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Invited Review

Service supply chain management: A review of operational models ☆

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ABSTRACT

Given the growing importance of service supply chain management (SSCM) in operations, we review a selection of papers in the operations research and the management science (OR/MS) literature that focus on innovative measures associated with the SSCM. First, we review and discuss the definitions of service supply chains (SSCs) and categorize SSCs into the Service Only Supply Chains (SOSCs) and the Product Service Supply Chains (PSSCs). Second, by classifying the literature into three major areas, namely service supply management, service demand management, and the coordination of service supply chains, we derive insights into the current state of knowledge in each area, and examine the evolution of the SSCM research over the past decade. Finally, we identify some associated research challenges and explore future directions for research on SSCM from an operational perspective.

1. Introduction

Services have received much attention in the operations research (OR) literature in recent years as the world economy has grown increasingly service oriented. For example, in developed markets such as the US, it is reported that over 90 percent of the GDP comes from the service industry. Even in developing countries, such as Brazil, Russia, India, China, and South Africa (BRICS), the service industry is developing rapidly. As a result, numerous projections predict that the world economy will eventually be ruled by services (Arnold, Javorcik, and Mattoo 2011).

Services play a crucial role in supply chain systems. There are a number of studies that review and discuss different definitions of service supply chain systems and service supply chain management (e.g., see Sakhuja, Jain, & Kumar, 2012).[1] In a supply chain system, by definition, there must be a "product" that is created by "the points of origin" and delivered at "the points of consumption". This "product" can be a tangible physical product or a service product. In the domain of service supply chain management, two types of supply chain systems arise, namely the Service Only Supply Chains (SOSCs) and the Product Service Supply Chains (PSSCs). In the following, we formally classify service supply chain systems into SOSCs and PSSCs to help us define the scope of our review and enhance the exposition of the discussions in the subsequent chapters. The corresponding meaning of "service supply chain management" is also illustrated in Fig. 1.

1.1. Service only supply chains

We define SOSCs as supply chain systems in which the "products" are pure services, and physical products do not play a role. For example, in many well-established service industries such as psychology advice, healthcare body checking, financial consultancy, and even fortune telling, the respective supply chains are SOSCs. We regard SOSCs as the most homogeneous kind of service supply chains, in which service management rules. Within the domain of SOSCs, there are numerous related definitions of service supply chain management.

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[1] In this paper, we do not exhaustively review and examine all of the related definitions of the service supply chain. Interested readers are advised to refer to the aforementioned studies for further information.

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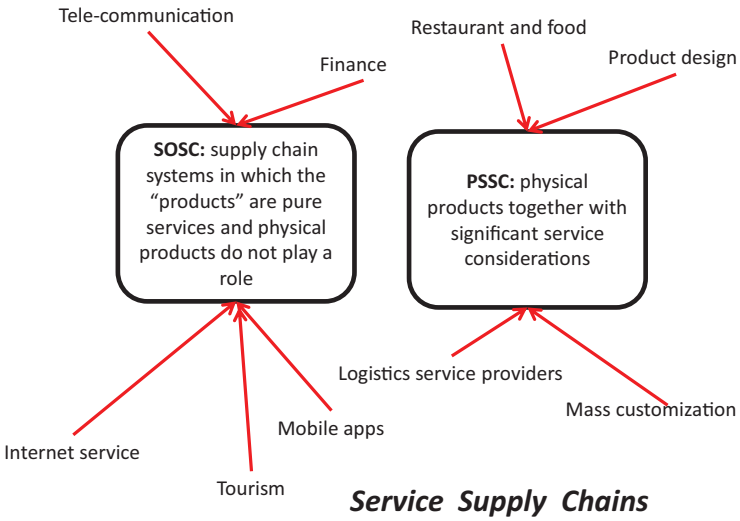

Fig. 1. Definition of service supply chains with examples.

Baltacioglu, Ada, Kaplan, Yurt, and Kaplan (2007) define a service supply chain system as "a network of suppliers, service providers, consumers, and other supporting units that performs the functions of transactions of resources required to produce services; transformation of these resources into supporting and core services; and the delivery of these services to customers." Sampson (2000) describes a service supply chain as a bidirectional system consisting of a customer, a service provider, and an initial service producer. Similar to Sampson (2000), Demirkan and Cheng (2008) define an application service supply chain as a system composed of three parties, the service producer for infrastructure, the retail service provider, and the customer. In the real world, SOSCs can be found in industries such as finance, tele-communication, internet service, mobile apps, and tourism.

1.2. Product service supply chains

Unlike SOSCs, many supply chains manage physical products together with significant service considerations. Thus, there are both "services" and "physical products" in these supply chain systems. We call such systems PSSCs. Ellram, Tate, and Billington (2004) define service supply chain management, in the context of our PSSCs, as follows: "Service supply chain management is the management of information, processes, capacity, service performance, funds, and forward and reverse flows of tangible goods from the earliest supplier to the ultimate end customer, including the return and/or disposal of any tangible goods purchased." Arguably, there are more PSSCs than SOSCs explored in the literature. For example, we can find PSSCs in restaurant and food retail supply chains, product design and retailing supply chains, mass customization operations programs of different industries, and logistics service providers.

Motivated by the importance of service supply chain management, in this paper, we review operational models concerning service supply chain management, focusing on business-related problems and excluding technical services with purely engineering perspectives (such as programming issues for developing a "cloud service"). Note that there are a few studies that review service operations/supply chain management. For instance, Chase and Apte (2007) provide a comprehensive review of service operations management. Spring and Araujo (2009) discuss the application of product services in supply chains, while Stavrulaki and Davis (2014) conduct an excellent overview of service supply chain management with respect to the service delivery process. However, in this paper we focus on examining the adoption of operations research models in service supply chain systems from the three core perspectives, service supply management, service demand management, and service supply chain coordination. Operations research is about the application of advanced analytical methods to help make better decisions,[2] and the operations research models adopted in those reviewed papers range from various programming models and stochastic optimization to game theoretical models. In the selection of the technical papers to be covered in this review, we focus on examining the mainstream OR journals, such as *Annals of Operations Research, European Journal of Operational Research, IIE Transactions, International Journal of Production Economics, International Journal of Production Research, Journal of the Operational Research Society, Management Science, Manufacturing and Services Operations Management, Operations Research, OR Letters,* and *Production and Operations Management*, and the references therein. We intentionally exclude some well-established areas such as stochastic networks, and scheduling services as they have already been reviewed by others.

