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Review

Mathematical Modeling and Optimization of Platform Service Supply Chains: A Literature Review

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Abstract: With the increasing importance of the platform service supply chain (PSSC) in creating economic value, academic research is paying more and more attention to it. The current literature's research topics and problems cover broad areas. This review adopts bibliometric analysis and thematic analysis to review the related literature systematically and comprehensively. We divided the literature about PSSC into six groups according to the literature's research topic and research question. Each literature's research problem and research method are categorized and summarized. Our review results demonstrate that the supply chain's members' operational decisions and the supply chain's coordination are two main types of research questions. Pricing decisions have received the most attention. In terms of the research method, game models are the most common method used in research to achieve the optimization of the PSSC.

Keywords: platform; service supply chain; mathematical modeling; optimization

MSC: 00-02

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1. Introduction

With the development of technology, innovation in the supply chain has developed rapidly and reached unprecedented heights [1]. Online platform services are the critical outcomes of innovation in the supply chain [1]. An increasing number of companies from different industries are joining online platforms or building their platforms to provide more value-added services for customers to obtain more profits. Platform modes have occupied all kinds of markets, like retail, tourism, accommodation, transportation, and so forth [2]. People become used to enjoying services like purchasing, ordering food, booking hotels, and sharing things with others through different platforms. The famous representatives include Alibaba.com, JD.com, Amazon.com, Airbnb, etc. [3]. Official statistics showed that the size of China's digital platform economy has surpassed USD 6 trillion in 2021. In this context, the platform economy has gained momentum, and supply-chain management has connected with it more closely [2].

With the increasing prevalence of platforms in the enterprise operation process, the platform service supply chain (PSSC) has become the mainstream of economic and social development. The commercial value and technological innovation promotion brought by PSSC has drawn a great deal of researchers' attention [2]. Many researchers studied firms' operation strategies under the platform mode and were concerned about different subjects' different decisions under various conditions. Meanwhile, some literature analyzed the dilemma and conflicts in the PSSC. Therefore, it is necessary to analyze and classify the research on the PSSC and to identify current research trends.

Some researchers have already conducted related reviews. Song et al. (2022) and Zhang and Zhao (2021) reviewed green and sustainable supply-chain management in platform economies [1,4]. Kuhzady et al. (2021) reviewed sharing platforms in hospitality and tourism [5]. Shroff et al. (2022) reviewed the development of online food delivery

platforms and identified potential future research themes [6]. Although these papers have reviewed the PSSC-related studies, the majority of them only concerned one specific area. Furthermore, these reviews seldom paid attention to the research methods and mathematical models that papers used to conduct research. Unlike these reviews, we do not limit our review to one specific area but consider every area that PSSC covers, and we analyze the models that the paper used in research.

As noted briefly above, despite the academic community and researchers having a growing interest in PSSC, a systematic and organized overview of the current state of the literature is missing. Although some attempts have been made in this problem, their research content does not cover all of the extensive fields involved in the PSSC. Works specifically targeting PSSC are still unavailable. Secondly, owing that different research backgrounds require different approaches to mathematical modeling, the examination of research methods in PSSC is important, yet the extent reviews of PSSC only concentrated on research topics and research problems. The exact analytical models that the paper conducted are neglected by researchers.

In light of these premises, the purpose of this review is to identify what kinds of PSSC can be divided into. What problems are researchers concerned about in each area? What mathematical modeling methods were used to research? Were there research gaps? In order to answer these questions, we will adopt bibliometric analysis to conduct a quantitative analysis to identify the research trend of the PSSC. Meanwhile, the most researched keywords will be analyzed, too. After that, we will analyze the research content clearly by thematic analysis. The favorite PSSC sectors will be identified. The contributions of this review are as follows. First, to the best of our knowledge, this paper is the first to analyze and categorize research topics and research contents on the PSSC systematically and comprehensively. We reviewed broad areas that the PSSC covers. Secondly, we reviewed the mathematical modeling and optimization of the PSSC comprehensively, which few papers concerned. We identify the normal models that researchers used to analyze their research questions.

2. Methodology

In order to identify the research trend and emergent themes in PSSC nowadays, we conduct a bibliometric analysis first. Through the bibliometric analysis, we in-depth analyze the correlations among papers and keywords and conduct a quantitative analysis of the literature of the PSSC to identify the research status. To answer the questions of what research problems researchers are concerned with and what methods were used, we conduct a thematic analysis to make a structured and comprehensive view of existing literature. To be specific, our review follows three steps.

