2017)	✓		✓		✓		✓		✓
Li et al. (2012)		✓	✓		✓		✓		✓
Lin (2006)	✓		✓			Heuristic	✓		✓
Liu and Van Ryzin (2008)	✓		✓		✓	Power utility function	✓		✓
Liu and Zhang (2013)	✓		✓		✓	Markov perfect equilibrium	✓	Maximize consumer's utility	✓
Liu et al. (2012)	✓		✓			Mean-variance analysis	✓	Maximize MV utility	✓
Şen and Zhang (2009)		✓	✓			Bayesian approach, Dynamic programming	✓		✓
Shao et al. (2013)		✓	✓		✓		✓		✓
Tang and Yin (2007)	✓		✓			Two-stage stochastic model	✓		✓
Webster and Weng (2008)	✓		✓				✓		✓
Wu et al. (2012)	✓		✓			General multiplicative random lead-time model	✓		✓
Wu et al. (2015)	✓		✓		✓	Dynamic programming	✓		✓
Xiao et al. (2015)		✓	✓		✓		✓		✓

Table 6
Major assumptions and extensions of the OR models on pricing strategies in FRSCM.

Reference	Major assumptions							Major extensions or future directions
	Uncertainty		Demand feature			Dynamic pricing	Others	
	Demand	Others	Deterministic	Random	Function			
Akçay et al. (2013)	✓	Customer valuation, Consumer arrival		✓	General distribution	✓	1. No extra cost for open-box sales; 2. No-return final open-box sales; 3. Homogenous consumers	Heterogeneous Consumer
Aloysius et al. (2013)	✓	Customer valuation, Consumer preference		✓	Random demand dependent on pricing decisions	✓	1. Myopic consumers; 2. Each consumer buying one unit of product; 3. Independent consumer valuation for the two products	Rational consumers
Charnsirisakskul et al. (2006)			✓		Given customer orders		1. Made-to-stock products; 2. Price customization or single price; 3. The longest order fulfillment time	Uncertain demand
Chen et al. (2017)	✓	Consumer arrival, Consumer choice		✓	Markovian demand process	✓	1. Heterogeneous consumers; 2. Deteriorating product quality; 3. Holding costs and menu costs	1. Compound Poisson demand; 2. General consumer utility function
Chen et al. (2015b)	✓			✓	A Stochastic function based on the price mean demand model	✓	1. Inventory holding costs and backorder costs; 2. Completely backlogged unsatisfied demand; 3. No salvage value; 4. Independent markets	Dependent markets
Chernonog and Kogan (2014)	✓			✓				