2. Service supply management

In SOSCs, in which services are the sole product, supply management is critical because the supplier usually plays the dominant role (Baltacioglu et al., 2007). In many service supply chains, the retailers/distributors simply act as brokers, while the supplier provides the real services directly to the final users/customers. For example, among Internet website hosting services, the technical support and real server hosting are provided by the supplier, and the retailers are the service agents who help achieve demand. There have only been limited studies on the supply management in this domain, partially because the respective service supply chains are relatively short and aspects such as supplier relationship management are ruled by the bargaining power between the service supplier and the service reseller (if any). Although service supply chains are usually short "vertically", it is worth noting that they can involve many parties "horizontally", which leads to some interesting analyses. For example, in the mobile phone service industry the respective supply chains involve many parties. Specifically, in this industry, nowadays consumers pay mobile phone companies (retailers) for services beyond just voice transmission, such as online data transfers and access services. These "additional" services are provided by third-party vendors, who pay to gain access to the mobile phone companies' consumer databases. It is

[2] This interpretation is found from Wikipedia, which shows the common understanding of operations research, across different disciplines.

common for consumers to pay in two parts, one for their basic phone services and the other for specific "additional" services such as online data transfer. It is interesting to note that from the service provider's perspective, there are variations. For instance, some mobile companies outsource their online portal services and acquire customers from other independent portals. Motivated by the industrial practices in mobile phone services, Chakravarty and Werner (2011) explore via a game-theoretic approach how the fees for phone services and customer database access should be optimally determined, and how they relate to the prices of third-party vendor services. Their results reveal that an invoicing process can change the income flow, which ultimately benefits the mobile network operator more than the other parties in this service supply chain. Furthermore, they determine the optimal number of vendors and develop a vendor ranking scheme for selecting the right vendors.

Outsourcing has become a timely issue in service supply management that is particularly critical in markets with fierce competition. Lahiri, Dewan, and Freimer (2013) examine pricing in telecomm services. As they explained, discriminatory pricing in telecomm services may increase profit, but harm social welfare. In a related study, Benjaafar, Elahi, and Donohue (2007) explore a case in which a buyer wishes to outsource a fixed demand to a group of supplier candidates for a service at a certain price. They study how supply-side competition affects the optimal decision and investigate the value of supplier competition. They further compare the supplier allocation rule (which allocates a proportion of demand to each supplier with respect to the quality of service it promises to offer) and the supplier selection rule (which allocates all demand to one supplier). Their analytical studies show that the buyer can orchestrate competition among the suppliers, prompting improved service quality. They also find that under an identical allocation scenario, the presence of a demand-independent service cost can yield a higher service quality for the buyer and a higher expected profit for the supplier under competition, when the supplier selection rule is used. In addition, the relative advantage of using the supplier selection rule rather than the supplier allocation rule is heavily dependent on the relative magnitude of demand-independent and -dependent service costs in the service model. It is also optimal for the buyer to limit the number of potential suppliers under the supplier allocation rule, but it is unwise to have such limitations under the supplier selection rule. The authors conclude by arguing that a service buyer can effectively induce the service suppliers to offer higher quality services by selecting an appropriate allocation rule. Co, David, Feng, and Patuwo (2012) consider a dual channel outsourcing model that consists of a domestic supplier and an intercontinental supplier. They model the domestic supplier as having a shorter lead time with a higher cost, and the intercontinental supplier as having a longer lead time with a lower cost. They analytically find the trade-off to select the optimal outsourcing supplier with respect to service failure. Jin and Ryan (2012) examine a service supply chain system in which the buyer outsources the manufacturing of a product to two symmetric make-to-stock manufacturers who compete on price and fill-rate service. This competition effect is also examined by Bernstein and de Vericourt (2008), who study procurement contracts with service guarantees constraints. Jin and Ryan (2012) construct a supplier score function, similar to the supplier selection model of Benjaafar et al. (2007), in which a probabilistic selection model with service competition is presented. Each supplier operates on a make-to-stock basis, following a base-stock policy and facing an exponential production time. Using sensitivity analysis, they find that the weight placed on price relative to service should decrease in both the buyer's backorder cost and the suppliers' holding cost. Furthermore, Jin and Ryan (2012) extend their study to examine cases in which the number of suppliers can vary and find that the buyer's cost increases with the number of suppliers, which helps characterize the situation under which the buyer would prefer single- to multi-sourcing.

In the electricity industry, the respective supply chain systems are SOSCs. Forgionne and Guo (2009) present an analysis of the electricity utility supply under competition. They identify the optimal net return for such an electricity utility supply chain. They show that the concurrent engineering approach is a suitable scheme for managing the electricity utility supply. Liu, Zhang, and Lieu (2010) develop a model to study the incentive mechanism in electricity supply chains. They propose the "generator semi-randomized matching" mechanism for an electricity bidding scheme. They conduct simulations for the proposed mechanism, which reveal that the equilibrium is affected by the clearing price, the total transaction volume, the profits of electricity generators, and the overall benefits of the purchasers.

There are many recent studies that examine specific measures in supply management for PSSCs. For example, Xie, Zhao, Jiang, and Chow (2015) examine a service-oriented manufacturing supply chain with information asymmetry. They consider a supply chain with a manufacturer and a retailer. The manufacturer produces and supplies the product to the retailer, who further processes the product with a particular value-added service before it is sold to the consumers. They assume that the retailer possesses private demand information and explore how three commonly seen supply contracts, franchise fee (FF), franchise fee with service requirement (FFS), and franchise fee with centralized service requirement (FFCS), affect the supply chain. They show that all three contracts help the manufacturer reveal the retailer's true private information on market demand, with the FFCS contract achieving the largest amount of supply chain system profit. In healthcare supply chain systems, Zhao, Xiong, Gavirneni, and Fein (2012) examine FFS contracts, which reflect a real-world industrial practice in pharmaceutical distribution supply chains. Under a FFS contract, there is an inventory cap that limits the amount of inventory that distributors hold at any time. In addition, inventory information must be shared from the distributors (buyers) to the manufacturers (sellers) under FFS, and the manufacturers pay the distributors a per-unit fee. They formulate a stylized multi-period stochastic inventory model to analyze the optimal inventory policy under the FFS and the non-FFS "traditional" approaches, and show that the FFS scheme can effectively improve the performance of the supply chain system. They further develop a computational heuristic that helps determine the per-unit fees capable of achieving a Pareto improvement in the supply chain. They also explore supply chain transparency and find that transparency is especially important for manufacturers when the demand variance is low but the inventory cap and product price increases are high. Wu (2012) examines a supply chain with a single retailer and two heterogeneous manufacturers. He considers a scenario in which the first manufacturer is traditional and produces new products and the second is a remanufacturer who produces products from used items. He assumes that both manufacturers offer their products under a bundle with warranty and advertisement services, and that all products are sold through the same third-party retailer who determines the retail selling price. He derives the equilibrium decisions and generates important insights in supply management in this unique PSSC.

After-sales service is a value-adding service that has been a hot topic in relation to PSSCs over the past few years. For example, Kim, Cohen, and Netessine (2007) study the effect of contracting on after-sales service supply chains. They use the principal-agent theory to analyze the discussed contracts. They find that a cost sharing contract is effective when the cost uncertainty is sufficiently small and the product deployment life cycle is affected by contracting decisions, in terms of factors such as the degree of cost uncertainty. They show that when the channel members are risk-averse, the optimal contract should include not only a cost-sharing incentive, but also a fixed payment and a performance incentive. Finally, they use aircraft maintenance data to conduct a numerical study and show the robustness of their model analysis for long-term strategic planning and contract negotiations. Li, Huang, Cheng, Zheng, and Ji (2014) study the

after-sales services in a PSSC. They consider a two-echelon single-supplier/single-retailer supply chain. The retailer gets the product from the supplier and sells the product bundled with after-sales services to the consumers. The market environment is competitive and the retailer's sales volume depends on its service level (note that service level is usually measured as inventory availability in the service supply chain.). They consider settings under which the retailer can build service capacity in-house or outsource. They find that the outsourcing scenario entices the retailer to provide a higher service level, which leads the manufacturer to lower its wholesale price. They further investigate how the decisions of supply chain agents are affected by the retailer's risk attitude and cost of outsourcing. If the manufacturer is willing to share the cost of service with the retailer, the profits of both the retailer and the manufacturer can be enhanced.