Firstly, we research related literature from scholarly databases to determine the scope of papers for the review. Secondly, we carry out a bibliometric analysis of the collected articles to identify the characteristics of the current status of the PSSC. We subsequently delve into the content of each paper and organize them based on different topics. Finally, we summarize the corresponding results of the research contents and research methods.

2.1. Data Collection

We search the relevant research papers from the largest scholarly database Scopus and the Web of Science database through titles, keywords, and abstracts [7]. We define some keywords including platform, service, and supply chain to extract the papers that are broadly related to our research topic for the first step. Based on the reality of the emergency and development of PSSC, we only analyze the English articles that were published in journals from 2000 to 2022. Similar to Kuhzady et al. (2021) [5], this review focuses on academic journals to guarantee the academic value of this review, and conference papers and review articles are not included. This is because that academic journals are considered the main source for research results. For the first study, we obtain 630 papers by setting platform, supply chain, and service as keywords. In the second step, we screen the papers

and limited the subject areas to business, management, decision sciences, mathematics, economics, and finance. Then 348 papers related to our review topic were selected. After that, we conducted descriptive statistics and bibliometric analysis taking these 348 papers as data to analyze the overall research situation in PSSC.

2.2. Descriptive Statistics

An analysis of the articles published during the review period indicated that research on the PSSC literature has increased significantly year by year (as indicated in Figure 1). We can find that the first paper was published in 2001, and the number of published papers surged until 2020, which is in accordance with reality. In 2020, with the development of electronic business and the outbreak of the COVID-19 epidemic, more platform services were developed. Given the increasing economic value and academic attention on the topic of the PSSC, it is possible that such research will continue to preoccupy scholars in the upcoming years.

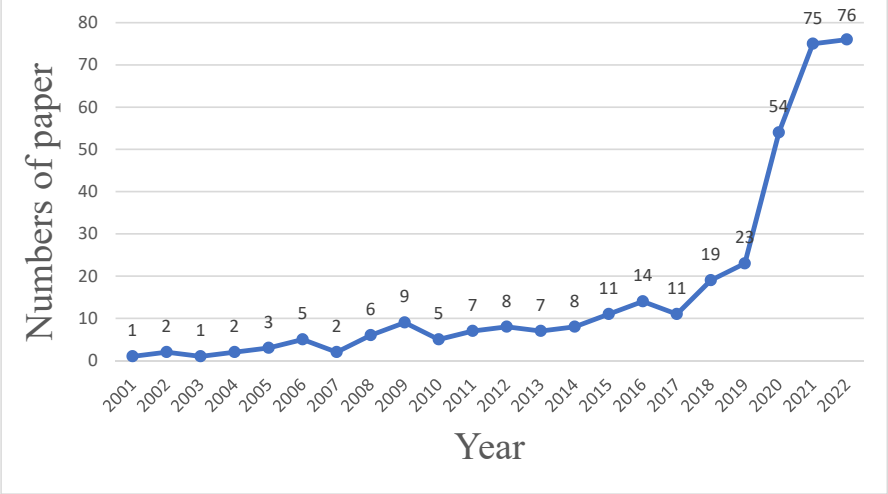

Figure 1. Number of articles published per year.

The distribution of articles published in journals indicates that over half of the related literature comes from five major journals, which are *the International Journal Of Production Economics, International Journal Of Production Research, Transportation Research Part E Logistics And Transportation Review, Annals Of Operations Research*, and the *European Journal Of Operational Research*. The *International Journal Of Production Economics* published 22 papers alone. Details can be seen in Figure 2.