					General distribution		1. No goodwill cost and salvage value; 2. Risk-averse retailer	The impact of risk aversion on the supply chain
Elmaghraby et al. (2008)			✓		Price-dependent demand	✓	1. Risk-neutral retailer and consumers; 2. Exogenous initial inventory level; 3. Constant consumer valuation	1. Declining consumer valuation; 2. Incomplete information
Huang et al. (2014c)		Reservation price	✓		A function of price	✓	1. Price change limit; 2. Replenishment limit; 3. Non-deteriorating quality; 4. Partial backlogging; 5. No comparison products in the market	1. Consumer behavior related factors; 2. Lead time
Jadidi et al. (2017)	✓				A Stochastic function based on price		1. The unit holding and shortage costs are zero to derive propositions; 2. The stochastic part of demand follows the normal or uniform distribution	1. A discount is given to the consumer if it combines orders of different products from a manufacturer
Li et al. (2012)	✓			✓	A price-dependent linear function containing a random variable		1. Announced constant discount policy; 2. Exogenous off-season product discount rate	1. Inventory strategy; 2. Optimal discount policy; 3. Incomplete information
Lin (2006)	✓	Consumer arrival rate, Consumer reservation price		✓	Negative binomial distribution	✓	1. Independent consumer reservation price; 2. No salvage value; 3. Correct consumer recording; 4. Continuous set of prices	1. Unrecorded lost consumers; 2. Time-dependent consumer arrival; 3. Batch demand; 4. Discrete prices
Liu and Van Ryzin (2008)		Consumer valuation	✓		Deterministic aggregate demand	✓	1. Heterogeneous consumer valuation and unit demand; 2. Identical consumer risk preferences; 3. Full knowledge of future prices and fill rate for consumers; 4. Preannounced pricing strategy; 5. Risk averse consumers and risk neutral retailers; 6. No disutility of unmet demands	1. Application of the optimal prices; 2. Discounting utilities and profits; 3. Normally or log-normally distributed consumer valuation; 4. Demand uncertainty; 5. Symmetry competition; 6. Other utility functions
Liu and Zhang (2013)		Consumer valuation	✓		Intertemporal demand substitution	✓	1. No rationing risk; 2. Exogenous quality level; 3. Heterogeneous consumer valuation; 4. Unlimited capacity; 5. Strategic consumers	1. Myopic consumers; 2. Static pricing;
Liu et al. (2012)	✓	Consumer return		✓	A price-dependent linear function containing a random variable		1. Partial refund; 2. Modularity-level-independent production cost; 3. Product-return-associated value loss	Modularity-level-dependent production cost
Şen and Zhang (2009)	✓			✓	Poisson distribution	✓	1. No inventory holding cost; 2. Expensive late orders; 3. Only one order for the off-shore supplier; 4. Multiple orders for the domestic supplier	In-season inventory replenishment
Shao et al. (2013)	✓			✓	Random initial demand plus spillover demand		1. Horizontal-differentiated products; 2. Risk-neutral members; 3. Only one allowed spillover demand for a consumer; 4. Retail duopoly	1. Multiple product variants; 2. Vertical-differentiated products; 3. Retail oligopoly; 4. Retail assortment policy
Tang and Yin (2007)		Supply yield	✓		A function dependent of price		1. One order and one price setting before the selling season; 2. Full knowledge of demand for the retailer	1. Emergency orders; 2. Multiple suppliers
Webster and Weng (2008)	✓	Overstock costs		✓	Random price-sensitive demand		1. Diseconomies of scale; 2. No goodwill cost;	Other demand functions
Wu et al. (2012)	✓	Lead time, Consumer utility		✓	Random demand dependent on price and lead time		1. A waiting cost for the consumers; 2. Credible lead time assumed by the consumers; 3. Inventory and lead time related costs	1. Other demand functions; 2. Tardiness cost
Wu et al. (2015)	✓	Market size		✓	An aggregate demand function	✓	1. Consumers updating reference price; 2. A full-price phase and a markdown phase; 3. An exogenous and constant full price; 4. Identical reference for all consumers	1. No markdown; 2. A myopic retailer; 3. Deterministic demand; 4. Retailer assuming rational consumers; 5. Assumption relaxation
Xiao et al. (2015)	✓	Consumer preference		✓	A function based on the Salop circular market		1. Identical price for all product variants; 2. No reservation utility for the supplier; 3. Constant shelf costs; 4. Identical demand for product variants	1. A more general demand function; 2. Insufficient shelf space; 3. Deliver lead time; 4. Competing suppliers

Table 7
Major features of the OR models on consumer behaviors in FRSCM.

Reference	Real case	Real data	Supply chain feature		Model setting		Single-period
			Decentralized	Centralized	Newsvendor model	Stackelberg model	
Altug and Aydinliyim (2016)	✓	✓			✓		
Aydinliyim et al. (2017)	✓						
Cachon and Swinney (2011)	✓	✓			✓		✓
Chen and Chen (2016)							✓
Chua et al. (2017)							
Elmaghraby et al. (2008)							✓
Li and Yu (2017)			✓		✓	✓	✓
Liu and Van Ryzin (2008)							
Swinney (2011)					✓		✓
Taleizadeh et al. (2016)			✓	✓		✓	
Wu et al. (2015)					✓		
Xu et al. (2015)			✓		✓		✓
Yan and Cao (2017)	✓	✓				✓	✓
Yoo et al. (2015)			✓			✓	

Reference	Multi-period	Single-product	Analysis tool			Objective		Exact solutions
			Close form analysis	Game theory	Others	Maximize profit/ revenue	Others	
Altug and Aydinliyim (2016)	✓	✓	✓	✓		✓	Maximize consumer's surplus	✓
Aydinliyim et al. (2017)	✓	✓	✓		Standard economic theory	✓	Maximize consumer's surplus	✓
Cachon and Swinney (2011)		✓	✓	✓		✓		✓
Chen and Chen (2016)		✓	✓	✓		✓		✓
Chua et al. (2017)	✓	✓	✓		Dynamic programming	✓	Minimize optimality loss	✓
Elmaghraby et al. (2008)		✓	✓	✓		✓		✓
Li and Yu (2017)		✓	✓	✓		✓	Maximize consumer's utility	✓
Liu and Van Ryzin (2008)	✓	✓	✓	✓	Power utility function	✓		✓
Swinney (2011)		✓	✓	✓		✓	1. Maximize consumer's surplus; 2. Minimize number of returns	✓
Taleizadeh et al. (2016)		✓	✓	✓		✓		✓
Wu et al. (2015)	✓	✓	✓	✓	Dynamic programming	✓		✓
Xu et al. (2015)		✓	✓	✓		✓		✓
Yan and Cao (2017)		✓	✓		Analytical-empirical interface	✓		✓
Yoo et al. (2015)		✓	✓	✓	Principle-agent paradigm	✓		✓

Table 8
Major assumptions and extensions of the OR models on consumer behaviors in FRSCM.