Customer service is a central topic in service supply management. For a PSSC, the customer service is usually expressed as a function of the capacity of the firm's service delivery system. In this domain, Hall and Porteus (2000) develop a service competition model and consider a case in which customer service is decreasing in the capacity of the firm's service delivery system. They derive the optimal service levels and apply the results to the Internet service provider industry. Bollapragada, Rao, and Zhang (2004) examine the supply management optimization problem with quantity and timing uncertainty in a two-echelon service supply chain. They identify both the optimal base-stock levels and optimal service level. Their numerical study reveals the benefits of a guaranteed supply lead time in such supply chains. Farahani and Elahipanah (2008) develop a genetic algorithm to optimize the trade-off between cost and service level in a just-in-time supply chain. Other related works include (i) Al Hamadi, Sangeetha, and Sivakumar (2014), who examine the optimal customer service in a finite-capacity continuous-review perishable supply chain, and (ii) Sarker, Rochanaluk, and Egbelu (2014), who develop a model to improve customer service level in a three-echelon supply chain by reducing backorders. They argue that the total cost of such a supply chain is significantly affected by backorders.

Supply chain contracts have been popularly examined in service supply management, particularly for performance-based contracts. Jin and Tian (2012) formulate an optimization model to explore the logistics service in a supply chain associated with performance-based contracts. They provide theoretical insights into how logistics services drive the trade-off between reliability design and inventory level under such contracts. Liang and Atkins (2013) study customer service level agreements in a supply chain with performance-based contracts using the principal-agent theory. They find that the supplier benefits from service level agreements with strategic dynamic behavior. Other studies on performance-based contracts include Guajardo, Cohen, Netessine, and Kim (2012), who compare supply chain performance between performance-based and time-and-materials contracts for after sales service, and Mirzahosseinian and Piplani (2011), who examine supply chain performance in relation to repairable parts services under performance-based contracts.

Supply chain disruptions management is very crucial to the success of the service supply chains, as the service constraints are very likely to be violated for the service-industry-related chains or the more traditional product-based chains when disruptions occur. Disruptions in service supply chains create numerous challenges and bring risk into the system. In the domain of PSSCs, many supply chain disruption studies examine inventory ordering related decisions such as "from whom to order" and "how to order" but under service constraints such as product availability or lead time constraint. For example, Xanthopoulos, Vlachos, and Iakovou (2012) study newsvendor-based inventory models under disruption risks in a dual-sourcing supply network. They consider service level constraints and assume that both sourcing channels are exposed to disruption risks. They further consider a situation involving both risk-neutral and risk-averse buyers and derive analytical closed-form solutions. They argue that contingency strategies in the form of dual-sourcing supply are effective in dealing with disruption risks. Similar to Xanthopoulos et al. (2012), Baghalian, Rezapour, and Farahani (2013) also take service level constraints into consideration. They study a robust supply network design problem when there are service level constraints against disruptions and uncertainty. They develop a multi-product supply network stochastic model to explore the optimal strategic facility location problem with a finite set of capacitated production facilities and distribution centers that supply retailers facing uncertain market demand. For the supply side, manufacturers and distribution centers are facing probable disruptions. Thus, both demand- and supply-side uncertainties are present in the supply network. They adopt a path-based model and apply the cut-set concept to formulate a nonlinear mixed integer programming problem. They solve the problem using a piecewise linear transformation method. They support their findings with a case study from the agricultural industry. Sawik (2014) investigates a situation in which the suppliers are located in geographically different places and formulates a mixed integer programming problem. He adopts the conditional value-at-risk as the risk measure in his model and the objective function is to maximize the expected worst-case customer service level. His results generate insights into optimal supplier selection choices from the customer service perspective.

Capacity management is critical to service supply management, especially for PSSCs. In the literature, Chao, Chen, and Zheng (2009) examine a service firm that needs to determine its capacity over a multi-period horizon. They develop optimal capacity expansion strategies and suggest that signing future contracts can help the firm obtain performance improvements if it has a lower initial capacity. Ching, Choi, and Huang (2011) develop a model to examine service capacity in outsourcing supply chains under competition. They indicate that the equilibrium service capacity increases in the penalty level. Cao and Jiang (2013) investigate the service capacity problem for public warehouse product service systems. They develop an algorithm to determine the optimal service capacity in such a supply chain. Wei, Hu, and Xu (2013) examine the service capacity issue in a service supply chain in which a supplier sells a service with a fixed capacity to two retailers. They derive the equilibrium prices, ordering, and service capacity allocation under both decentralized and centralized settings, and find that the retailer's response does not influence the supplier's service capacity allocation. Note that the analysis conducted by Wei et al. (2013) applies to both SOSCs and PSSCs. Chou and Chung (2009) explore a supply chain, focusing on service capacity and supply risks. They provide an explanation of their analytical model and results based on the airline industry, which is a kind of SOSC. They note that in many global manufacturing service supply chains, the supply risk is a critical issue, as many manufacturers are conservative in their capacity expansions because of high demand uncertainty (e.g., from market disruptions) and investment costs. They analytically derive an optimal service-based demand rationing rule and examine the equilibrium supply strategy under a duopoly setting. Roels (2014) examines three types of co-productive services (i.e., services, service factories, and self-services) for a service supply chain. From the above review, we summarize the key topics and related references in Table 1, and the features of formulation in Table 2.

3. Service demand management

Demand management relates to how service operations manage customer demand. Important functions such as demand forecasting and strategies for effectively dealing with demand uncertainty are all critical. Obviously, service demand management is crucial to service supply chain management because the success of virtually all service supply chain activities depends on proper demand planning and related operational measures. Today, agile supply chain management is well advocated and service supply chain processes should be driven by demand.

Table 1
Important supply management issues in service supply chains.