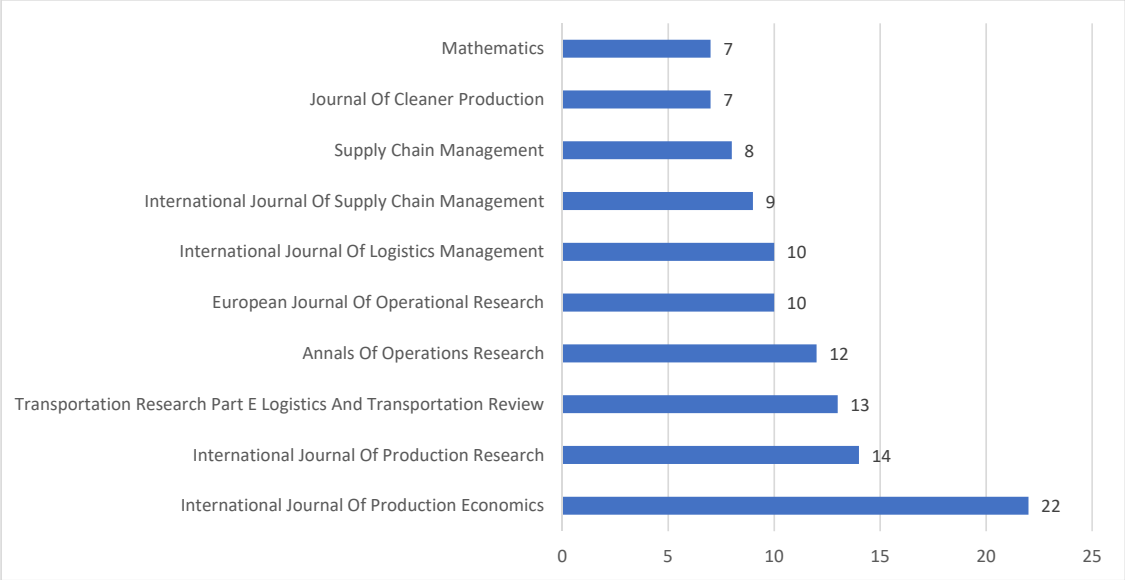

Figure 2. Number of articles published in major journals.

2.3. Bibliometric Analysis

In this part, we used Citspace to conduct the bibliometric analysis, which can establish a scientific network and image by using the literature information in the publication academic database [3]. According to Kuhzady et al. (2021) [4], the keyword describes the main topic of an article and is usually used to analyze emerging trends in research. Therefore, based on the keywords in the selected articles, which reflect the salient information contained in them, we performed content analysis by using CiteSpace to generate the complex relationship between keywords of PSSC through co-word analysis.

To be specific, we studied the temporal evolution of the key intellectual foundations of the PSSC literature to examine the research on this topic. Through the co-word analysis, we identify the evolution of PSSC along with the timeline. Meanwhile, we conducted the cluster analysis. These keywords are clustered based on their frequency of co-occurrence. The word represents the key thematic areas researched. The line between word bubbles indicates the relationship between thematic areas. We examined and ranked the frequency of keywords in the reviewed papers. The top ten keywords are shown in Table 1.

Table 1. Top 10 most frequent keywords.

Keywords	Number of Papers	Percentage
supply chain	154	44.25%
supply-chain management	77	22.13%
electronic commerce	38	10.92%
sale	33	9.48%
manufacture	32	9.20%
cost	31	8.91%
blockchain	28	8.05%
decision making	24	6.90%
profitability	21	6.03%
competition	17	4.89%
game theory	17	4.89%

Through analysis, the most frequently used keywords were 'supply chain', 'supply chain management', 'electronic commerce', 'sale', and 'manufacture'. These keywords show the main research interest of PSSC concerns supply-chain members' operational decisions. E-commerce is the main area that researchers are concerned about, which is consistent with the reality that e-commerce platforms are booming. Furthermore, we can find that

research problems concern economic aspects like operation costs and sales activities. With the development of technology, blockchain and other Internet technologies are playing an increasing role in PSSC. Our results also show the main method to solve research problems: game theory, which we will analyze in detail in the later section.

Through Figure 3, cluster 0 (sale) was the basement of the early research on the PSSC since 2001. Clusters 1, 2, 3, and 6 demonstrated that the research on PSSC was related to novel technology, which is in accordance with the development of PSSC. Cluster 4 (Stackelberg game) pointed out the main research method that researchers adopted. Clusters 9, 10, and 11 indicated that the main research questions in PSSC are decision-making and supply-chain integration. What is more, through the cluster results, we found that supply-chain finance in PSSC attracted many researchers' attention after 2018.

Figure 3. Keywords cluster.

3. Thematic Analysis

In this section, we examined all the articles in their entirety and retained only those articles that use mathematical modeling methods for PSSC's operational decision-making and optimization problems. After reading the title, abstract, and model, we generated a list of literature, for a total of 106 articles. Thereafter, we selected these research articles for the next steps of thematic analysis. To be specific, firstly, we will analyze the articles from their research focuses and research methods. After that, we will identify each paper's key research themes and cluster the related literature based on their thematic commonalities, that is, the topic the paper discussed.