Reference	Major assumptions							Major extensions or future directions
	Uncertainty		Demand feature			Strategic consumer	Others	
	Demand	Others	Deterministic	Random	Function			
Altug and Aydinliyim (2016)	✓	Consumer valuation		✓	General distribution	✓	1. Risk-neural consumers; 2. Exogenous clearance price	1. Expensive product returns; 2. Retailer competition
Aydinliyim et al. (2017)	✓	Consumer valuation		✓	A function dependent on price, inventory, and disclosure decisions	✓	1. Heterogeneous consumers; 2. Postponing costs; 3. Honest retailer; 4. Stock-out penalty	Stochastic market size
Cachon and Swinney (2011)	✓	Consumer quantity		✓	General distribution	✓	1. Homogenous consumers; 2. Replenishment before or after the demand updating; 3. Identical clearance prices for the two systems	The effect of the combination of enhanced design and quick response in fast fashion
Chen and Chen (2016)	✓	Consumer valuation		✓	A function of consumer valuation, price, and		2. Returned product handling costs; 3. Proportional product returns	Multiple retailers

					return policy lenient level			
Chua et al. (2017)	✓			✓	Discrete distributions		1. No inventory replenishment lead time; 2. An exogenous discount price	1. New pool of consumers; 2. Longer shelf life; 3. The retailer deciding the return policy
Elmaghraby et al. (2008)			✓		Price-dependent demand	✓	1. Risk-neutral retailer and consumers; 2. Exogenous initial inventory level; 3. Constant consumer valuation	1. Declining consumer valuation; 2. Incomplete information
Li and Yu (2017)	✓	Market size		✓	A distribution with an increasing failure rate	✓	1. Observable inventory level for consumers; 2. Different consumer groups with different patience levels; 3. Exogenous salvage value	1. Uniformly distributed consumer patience level; 2. Consumers with incomplete information; 3. Endogenous salvage value; 4. Imperfect market size information
Liu and Van Ryzin (2008)		Consumer valuation	✓		Deterministic aggregate demand	✓	1. Heterogeneous consumer valuation and unit demand; 2. Identical consumer risk preferences; 3. Full knowledge of future prices and fill rate for consumers; 4. Preannounced pricing strategy; 5. Risk averse consumers and risk neutral retailers; 6. No disutility of unmet demands	1. Application of the optimal prices; 2. Discounting utilities and profits; 3. Normally or log-normally distributed consumer valuation; 4. Demand uncertainty; 5. Symmetry competition; 6. Other utility functions
Swinney (2011)	✓	Consumer valuation & population		✓	An equilibrium demand function	✓	1. Unobservable inventory levels and observable retailer policies for consumers; 2. No production capacity limit; 3. No returns	1. Consumer return; 2. Endogenous Price
Taleizadeh et al. (2016)			✓		A linear function of multiple factors		1. Identical consumer price sensitivity and market effort sensitivity; 2. Economical reproduction; 3. Identical price and quality for new and reproduced products; 4. Identical price in the two channels	Different prices between the two channels
Wu et al. (2015)	✓	Market size		✓	Aggregate demand function	✓	1. Consumers updating reference price; 2. A full-price phase and a markdown phase; 3. An exogenous and constant full price; 4. Identical reference for all consumers	1. No markdown; 2. A myopic retailer; 3. Deterministic demand; 4. Retailer assuming rational consumers; 5. Assumption relaxation
Xu et al. (2015)	✓	Consumer valuation		✓	General distribution		1. Expected utility and observed utility; 2. Homogenous consumers; 3. Exponentially distributed return time points	1. Moral hazard; 2. External effect; 3. Inertia of consumers
Yan and Cao (2017)			✓		A linear function of price and return policy lenience level		1. Information asymmetry; 2. No production costs	More information sharing (like payment information)
Yoo et al. (2015)			✓		A linear function of potential demand, price, and refund price		1. Full knowledge of demand for both the supplier and retailer; 2. Stronger bargaining power for the supplier; 3. Deterministic return rate	1. Uncertain demand; 2. Retailer competition; 3. Diverse SC leadership

Table 9
Major features of the OR models on the frequently applied coordination contracts in FRSCM.