Scope	Issues	Related references
SOSC	Outsourcing	Benjaafar et al. (2007), Chakravarty and Werner (2011)
	Mobile related service industry	Chao et al. (2009), Chakravarty and Werner (2011)
	IT service	
	Service competition	Hall and Porteus (2000)
	Service capacity	Chou and Chung (2009), Wei et al. (2013)
	Electricity utility service	Forgionne and Guo (2009), Liu et al. (2010)
PSSC	Franchise fee with service	Xie et al. (2015)
	Fee-for-service contract	Zhao et al. (2012)
	Performance-based contract	Mirzahosseinian and Piplani (2011), Guajardo et al. (2012), Jin and Tian (2012), Liang and Atkins (2013)
	Product bundle with warranty/after sales service	Kim et al. (2007), Mirzahosseinian and Piplani (2011), Wu (2012), Li et al. (2014), Guajardo et al. (2012)
	Supply management with disruption risk and service	Xanthopoulos et al. (2012), Baghalian et al. (2013), Sawik (2014)
	Outsourcing	Kouvelis and Milner (2002), Benjaafar et al. (2007), Ching et al. (2011), Jin and Ryan (2012), Co et al. (2012), Li et al. (2014)
	Service competition	Hall and Porteus (2000), Tsay and Agrawal (2000)
	Customer service	Bollapragada et al. (2004), Caggiano, Jackson, Muckstadt, and Rappold (2007), Farahani and Elahipanah (2008), Al Hamadi et al. (2014), Liang and Atkins (2013), Matsui (2014), Sarker et al. (2014)
	Logistics service	Jin and Tian (2012), Ghosh, Lee, and Ng (2015)
	Service commitment strategy	Bossert and Willems (2007), Klosterhalfen, Dittmar, and Minner (2013)
	Service capacity	Ching et al. (2011), Cao and Jiang (2013), Wei et al. (2013), Roels (2014)
	Bonus contract	Yin and Ma (2015)

Table 2
Features of selected supply management formulations in service supply chains.

Formulation	Features		Objective functions	
	Customer model	Competition	Profit maximization	Cost minimization
Formulations that consider outsourcing				
Benjaafar et al. (2007)		√	√	
Jin and Ryan (2012)			√	
Li et al. (2014)			√	√
Ching et al. (2011)		√		√
Kouvelis and Milner (2002)			√	
Formulations that consider service capacity				
Wei et al. (2013)		√	√	
Chou and Chung (2009)		√	√	
Cao and Jiang (2013),				√
Formulations that consider service contracts				
Xie et al. (2015)			√	
Zhao et al. (2012)				√
Jin and Tian (2012)	√			√
Liang and Atkins (2013)			√	√
Formulations that consider after-sales service				
Wu (2012)		√	√	
Li et al. (2014)			√	√
Kim et al. (2007)	√			√
Formulations that consider service industries				
Chakravarty and Werner (2011)	√	√	√	
Chao et al. (2009)			√	√
Forgionne and Guo (2009)				√
Liu et al. (2010)			√	
Formulations that consider customer service				
Bollapragada et al. (2004)				√
Matsui (2014)	√		√	
Al Hamadi et al. (2014)				√
Sarker et al. (2014)				√

In light of demand uncertainty for services, service capacity is a timely and crucial issue, and has led to some studies on the dynamic optimal capacity expansion problem for service providers. For example, Netessine, Dobson, and Shumsky (2002) develop a single-period two-stage service supply chain for car rental and airline business operations. Both the service capacity and the market demand are stochastic. They model the market demand as a multivariate normal random variable, develop and identify the equilibrium capacity, and study the effects of increasing demand correlations on the optimal capacity.

Outsourcing affects not only service supply management, but also service demand management. From the perspective of service demand management, Lu, Meng, and Goh (2014) compare the supply chain performance in self-managing and outsourcing scenarios. They show that outsourcing performs well if the external coordinator has a low knowledge transfer cost. Chen and Chen (2014) examine an outsourcing supply chain with one original equipment manufacturer and one contract manufacturer. They find that technology spillovers benefit the contract manufacturer's production efficiency, and may make it profitable for the original equipment manufacturer to continue

cooperating. Tang, Fang, and Cheng (2014) study the strategic interaction in an SOSC system in which the services include consulting, service outsourcing, and travel services. Under a stylized SOSC model, they examine a situation in which two competing vendors sell goods through one integrator and the market demand is directly affected by the quality of service. They derive and explore the equilibrium service level and prices. Wang, Niu, and Guo (2013, 2014a), similar to Chen and Chen (2014), also examine outsourcing supply chains. Wang et al. (2013) explore the effect of quantity leadership in such service supply chains and Wang, Wu, Liang, and Huang (2014b) compare push and pull contracts in a three-tier service supply chain. Benaroch, Webster, and Kazaz (2012) focus their attention on transaction-based, information-intensive service process outsourcing. They examine the effects of demand uncertainty and provide several important theoretical insights into such outsourcing service supply chains. Liu and Nagurney (2011) develop a model to investigate the effects of foreign exchange risk and competition intensity in an outsourcing supply chain. Feng and Lu (2012) study the competing manufacturers' "low cost outsourcing behavior." They identify an interesting bargaining framework under which competing manufacturers outsource to a common supplier and find that the manufacturer's bargaining power significantly affects the disagreement payoff of the supplier. They also present counterintuitive results, which show that the manufacturer's profit may decrease with bargaining power.

Due to the popularity of e-commerce, dual channel selling operations are very popular in many industries. These days, online stores serve as an important channel in service supply chains, under which the service quality is the key to attract more consumers because it fosters trust and trust rules e-commerce. Chen, Kaya, and Özer (2008) investigate the strategic interaction between the manufacturer and retailer under service competition in a dual channel PSSC. They consider a case in which market demand is influenced not only by consumers' valuation of the product and shopping experience, but also by the levels of service in both channels. Services include the delivery lead time for the product and product availability. They identify the optimal service levels and find that the cost of managing a direct channel, retailer inconvenience, and product characteristics all influence the optimal service levels. Furthermore, they conduct behavioral experiments to confirm the validity of the analytical recommendations. Dan, Xu, and Liu (2012) investigate the retail services in a dual channel PSSC, which include demand-enhancing services such as immediate customer support, presale advice, in-store advertising and promotions, technical and shopping assistance, and return services. These types of retail services are similar to the retail promotional efforts examined in Krishnan, Kapuscinski, and Butz (2004). Krishnan et al. (2004) identify the optimal service level and prices for both decentralized and centralized supply chains. They find that the service level significantly affects the channel parties' pricing decisions and profit in the presence of retail promotional efforts.

It is well documented that customer service level can significantly affect demand. With service level-dependent demand models, Chiu, Choi, Li, and Xu (2014) examine a duopoly service game with two competing service providers. They find that the service cost affects the unique Nash equilibrium in service prices and levels. They examine when a service war may arise, under which the service providers compete by increasing service levels, and develop several service strategies. Shen and Daskin (2005) point out the trade-off curve between customer service and cost in a supply chain. They identify a heuristic solution for generating optimal or close-to-optimal solutions. They find ways in which the customer service level can be improved at a small incremental cost. DiPalantino, Johari, and Weintraubc (2011) examine whether service firms should offer a guaranteed service level in a service supply chain. They argue that offering a guaranteed service level can increase competition and reduce the equilibrium price. Kurata and Nam (2010) examine the after-sales service in a two-echelon supply chain with durable consumer products. They consider the scenario in which an upstream manufacturer offers a basic warranty service to all customers (who have bought its product), and the downstream retailer offers an additional yet optional after-sales service (at a charged "fee") to the customers. They investigate the operational challenges with these two services. They find that the profit maximizing "optimal service plans" are different from the ones which best satisfy customers. Kurata and Nam (2013) further investigate the effect of uncertainty on after-sales service and find that information uncertainty can seriously harm the optimal after-sales service. They also explore a case under which efficient service increases the chance of accidental outperformance under uncertainty.