We found that the literature we reviewed can be clustered into six groups according to their specific research topics and the problems they addressed characteristics. The six clusters are the E-commerce retailing platform, the online tourism platform, the sharing platform, the digital platform, the recycling and remanufacturing platform, and the financial service platform. The specific classification can be seen in Table 2. Among them, the E-commerce retailing platform has drawn the most attention, and the literature research on this topic accounts for more than 50% of our reviewed papers. Research on the online tourism platform, the sharing platform, and the digital platform is on the rise, which is inseparable from the development of information technology and the sharing economy. What is more, with the importance given to sustainable and corporate social responsibilities, the recycling and remanufacturing platform also attracted many scholars' interest. Meanwhile,

financial service platforms are becoming a hot topic with the booming of supply-chain finance. In the following content, we will analyze the related literature in detail.

Table 2. Topic clusters.

Topic	Number of Papers	Percentage
E-commerce retailing platform	55	51.40%
Online tourism platform	13	13.08%
Sharing platform	13	12.15%
Digital platform	13	12.15%
Recycling and remanufacturing platform	6	5.61%
Financial service platform	6	5.61%

Through the analysis of the model part of the article, we find that the major methods that researchers adopted in their papers include game theory, optimal control theory, and mixed-integer linear programming. Among them, game theory is the most used in the research. During the modeling of game progress, the literature first defines the game objectives, power structure, and game events sequence. Among their models, consumer demand functions normally have three formats. The most common one is the linear function, which is related to the market size, retailing prices, merchants' efforts, etc. The inverse demand function is the second format adopted by some literature. Furthermore, some papers conducted consumer utility functions to consider consumer heterogeneity. In terms of the supply-chain members' profit functions, papers normally modeled merchants' service effort, advertising, and quality input, et al., as a quadratic cost function. Then they solved the models to obtain equilibrium optimal results to achieve the supply-chain members' profit maximization. When considering the uncertain demands or information values, the common format is to use a non-negative random variable to model, to assume it follows one distribution, and to conduct expected profit functions to analyze the equilibrium results. After obtaining the optimal results, researchers conducted numerical analysis to analyze the change trends of the optimal results and to visually compare the performance of the supply chain under different scenarios.

3.1. Cluster 1: E-Commerce Retailing Platform

3.1.1. Research Topic

In the past decade, online retailing has developed rapidly. Consumers are becoming more and more accustomed to purchasing online platforms and enjoying various services such as delivery. The cluster of papers that research the e-commerce retailing platform is reasonably large. At present, there are two main types of service platforms spawned by e-commerce: typical online sale platforms and on-demand service platforms.

- Typical Online Sale Platform

Typical online sale platforms are the business mode that retailers or manufacturers sell their products on online platforms that were previously sold only in physical stores. Through online sales platforms, like eBay, Amazon, JD.com, and Taobao, customers can purchase almost everything they need through the e-platform without time and space limitations. The platform will provide delivery services to customers according to their orders.

According to the research, there are two main operation modes in reality. The first one is that the platforms charge commission fees from merchants but do not own products, like eBay and Taobao. The second one is the platform that wholesales products from manufacturers and resells them to customers, like Amazon.com and JD.com [8,9].

Our review indicates that the pricing [10–12], quality [13,14], logistics [15,16], service [8,17,18], advertising [19–21], and return [22,23] strategies of retailers, suppliers, and online platforms are one of the main research issues in this field.

Research on pricing mainly concerns the setting of products' sales prices in different online and offline channels, like in [8,10,17,18]. Pricing strategy under bundling strategy and presales was also studied [8,11,12].

Research on product quality concerns quality control and quality information disclosure strategies. For example, Wen et al. (2021) researched online-shopping product quality control under government supervision [13]. Liu et al. (2021) analyzed ex ante blockchain-adoption and ex post voluntary-disclosure quality information strategies [14].

In terms of logistics, there are two kinds of logistics models within e-commerce platforms: self-built logistics of e-platforms and logistics outsourcing [15]. How to choose the optimal delivery service strategy is a crucial problem for e-tailers in practice [16]. Therefore, researchers analyzed different logistic strategies by considering different logistics models' costs, delivery service fees, commission rates, and so forth [15,16]. Wang et al. (2021) studied cooperation between third-party logistics service providers and e-platforms [15]. Tu et al. (2022) compared logistics service efforts under different contracts when green agriculture products are sold by online platforms [24]. He et al. (2022) researched logistics service integration issues in an e-commerce PSSC and proposed two coordination mechanisms [25].