Contract	Amount	Example reference	Real case	Supply chain feature		Model setting		Single-period
				Decentralized	Centralized	Newsvendor model	Stackelberg model	
Buyback	19	Chen and Bell (2011)	✓	✓		✓		✓
Wholesale pricing	15	Wei and Choi (2010)		✓	✓	✓	✓	✓
Profit sharing	7	Shen et al. (2016b)	✓	✓	✓		✓	
Quantity discount	6	Chiu et al. (2016)						✓
Return	5	Yue and Raghunathan (2007)					✓	
Revenue sharing	5	Cao (2014)		✓	✓		✓	✓
Minimum ordering quantity	4	Chow et al. (2012)			✓	✓		✓
Sales rebate	4	Huang et al. (2014b)				✓		✓
Two-part tariff	4	Choi et al. (2013)		✓	✓		✓	
Markdown money	3	Choi (2016c)				✓		

Contract	Multi-period	Single-product	Multi-product	Close form analysis	Analysis tool		Objective		Exact solutions
					Game theory	Others	Maximize profit/revenue	Others	
Buyback		✓		✓	✓		✓		✓
Wholesale pricing		✓		✓	✓	Mean-variance	✓	Maximize the MV optimization problem	✓
Profit sharing		✓		✓	✓		✓		✓
Quantity discount		✓		✓	✓		✓		✓
Return	✓	✓		✓	✓		✓		✓
Revenue sharing		✓		✓	✓		✓	Maximize consumer's utility	✓
Minimum ordering quantity		✓		✓		Bayesian updating	✓		✓

Sales rebate	✓	✓		✓	✓		✓		✓
Two-part tariff		✓		✓	✓		✓		✓
Markdown money	✓		✓	✓		Mean-variance	✓	Minimize retailer's risk	✓

Table 10
Major assumptions and extensions of the OR models on the frequently applied coordination contracts in FRSCM.

Example reference	Major assumptions						Major extensions or future directions
	Uncertainty		Demand feature			Others	
	Demand	Others	Deterministic	Random	Function		
Chen and Bell (2011)	✓			✓	Price-dependent stochastic demand	1. Fixed returned product handling costs; 2. Goodwill costs and overstock costs; 3. No initial inventory	Comparison with other contracts
Wei and Choi (2010)	✓			✓	General distribution	1. Exogenous price; 2. Information symmetry	Information asymmetry
Shen et al. (2016b)			✓		The potential market size minus retail price	1. Innovation-effort-independent production costs; 2. Market size-dependent design costs	Bargaining power
Chiu et al. (2016)	✓	Market situation		✓	A price-dependent stochastic demand	1. No salvage value; 2. Random market situation in stage 1 and a deterministic market situation in stage 2	1. Channel leadership; 2. Risk sharing; 3. Profit allocation
Yue and Raghunathan (2007)	✓			✓	A function of the base demand (discrete distributed) and price	1. No salvage value; 2. Risk neural partners; 3. Information asymmetry	A uniform distributed base demand
Cao (2014)			✓		A linear function of market size, price, and channel substitutability	1. No reservation profit; 2. Producing according to the demand	1. Multiple periods; 2. Non-linear demand; 3. Information asymmetry; 4. Diverse coordination contracts
Chow et al. (2012)	✓			✓	Normal distribution	1. One order long before the season (old system); 2. A Postponement order (QR system) with a minimum ordering quantity	Dynamic minimum ordering quantity
Huang et al. (2014b)	✓	Consumer valuation		✓	General distribution	1. Exogenous price; 2. Homogeneous consumers; 3. Separate markets; 4. Separate consumer groups; 5. Independent demands;	1. Endogenous price; 2. Heterogeneous consumers; 3. Market overlapping; 4. Conditionally independent demands
Choi et al. (2013)			✓		A linear price-dependent demand	1. Identical quality of returned and new products; 2. Collection-effort-related return quantity	1. Stochastic demand; 2. Risk aversion; 3. Reproduction availability
Choi (2016c)	✓			✓	General distribution	1. One product for one period; 2. An end-of-period paid replenishment fee	1. Carbon emission tax & quota; 2. Minimum ordering quantity

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