Financial services have been shown to significantly affect firms' performances in supply chains. Dong and Tomlin (2012) examine the effects of providing business interruption insurance services in a supply chain with disruption risk. They show that insurance services and operational measures are not always substitutes for one another, in that the value of insurance services is most significant when disruptions are modestly long and rare. They argue that for firms with a weaker capability for dealing with financially significant disruptions, insurance services are a more desirable choice. Kouvelis and Zhao (2012) consider a scenario in which a bank provides trade credit financial services to a supply chain system that includes a retailer and a supplier. They show that bank credit financial services are more expensive than optimally-priced trade credit. In addition, the retailer is more willing to force the supplier to use bank financial services rather than trade credit contracts because more expected terminal cash flows can be received.

Contracts are popularly adopted in service supply chains. Kim, Coen, Netessine, and Veeraraghavan (2010) examine performance-based contracts when considering disruption risk in an outsourcing service supply chain. Their analytical results reveal that performance-based contracts can create potentially high agency costs. They argue that if disruption is driven by an exogenous event such as a natural disaster, a performance-based contract can yield optimal results. Huber and Spinler (2012) study warranty service contracts in a supply chain that includes a manufacturer, an agent, and a customer. They identify the optimal sales price, warranty price, and warranty period for the manufacturer, and the optimal maintenance cost for the agents. Esmaeili, Gamchi, and, Asgharizadeh (2014) examine the pricing issue in a full-service repair contract, which they find to be strongly affected by the repair cost uncertainty. In other words, information on repair costs is significant for a firm's profitability.

Logistics services are important in PSSCs, as they significantly influence customer demand. So (2000) conducts a pioneering study on the delivery service in a supply chain under competition. He finds that the monopoly case is significantly different from the competitive case. In particular, firms differentiate their delivery services under competition. Sharif, Irani, Love, and Kamal (2012) use a semi-fuzzy approach to examine the third-party logistics service provider in a supply chain. Hu and Qiang (2013) propose a supply chain in which there are manufacturers, e-tailers, express service providers, and consumers. The quality of the logistics services is determined by the express service providers. They identify the equilibrium decisions for each party in such a supply chain. Xu, Govindan, Bu, and Yin (in press) examine the sea-cargo services in a supply chain with empty equipment repositioning. They find that the optimal empty equipment repositioning strategy is significantly influenced by the corresponding cost. Yao and Zhang (2012) use both analytical and empirical approaches to examine logistics services in e-commerce. They derive several interesting implications for online retailers, further suggesting that such retailers either strategically set shipping and base prices, or provide menu pricing for different shipping options.

Consolidation-based transportation services have existed for a long time, and much of the related literature has been well covered in the logistics/optimization literature. Here, we emphasize some newly

derived results specifically related to handling demand uncertainty. Lium, Crainic, and Wallace (2007, 2009) show that the use of consolidation services (i.e., the use of hub-and-spoke networks, common among both airlines and large freight companies) is not only a way to handle many small volumes that do not allow for door-to-door deliveries, but also a way to hedge against demand uncertainty and variation. They also demonstrate how correlations between customer demands affect the optimal service network design. The strategic/tactical decisions regarding the service network design and operations of the service network are closely connected, and the best way to handle demand variation is to be prepared for it. In a later work, Bai, Wallace, Li, and Chong (2014) add the possibility of rerouting vehicles in real time as a hedging devise. They demonstrate how this affects the initial design, and show that, at times, this leads to the designs coming from deterministic models (which by definition ignore uncertainty) being robust and well behaved even in a stochastic environment.

Information technology (IT) services are also important in SOSCs. In a business research, Bashyam (2000) develops a model to examine information services with price competition. He examines a case in which service providers can convey information through the Internet or telecom networks and derive optimal strategies for information service providers. Ghose, Mukhopadhyay, and Rajan (2007) examine the effect of Internet referral services on a supply chain. They find that retailers would like to use Internet referral services to differentiate between consumers and help sell their products to the high-valuation consumer segment via online channels. Lee, An, and Connors (2009) examine demand disturbances in the IT software development services in a supply chain. Under this SOSC, they identify the optimal feedback control system to manage the resource capacities and find that workforce resource management should use a combination of multiple feedback control schemes. Moreover, the feedback control schemes can substantially reduce oscillation between acquisition and release and enhance workforce management. Sen and Raghu (2013) examine IT service outsourcing and its incentive design. Their analytical results imply that the service process components such as risk profile, random noise, value-cost ratio, and process structure significantly affect the equilibrium incentive rates.

Service quality is a measure of customer satisfaction. There is little doubt that it is an important topic in service demand management. It is well known that price and service quality affect consumer demand. In this scope, Bernstein and Federgruen (2004) propose several demand functions that depend on the retailers' prices and service quality levels under competition. They find that optimal service quality levels are positively influenced by price. Under linear demand functions, they prove that firms' equilibrium service quality levels are affected by their own input characteristics. They show several examples, including amazon.com and barnesandboble.com, to illustrate their analytical findings. Xiao and Yang (2008) examine how the price and service quality level affect a supply chain under competition. They find that the retailers' risk aversion decreases with the corresponding optimal service quality level and retail price. In particular, if a service provider uses "service commitment" as a strategic tool, carefully deciding the respective optimal price enhances the service provider's performance. Service and pricing decisions are fundamental in service demand management and the risk aversion of supply chain agents is an important consideration.[3] Xiao, Choi, Yang, and Cheng (2012) examine the service commitment strategy and pricing decisions in a two-echelon supply chain in which both the retailer and supplier are risk averse. They compare cases in which the retailer either does or does not provide a service guarantee and explore the effect of risk aversion on service commitment strategies. Following previous studies (Hauser, Simester, & Wernerfelt, 1994; Holmström & Milgrom, 1991; Michalk, Filipova-Neumann, Blau, & Weinhardt, 2011; Xiao & Qi, 2010), Xiao et al. (2012) consider the consumer's certainty equivalent under no service guarantee and service guarantee. They find that the consumer's degree of risk aversion is the most important factor for determining the service commitment strategy, and that the degrees of risk aversion experienced by both the supplier and the retailer influence the service commitment strategy only when consumers are risk averse. They also show that the retailer's motivation to use service guarantees decreases with the retailer's risk aversion level, but increases with the consumer's risk aversion level. They examine the effects of endogenizing the unit wholesale price in a supply chain and find that it can motivate the retailer to adopt the service guarantee strategy. In addition, they extend their study to consider both availability guarantee and service commitment under a make-to-stock setting. They find that the endogenization of a service reliability target does not change the monotonicity of the motivation to use service guarantee for all factors.

In service supply chain management, queuing models have become popular to study various customer-related service problems, such as in healthcare and service operational systems. For example, in a service operational setting, Allon and Federgruen (2007) and Allon, Bassamboo, and Gurvich (2011) use queuing models to examine the efficiency of service supply chains. Allon and Federgruen (2007) study a firm's service level (which is defined as the difference between the benchmark waiting-time standard and the firm's actual waiting-time standard) under competition. Allon et al. (2011) conduct an empirical study to measure the importance of waiting time performance with regard to the firm's market share and pricing decision. They analyze data collected from fast-food drive-through restaurants via structural estimation methods. According to their model estimation, the customer waiting time is evaluated as a very high cost. In a healthcare context, both Andritsos and Tang (2013) and Andritsos and Tang (2014) adopt queuing economics models to examine the relationships among the patients, the hospitals and the healthcare funders for the healthcare service. Andritsos and Tang (2013) find that cross-border patient movement may improve the patients' social welfare. Andritsos and Tang (2014) propose to outsource a high cost country's elective care services to a low-cost country. For more studies of healthcare services, readers are advised to read the review work by de Vries and Huijsman (2011).