Platforms' service investment strategy and sellers' service level are two main problems that related literature covers [8,17,18,26,27]. For example, Zhang et al. (2021) researched a platform's service investment strategy when a supplier encroaches on its retail market by opening a direct channel on the platform [27].

With the increase of fierce competition in the market, more merchants adopt advertising to attract consumers [20]. Therefore, many scholars are concerned with advertising equilibrium strategies under different conditions [19–21], like considering the delayed effort of advertising, platform goodwill, and brand goodwill [20,21].

In terms of return policy, Wang et al. (2021) analyzed different return policies when the platform retailer resells products or just provides a platform to suppliers [22]. Mondal et al. (2022) investigated refund and replacement policies for defective products and e-commerce platforms' exchange offers [23].

Apart from operational strategies, with the introduction of e-platforms, business modes and channel selection [3,26], and coordination [19,28,29] are e-platforms' major operation problems in both online and offline dual-channel operation modes.

The research on coordination proposed different contracts and other improvement strategies by considering fairness concerns [28] and altruistic preference [15,29], like revenue-sharing plus a fixed-fee contract, state-dependent contract, etc [3,19]. For example, Wang et al. (2020) studied the e-commerce supply chain's coordination when the platform provides extended warranty service and proposed a revenue-sharing joint commission contract [30]. Considering the showrooming effect, Wang et al. (2022) researched the interplay between the manufacturer's offline service effort strategy and the platform's online sales mode selection [26]. Wang et al. (2022) designed the Nash bargaining contract and Rubinstein bargaining contract to mitigate conflicts in the green supply chain that contains an e-commerce platform [31]. For more similar literature, we refer the readers to [8,9,17].

Besides, enterprises, especially small- and medium-sized enterprises, often face financial constraints. With the development of e-commerce, many platforms can provide financial services to capital-constrained suppliers or retailers, like JD Finance [32]. Many merchants face the problem of making financing decisions. The literature compared the performances of bank financing, credit financing, and financial services provided by e-commerce platforms and analyzed merchants' finance choices [33,34]. Tao et al. (2022) considered online retailers' risk-aversion and proposed revenue–cost-sharing contracts to coordinate [33]. Chang et al. (2022) studied the interaction between the retailers' financing strategies and the channel sales cooperation contracts [35]. Considering the seller's performance risk, Rath et al. (2021) analyzed optimal interest rates that the platform charge the seller and proposed contracts as an incentive [36]. For more references, we refer the readers to [37–41].

With the development of novel technology, the application of digital technology like blockchain and cloud computing in PSSC attracts many researchers' attention. Liu (2022) studied the operation of an agricultural products e-commerce platform based on cloud computing [42]. Wu et al. (2022) analyzed each supply-chain member's optimal blockchain strategy from the perspectives of information transparency and transaction cost. Besides,

the development of the live streaming industry spawned by e-commerce platforms has also attracted the attention of some scholars [43]. Zhang et al. (2022) studied the e-commerce platform's decision-making problem of whether or not to introduce and how to introduce live streaming services [44].

- On-demand Service Platform

With the development of e-commerce, many offline merchants provide instant delivery services to customers according to their orders when they place orders on the online platform. This gave birth to the on-demand service platform, which is also known as online-to-offline (O2O) instant delivery service platform. Our review shows that the on-demand service platforms mainly include three categories. The first one is mainly for the distribution of daily necessities, fresh food, and other items by community supermarkets, such as Alibaba's Hema and JD's 7fresh [45]. Through these platforms, customers purchase various products, and platforms deliver orders by vehicles to customers within one hour or half an hour. The second one is the freight O2O platform mainly for goods delivery. The representatives include Lalamove, Yunniao, and Gogovan in China and Cargomatic, Convoy, and Loadsmart in the US [46]. The last one is the on-demand food delivery platform, i.e., the takeout platform. The representatives include Ele.me, Meituan, Grubhub, Postmates, and so forth [47]. With the increase in consumer demand, platforms simultaneously distribute medicines, flowers, etc., nowadays.

Different from a typical online sale platform, owing to the requirement of delivery time, more research on on-demand service platforms concern the design of instant delivery scheduling models that include order fulfillment and routine planning in order to minimize the delivery time, distances, and costs. In reality, these platforms only accept orders within a certain distance of the offline stores and deliver them to consumers within a specified time [45]. When designing different scheduling models, some scholars are concerned with order-picking and dispatch. For example, Zhang et al. (2019) considered multiple pickers' learning effects when studying the online integrated order picking and delivery problem [45]. Li et al. (2020) proposed an assignment matching strategy in freight O2O platforms [46]. Wang et al. (2020) proposed a three-stage order dispatch scheme [48]. Other research on order dispatching can be seen in [49,50]. Some scholars researched delivery routine plans and optimization, like [51,52]. Besides, He et al. (2020) analyzed the on-demand service platform's decisions about matching order volume with a self-scheduling delivery capacity [53]. Pachayappan and Sundarakani (2022) proposed sustainable drone delivery strategies [54].

Like normal PSSC, operational decision-making issues such as pricing [46,55], service [56], distribution fees [53], modes and logistics selections [57,58], and coordination [47] have received a lot of attention under this subject too. He et al. (2020) studied the O2O platform's pricing and market expansion strategy to attract grocery retailers, and they analyzed how to charge customers for delivery fees [53]. Tong et al. (2019) pointed out that dynamic pricing strategies are better than static pricing based on the two-sided market theory [55]. Other research about optimal pricing decisions can be seen in [46,56].

Research on modes, logistics selection, and coordination mainly focuses on O2O food delivery platforms. Scholars are concerned about the restaurants' decisions and coordination between them and platforms. The review shows that, first, restaurants face the choice of joining the platform or not [47]. Second, like typical online sale platforms, merchants or restaurants can choose platform logistics or self-logistics [58]. The results show that merchants' optimal decisions depend on customer demand, commission, and advertising effect, etc. [57,59].

In terms of coordination, research shows that there are profit conflicts between the restaurant and the platform due to the commission [60]. Therefore, many scholars are concerned about this problem and designed different contracts to coordinate, like the sales reward contract, the revenue-sharing contract with adding social responsibility, the one-way revenue-sharing contract with a price ceiling, and the two-way revenue-sharing contract, etc. [47,56,61].

3.1.2. Research Methods

Through our review, we find that the majority of research conducted analytical models based on game theory to study, especially when researching members' operational decisions under typical online sale platforms and on-demand service platforms. The models include the Stackelberg game, evolutionary game [12], and differential game [20].

In the literature about the typical online sale platform, the Stackelberg game model is the most used method. More than half of the literature we reviewed used typical Stackelberg game models and conducted numerical experiments [7–9,14,17,25,27–31,33]. For example, Fu et al. (2021) developed dynamic game models in four dual-channel e-retail structures [7]. Ma et al. (2022) conducted a multi-period game-theoretic model [38]. Zhang et al. (2021) considered the online retailer and a manufacturer facing a situation like the classical newsvendor problem [40].

Besides the Stackelberg game, part of the literature researched evolutionary game and differential game models. Wen et al. (2021) constructed an evolutionary game model to discuss the dynamic process of quality behaviors and analyze the key triggers of the evolutionary directions in online shopping [12]. Liu et al. (2021) built a three-party evolutionary game model including the service platform, the government, and the consumers to analyze governance mechanisms for preventing the service platform's discriminatory pricing behavior [13]. Wu et al. (2018) used differential game theory to give the optimal pricing and advertising strategies in decentralized and centralized scenarios [18]. Wu et al. (2020) used the optimal control method to discuss the consignment platform's advertising investment decisions [19]. Wu and Yu (2022) studied two suppliers who played a Bertrand game to analyze the blockchain's impact on PSSC [43]. In terms of the on-demand service platform, research on the design of instant delivery operation schemes adopted mixed-integer linear programming methods and design algorithms as a solution [45,46,54]. For example, Li et al. (2020) proposed an assignment matching strategy by using mixed-integer linear programming to jointly optimize the matching and pricing strategies with optimal delivery routes to multiple retailers [46]. Chen et al. (2022) abstracted the on-demand food delivery problem as a static generalized assignment problem with a rolling horizon strategy and proposed a limitation learning-enhanced iterated matching algorithm to solve the problem [50]. Yildiz and Savelsbergh (2019) studied the routing problem by considering the known order arrival information and used the method of generating columns and rows at the same time to solve the food delivery service and restaurant problem [52].

Research on the decision strategies of platforms and merchants used game models, such as research on typical online sale platforms. For some related works, we refer readers to [47,55–57,59,61].