Smith, Gunther, Rao, and Ratlife (2001) discuss how operational models can optimize airline services. Lately, Prince and Simon (2015) examine the impacts of incumbent on-time performance on airline service quality. Regarding the studies of service supply chain management in the hospitality industry, readers can refer to Zhang, Xu, and Wu (2009) for the related research.

From the above review, we summarize the key issues for service demand management in Table 3. The features of the model formulations are listed in Table 4.

4. Service supply chain coordination

In a service supply chain, it is important for every supply chain member to take care and work with other members in the system. In fact, the key spirit of modern supply chain management, which differentiates it from the more classical logistics management, is the emphasis on coordination and collaboration between supply chain channel members. Thus, coordination is essential in service supply chain management. In this section, we define coordination as the process or mechanism used to achieve the best (possible) performance in a service supply chain system.

Customer service affects supply chain coordination. Boyaci and Gallego (2004) investigate how customer service achieves supply chain coordination under competition. They find that the optimal

[3] Service is considered to broadly represent all forms of demand-enhancing efforts, such as customer services, before and after sales (repair, emergency services, etc.), order accuracy, product availability, and inventory level (Desiraju & Moorthy, 1997; Tsay & Agrawal, 2000).

Table 3
Important demand management issues in service supply chains.

Scope	Issues	Related references
SOSC	Outsourcing	Benaroch et al. (2012), Sen and Raghu (2013)
	Mobile related service	Lahiri et al. (2013)
	IT service	Bashyam (2000), Ghose et al. (2007), Lee et al. (2009), Zhang, Tan, and Dey (2009), Sen and Raghu (2013)
	Service competition	DiPalantino et al. (2011), Chiu et al. (2014)
	Service capacity	Netessine et al. (2002)
	Healthcare service	Andritsos and Tang (2013), Andritsos and Tang (2014)
	Customer service	Allon and Federgruen (2007), Zhang, Song, and Huang (2009), Allon et al. (2011), DiPalantino et al. (2011), Hu and Li (2012), Su, Tian, and Wang (2012), Quan (2014), Luo, Qin, Che, and Lim (2015)
PSSC	Fee-for-service contract	Kim et al. (2010), Huber and Spinler (2012), Esmaeili et al. (2014)
	Performance-based contract	Kim et al. (2010)
	Product bundle with warranty/after sales service	Kim et al. (2010), Kurata and Nam (2010), Kurata and Nam (2013), Esmaeili et al. (2014)
	Supply management with disruption risk and service	Dong and Tomlin (2012)
	Outsourcing	Kouvelis and Milner (2002), Kim et al. (2010), Liu and Nagurney (2011), Feng and Lu (2012), Wang et al. (2013, 2014a), Chen and Chen (2014), Lu et al. (2014), Tang et al. (2014), Wang et al. (2014b)
	Service competition	Bernstein and Federgruen (2004, 2007), Xiao and Yang (2008), Chen et al. (2008), Kurata and Nam (2010, 2013)
	Customer service	Shen and Daskin (2005), Disney, Farasyn, Lambrecht, Towill, and Van de Velde (2006), Allon and Federgruen (2007), Bendoly, Blocher, Bretthauer, and Venkataramanan (2007), Faria, Nunes, and Matos (2010), Allon et al. (2011), Xiao et al. (2012), Jammernegg and Kischka (2013), Quan (2014)
	Logistics service	So (2000), Cohn and Barnhart (2006), Lium et al. (2007, 2009), Sharif et al. (2012), Yao and Zhang (2012), Hu and Qiang (2013), Bai et al. (2014), Liu, Xie, Liu, and Liu (2015), Xu et al. (2014)
	Service commitment strategy	Xiao et al. (2012)
	Service capacity	Lium et al. (2007, 2009), Bai et al. (2014), Liu et al. (2015)
	Financial service	Dong and Tomlin (2012), Kouvelis and Zhao (2012)

Table 4
Features of selected demand management formulations in service supply chains.

Formulation	Features		Objective functions	
	Customer model	Competition	Profit maximization	Cost minimization
Formulations that consider outsourcing				
Sen and Raghu (2013)	√		√	
Lu et al. (2014)			√	
Chen and Chen (2014)		√	√	
Wang et al. (2013)		√	√	
Liu and Nagurney (2011)	√		√	
Feng and Lu (2012)		√	√	
Lium et al. (2007, 2009)				√
Formulations that consider service capacity				
Netessine et al. (2002)			√	
Liu et al. (2015)			√	
Lium et al. (2007, 2009)				√
Formulations that consider service contracts				
Kim et al. (2010)	√		√	
Huber and Spinler (2012)			√	
Esmaeili et al. (2014)			√	
Formulations that consider after-sales service				
Kurata and Nam (2010)			√	
Kurata and Nam (2013)			√	
Formulations that consider service industries				
Lahiri et al. (2013)	√		√	
Ghose et al. (2007)	√	√	√	
Bashyam (2000)		√	√	
Zhang et al. (2009)		√	√	
Lium et al. (2007, 2009)				√
Bai et al. (2014)				√
Formulations that consider customer service				
DiPalantino et al. (2011)		√	√	
Quan (2014)			√	
Hu and Li (2012)		√	√	
Jammernegg and Kischka (2013)			√	
Bendoly et al. (2007)				√
Shen and Daskin (2005)				√
Xiao et al. (2012)	√	√	√	

retail service level is higher in a coordinated supply chain than that in an un-coordinated supply chain. They further show that supply chain agents are more likely to share the inventory burden under channel coordination. Finally, they reveal that consumers can receive the largest benefits from supply chain coordination among all of the parties in their model. Bernstein and Federgruen (2007) examine supply chain coordination with service and price competition in a two-echelon supply chain. They find that if the service level is exogenous, a simple linear wholesale pricing contract can achieve supply chain coordination. However, if the service level is endogenous, they prove that a simple linear wholesale pricing contract cannot achieve channel coordination. To overcome this coordination problem for the endogenous service case, they develop a new scheme that combines the wholesale pricing contract with a set of constant per-unit backlogging penalties (paid by the retailers). Sethi, Yan, Zhang, and Zhou (2007) examine a single-period two-stage service supply chain with information updating. They consider a case in which the buyer can reorder after observing a market signal for improving the service quality (i.e., fill rate). They identify the optimal order quantity and study the effect of order cancellations in such a service supply chain. They use the buyback contract to coordinate the supply chain in the presence of a service constraint. Katok, Thomas, and Davis (2008) examine how the inventory service-level commitment strategy can be used as a supply chain coordination mechanism via a behavioral experiment. They first construct analytical models and then investigate the problem in a controlled laboratory with human decision-makers. They suggest that supply chain managers should use the service-level commitment strategy to mitigate the double marginalization effect, and think carefully about the length of the review period. Chen and Shen (2012) examine the effect of customer service level in a one-period two-member PSSC. They find that the optimal service level non-increasingly affects the retailer's profit, but non-decreasingly affects the supplier's profit. They develop a special class of contracts to coordinate the PSSC system, under which the profits of both parties do not decrease, with at least one being strictly better off (i.e., a Pareto improvement). Sieke, Seifert, and Thonemann (2012) propose several service-level-based supply contracts to achieve supply chain coordination. They identify the optimal service level contracts and show how the supply chain performance differs. Xiao and Xu (2013) study the service level in a supply chain under the vendor managed inventory (VMI) system. They identify the equilibrium prices and service levels under both decentralized and centralized scenarios and find that a revenue-sharing contract can achieve supply chain coordination. Heydari (2014) investigates a coordination mechanism in a supply chain with customer service level consideration and finds that stochastic lead time harms the customer service level.

Supply chain coordination has been the critical strategy for performance improvements in the telecommunications industry. In this domain, Canakoglu and Bilgic (2007) study a two-stage multi-period supply chain, in which the market demand is technology-dependent and stochastic. They consider the telecommunication service provider as an operator who decides the capacity and find that a well-designed quantity discount contract can achieve coordination under such a system. Hasija, Pinker, and Shumsky (2008) study how a call center service provider can help achieve supply chain coordination in a service supply chain. Based on their observations of one large vendor, they examine several supply chain contracts, including pay-per-time, pay-per-call, service-level agreements, and constraints on service rates and abandonment. They derive the optimal staffing level that helps achieve supply chain coordination under both pay-per-time and pay-per-call. They find that information availability significantly affects decisions regarding the service rate constraints. They also prove that under the setting of information asymmetry, clients are unwilling to work with the call center using either pay-per-time or pay-per-call if there is no service rate constraint.

Lodree and Taskin (2008) study the provision of insurance services with the goal of coordinating the supply chain. They take both emergency response logistics services and supply chain disruption risks into consideration. They find that the optimal insurance service level is associated with stocking decisions and proactive disaster-relief planning. Serpa and Krishnan (2014) investigate how insurance services help firms to credibly commit to lower efforts and mitigate the incentives of the wealth-constrained firms to free-ride. Liu, Xie, and Xu (2013) examine a coordinating mechanism in the logistics service industry for a multi-period supply chain. They find that well-determined punishment intensity helps to ensure the quality of logistics service. They suggest several approaches, such as reducing information asymmetry, making logistics more visible, and reviewing periodically the potential service quality to improve the quality of logistics services. Liu and Xie (2013) investigate the effects of service quality on logistics service supply chains for achieving channel coordination. They identify the optimal service quality, which increases with customer punishment. Matsui (2014) examines the effects of information services for product characteristics in a global supply chain in the presence of a gray market. They suggest economic implications for multinational firms, arguing that if consumers are more segmented, then multinational firms are more willing to convey product information. Oliveira, Ruiz, and Conejo (2013) study how supply chain contracts achieve channel coordination in the electricity industry. They identify that the two-part tariff is the best contract for achieving supply chain coordination, as it effectively increases supply chain performance.

Channel coordination is driven by supply chain contracts. Xie, Jiang, Zhao, and Shao (2014) explore a franchise fee contract in a product service supply chain for achieving channel coordination. They provide several interesting insights and suggest that the franchise fee contract can generate a higher profit for the retailer and entice the retailer to offer a higher quality of service. Jain, Hasija, and Popescu (2013) study channel coordination via a performance-based contract when a firm outsources its repair and restoration services to an external service provider. They find that the structures of performance-based contracts significantly affect the optimal channel profit. They show how the contract structures affect double-sided moral hazards and the financial concerns of vendors. Roels, Karmarkar, and Carr (2010) investigate fixed-fee, time-and-materials, and performance-based contracts in a service supply chain. They find that if the service output is more sensitive to the vendor's effort, the fixed-fee contract is preferable, whereas if the output is equally sensitive to both the buyer's and the vendor's inputs, the performance-based contract achieves the best performance. Their analysis implies that the contract type significantly affects the channel efficiency in a service supply chain.

One important industrial sector with SOSCs is the financial services industry. Chen and Cai (2011) investigate not only financial services, but also logistics services. They identify the problems for companies such as UPS, which owns UPS Capital: the logistics and financial services are integrated through third-party logistics firms. They consider a supply chain consisting of a supplier, a budget-constrained retailer, a bank, and a third-party logistics firm. They find that different supply chain parties benefit from different perspectives. The retailer benefits from a lower interest rate, the supplier benefits from a larger demand, and the third-party logistics firm benefits from the integration of financial and logistics services. Their research provides insights into the theoretical support for companies that have integrated financial and logistics services, such as UPS.

From the perspective of service supply chain coordination, one important industrial area is the IT sector. Demirkan and Cheng (2008) examine an application service supply chain in which one application infrastructure provider (AIP) supplies computer capacity to an application service provider (ASP), which sells a value-added application service to the market. They consider a case in which the market

Table 5
Important coordination challenges in service supply chains.

Scope	Issues	Related references
SOSC	Outsourcing	Roels et al. (2010)
	Mobile related service	Canakoglu and Bilgic (2007), Hasija et al. (2008)
	IT service	Demirkan and Cheng (2008)
	Service competition	Iyer (1998)
	Electric utility service	Oliveira et al. (2013)
	Customer service	Sethi et al. (2007)
PSSC	Franchise fee with service	Xie et al. (2015)
	Fee-for-service contract	Roels et al. (2010), Sieke et al. (2012)
	Performance-based contract	Roels et al. (2010), Jain et al. (2013)
	Product bundle with warranty/after sales service	Jain et al. (2013)
	Supply management with disruption risk and service	Lodree and Taskin (2008)
	Outsourcing	Tarakci, Tang, Moskowitz, and Plante (2006), Jain et al. (2013)
	Service competition	Bernstein and Federgruen (2007)
	Customer service	Boyaci and Gallego (2004), Sethi et al. (2007), Chen and Shen (2012), Liu and Xie (2013), Xiao and Xu (2013), Heydari (2014)
	Logistics service	Lodree and Taskin (2008), Chen and Cai (2011), Liu et al. (2013), Liu and Xie (2013)
	Service commitment strategy	Katok et al. (2008)
	Financial service	Lodree and Taskin (2008), Chen and Cai (2011), Serpa and Krishnan (2014)

Table 6
Features of selected supply chain coordination formulations.