3.2. Cluster 2: Online Tourism Platform

3.2.1. Research Topic

With the development of e-commerce, the online travel platform has become a novel development trend. Customers can purchase various tourism services through online travel platforms. For example, they can make hotel reservations and ticket bookings and gain tourist information through applications. Orbitz.com, Booking.com, Expedia, Travelocity, and Ctrip.com are some typical online tourism platforms [62–64]. Like typical online sale platforms, online tourism platforms also have two operating models: the agency model and the wholesale model (merchant model). The platform only charges commission fees from tourism service providers in the former mode and has the power to price in the latter mode [62,64]. Furthermore, hybrid online selling modes have been rising in recent years too [65].

The literature in this field mainly concerns the decisions of the platform, hotels, and scenic spots. The first strategy question they are concerned about is the choice between the agency model and the wholesale model [62,64,66–68]. The second topic is operation decisions, especially pricing and information sharing strategy [63,65,69]. Furthermore, much research concerned the coordination of the online tourism platform supply chain by contracts [70,71].

Our review shows that research analyzed the effects of prices, sales costs, commission rates, market demand, value-added service efficiency, demand forecast accuracy, altruism preference, and corporate social responsibility on the models' choices [62–64]. They discussed the effects of these different variables on platforms and tourism providers' mode decisions. We find that almost all literature did not point out which mode was the best.

Research on pricing mainly concerned optimal pricing, including analyzing different variables' effects and comparing different models' pricing strategies. For example, Yang et al. (2016) analyzed the online travel agency platform's pricing strategies when overbooking is allowed [65]. Mao et al. (2021) analyzed the optimal differential pricing strategy when information transparency can change by charging travelers [72]. For more similar research, we refer the readers to [65].

The online travel market's seasonal and random characteristics make research on demand and product information disclosure and sharing necessary [64]. Related literature analyzed platforms' information sharing decisions under different modes and discussed different methods to motivate sharing information to achieve Pareto improvement, like designing the transfer payment contract and the two-part tariff contract [62,64]. Besides, the application of blockchain in information disclosure has also been studied in recent years [73].

In terms of the coordination of the online tourism PSSC, scholars designed and compared different contracts to achieve channel coordination, like the fixed payment contract, the cost-sharing contract, the revenue-sharing contract, and the service commission contract, etc [70,74].

3.2.2. Research Methods

Game models are common models that researchers use to study. For example, Zhang et al. (2021) conducted a multistage game under demand uncertainty to analyze the selection of the cooperation model [64]. Yang et al. (2016) conducted Bertrand and Stackelberg game models when analyzing the online travel agency platform's pricing strategies [65]. Liao et al. (2017) consider a Stackelberg game and conducted the discount demand function [66]. He et al. (2021) researched the hotel and the platform's optimal service levels, advertising investment, and retail price in different modes by using differential equations to describe the dynamics of perceived service quality [69]. Taking the number of reserved rooms as a decision variable, Zha et al. (2015) used a newsvendor setting to depict the demands independently [70]. Mao et al. (2021) used a variation of the Hotelling model to study how to optimize online travel platforms' revenue [72]. Shi et al. (2021) established a principal-agent model when designing a service commission contract [74]. Other literature that used game models can refer to [62].

Besides, Wan et al. (2020) used variational inequalities to model the online travel agent platforms' altruistic preferences and the consumers' low-carbon preferences and used the improved projection gradient algorithm to obtain optimal results. They conducted a numerical case analysis to verify the effectiveness of the model [63].

3.3. Cluster 3: Sharing Platform

3.3.1. Research Topic

A significant economic model innovation brought by the PSSC is the sharing economy. Sharing platforms have been popular in recent years, especially with the improvement of mobile internet technology and the change in customers' life habits. People can share various products, like bicycles, boats, clothing, accessories, electronics, luxuries, cars, and apartments through different online sharing platforms [75]. Common examples include car-rental platforms like Turo, Zipcar, TOGO, GoFun, and EVCARD; carpooling platforms like Uber and Didi; and accommodation-sharing platforms like Airbnb [76–80]. In reality, business-to-consumer (B2C) and consumer-to-consumer (C2C) are two common sharing models owing to the differences in market participants, product ownership, and profit allocation [81]. These platforms are normally owned by manufacturers or third-party corporations [82].

The literature in this field mainly concerns the choices of sharing models and other economic operational decisions, including the pricing, service effort, dispatching plan, and so forth [78].