Formulation	Features		Objective functions	
	Customer model	Competition	Profit maximization	Cost minimization
Formulations that consider outsourcing				
Tarakci et al. (2006)		✓	✓	
Formulations that consider service contracts				
Xie et al. (2015)			✓	
Sieke et al. (2012)			✓	
Roels et al. (2010)			✓	
Formulations that consider after-sales service				
Jain et al. (2013)			✓	
Formulations that consider service industries				
Canakoglu and Bilgic (2007)			✓	
Demirkan and Cheng (2008)			✓	
Hasija et al. (2008)	✓		✓	
Formulations that consider customer service				
Boyaci and Gallego (2004)		✓	✓	
Chen and Shen (2012)				
Xiao and Xu (2013)			✓	
Heydari (2014)				✓
Sethi et al. (2007)			✓	

demand is price dependent with uncertainty. The ASP's objective is to maximize its profit by determining the optimal capacity and price of its service, whereas the AIP's goal is to maximize its profit by selling the capacity to the ASP. Demirkan and Cheng (2008) then study four types of supply chain coordination strategies involving risk and information sharing between the ASP and AIP. They find that the competitive aligned coordination strategy is an effective decentralized mechanism for achieving the goal of maximizing the overall supply chain performance. Moreover, they find that when the ASP coordinates the supply chain, the whole supply chain's expected profit is greater than when the AIP coordinates the supply chain. This finding seems to suggest that it is better to let whichever player is closer to the market coordinate the supply chain.

Table 5 summarizes the issues and the related references on service supply chain coordination. The features of the formulations are listed in Table 6.

5. Evolution of service supply chain management research

From the reviews in Sections 2–4, we find that the OR literature has examined various aspects of service supply chain management. Based on the review findings, we conduct a content analysis and show the evolution of and trends in the topical areas of service supply chain management (Table 7).

1. SOSC versus PSSC: The review results clearly show that there are significantly more studies being conducted on PSSC management than on SOSC management. This finding is expected, as the traditional supply chain management literature focuses on systems with physical products and the majority of studies are on manufacturing systems. With the emergence of service operations, it is understandable that the first step will be to extend the physical product supply chains to include services. Meanwhile, important pure service operations such as telecommunications and mobile technologies have emerged in recent years, and hence the corresponding research is on-going.
2. Supply management, demand management, and coordination: The review results show that there are more studies being conducted on service supply management than on service demand management or service supply chain coordination. Essentially, there are much fewer studies on service supply chain coordination than on the other types. This finding has two implications. First, the literature on service supply chain management remains underdeveloped, as most studies focus on a single aspect, i.e., either service supply management or service demand management. Second, there is a need to combine both supply and demand manage-

Table 7
Popularity of topics.

Scope	Issues	Supply management	Demand management	Coordination
SOSC	Outsourcing	*	**	*
	Mobile related service	**	*	*
	IT service	X	***	*
	Service competition	*	**	*
	Service capacity	*	*	X
	Electricity utility service	**	X	*
	Customer service	X	***	*
PSSC	Franchise fee with service	*	X	*
	Fee-for-service contract	*	**	**
	Performance-based contract	**	*	**
	Product bundle with warranty/after sales service	***	**	*
	Supply management with disruption risk and service	**	*	*
	Outsourcing	***	***	**
	Service competition	**	***	*
	Customer service	***	***	***
	Logistics service	**	***	**
	Service commitment strategy	**	*	*
	Service capacity	**	*	X
	Financial service	X	*	*

Notes: *** very popular; ** popular; * have been examined; X underexplored.

ment to achieve a best service supply chain system. Thus, a higher emphasis on service supply chain coordination is necessary.

3. Industry: In service supply chain management, industries such as IT and telecommunications, electricity, finance, and logistics have been popularly examined in the OR literature. However, other industries such as healthcare have not been well-explored in OR journals. There are many scheduling and queuing service OR studies on healthcare organizations, but these topics are excluded from this review. Therefore, more studies are called for in these areas.
4. Game theoretic analysis: Driven by the Nobel Prize-winning theories in economics, game theory research has been very popular in supply chain management. This trend also applies to the analysis of service supply chain management as many studies use game theory in conducting their analyses.
5. Risk analysis: Service supply chain systems are open to both supply- and demand-side uncertainties. Risk analysis is hence a crucial part of proper service supply chain management. In the reviewed studies, some extensively consider risk. However, the current studies are far from sufficient, as they only address a small area of the topic (e.g., examining how a service agent's degree of risk aversion affects its optimal decision). Lium et al. (2007, 2009) as well as Bai et al. (2014) study how a properly set-up service network provides operational flexibility and hence hedges against demand uncertainty. But more studies on operational risk, e.g., proper hedging mechanisms, associated with service supply chain operations, are needed.
6. Social welfare and environmental sustainability: Timely issues such as social welfare, non-profit service operations, and environmental sustainability in relation to service supply chain systems have not yet been addressed, opening new areas for future research.

6. Future research directions

After reviewing the topic of service supply chain management in OR/OM/MS journals, it is crystal clear that service supply chain management is still understudied, which open avenues for future research. We discuss some specific future research directions as follows.

a. Outsourcing

Outsourcing has been one of the most important issues in service supply chain management. Our review shows that although numerous studies have been conducted on outsourcing in the context of PSSCs, it is significantly understudied in the context of SOSCs. Important areas, such as outsourcing of healthcare services, telecommunication, and even financial services, should hence be explored in the future. This is also in line with the recent advances of big data analytics and the significance of the respective analytical optimization models.

b. Customer service

Customer service is a critical topic in supply chain management. As such, it is very commonly seen in studies on PSSCs. According to our review results, there are not many analytical customer service studies being conducted on SOSCs. Furthermore, the current studies only focus on service demand management. This is intuitive, because customer service is related to demand. However, it also indicates that there is a need for investigations of customer service in SOSCs for other issues, such as service supply management and supply chain channel coordination.

c. Competition

Service competition is a hot topic in service supply chain management. Game theoretic studies of competition in service supply chain operations are commonly observed in PSSCs. However, there is currently no published work focusing on the scope of channel coordination in SOSCs under competition. Future research should hence be conducted to fill this important gap.

d. Consumer welfare

The objective of the "total service supply chain system management" should include consumer welfare. Consumer welfare is now an extremely important topic in industries such as IT, telecommunications, healthcare, and electricity. In fact, consumer welfare can be quantified by some societal influence measures that may involve public interests, such as in a healthcare supply chain. Despite the importance of consumer welfare in these service industries, most current related studies only focus on single-echelon problems and have yet to examine the system optimization issue from the viewpoint of the whole service supply chain system. Thus, the incorporation of consumer welfare into the optimization models as well as achieving the system optimization are both critical but underexplored areas in service supply chain management. Thus, future research should include them.

e. Operations risk management

Risk management is critical in supply chain operations management. However, in service supply chain systems, operations risk management has only been examined in relation to service supply and demand management, with very little on the latter. Risk management in service coordination is a particularly underexplored issue. This leaves a large area for further studies. Finally, we proposed and discussed future research directions.

7. Concluding remarks

Service is the engine for economic growth. Given the importance of service supply chain management, we examined in this review paper the operational models in two types of service supply chain systems, SOSCs and PSSCs. We reviewed a selection of articles from the mainstream OR and management sciences literature that focuses on the innovative measures associated with service supply chain management. In this study, a review of methodological contribution is not our focus and instead we focus on reviewing those works that apply OR tools to achieve better business decisions for the service supply chain. We systematically classified the literature into three main areas: service demand management, service supply management, and coordination of service supply chains. Based on the literature review, we examined the evolution of OR-related service supply chain management studies. Finally, we proposed and discussed future research directions.

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