Our review shows that research on model choice mainly exists regarding car-sharing platforms. Manufacturers face the decision of making self-built platforms or collaborating with third-party platforms [75]. Research showed that costs, including product cost, sharing transaction and offline operating costs, commission rate, value perception factor, etc., will influence firms' optimal strategies [76,80,82,83]. Besides, Bian et al. (2021) explored whether a third-party C2C sharing platform firm launches its own sharing service by offering its own products [75]. Guo et al. (2022) discussed the third-party B2C car-sharing platform's value-added service investment strategy to compete with manufacturers when they provide the car-sharing services by themselves [80].

Other well-studied operational decisions focus on pricing strategies. For example, Bian et al. (2021) studied pricing decisions in a hybrid sharing model integrating both C2C and B2C sharing models [75]. Liang et al. (2021) compared the market pricing and platform pricing strategies' under B2C and C2C modes to obtain the car-sharing platforms' optimal pricing mechanism [78]. Chen et al. (2021) researched the accommodation-sharing platform Airbnb's dynamic pricing strategy by considering market conditions, quality, and risk preference [79]. Huang et al. (2022) examined the B2C car-sharing platform's optimal pricing and pricing policy selection during peak and off-peak hours. The platform can choose a fixed pricing policy or a dynamic pricing policy. Their results show that implementing a dynamic pricing policy can increase the sharing platform's profit and off-peak hours' demand but decrease the consumer surplus, social welfare, and peak hour demand [84]. For more related works, we refer the readers to [76,82,83,85].

Apart from the aforementioned operation strategies, Guo et al. (2022) researched platforms' dispatching strategy from the perspective of sustainability [77]. Cai et al. (2021) researched triple marginalization and hazard problems caused by the platform operation and proposed adopting blockchain technology and a "discounted" markdown sponsor contract to coordinate [81]. Wen et al. (2022) researched the sharing platforms' optimal product quality improvement efforts [85]. Sun et al. (2020) examined a free-floating sharing platform that owns a durable product and leases it to consumers and the platform's optimal product quality, input quantity, and dynamic advertising investment strategy [86]. Choi et al. (2020) analyzed rental-service platforms' product information disclosure strategy supported by blockchain technology [87].

3.3.2. Research Methods

According to our analysis, game models remain the most common approach. Most research was conducted on Stackelberg game models. For example, Guo et al. (2022) used a three-stage Stackelberg game model in which the original equipment manufacturer is the leader and the platform is the follower [80]. Cai et al. (2020) used the newsvendor product game model to explore the platform's operation [81]. For some related works, we refer the readers to [75,76,78,82,84].

Besides, Chen et al. (2021) developed a Hoteling model and extended the research into dynamic pricing decisions in the presence of Bayesian social learning that captures the interactions between social learning and platform strategies [79]. Wen et al. (2020) employed the mean-variance theory to model the risk-averse attitudes of decision-makers and analytically derive the platforms' optimal product quality improvement efforts and the optimal prices [85]. Sun et al. (2020) used an optimal control model and solved the problem via the maximum principle and an algorithm in their research [86]. Choi et al. (2020) constructed a stylized duopoly model to analyze the product information disclosure Nash game between two rental-service platforms [87].

Apart from the game model, Guo et al. (2022) conducted a holistic multi-objective mathematical model to study platforms' dispatching strategy. They proposed an effective method

to solve the model and an approach to efficiently generate the Pareto front. Besides, they conducted extensive case studies of different scenarios with real data to validate the model [77].

3.4. Cluster 4: Digital Platform

3.4.1. Research Topic

In the last decade, the proliferation of digital platforms has generated substantial and growing revenues with the development of the internet [88]. Some digital platforms, such as Apple's App Store, Google Play, the Windows Phone Store, and BlackBerry App World are becoming hot research issues [89,90]. These digital platforms provide virtual-products-related services, and consumers can use applications or enjoy other services. Our analysis results show that research on this topic mainly concerns the operational decision-making and coordination between the digital platform and service distributors.

Through our review, we find that many scholars researched optimal pricing, quality effort service, and advertising strategies. For example, Liu et al. (2020) analyzed the optimal product quality and the platform's optimal advertising effort when considering the reference price and goodwill [90]. Xing et al. (2022) investigated the digital platform supply chain's optimal pricing and service quality strategies while considering the network externality's impact [91]. Ji et al. (2019) researched a mobile platform's joint advertising investment and in-app advertising adoption decisions [92]. Liu and Liu (2019) researched a dynamic advertising strategy model for one platform and multiple apps under decentralized and integrated conditions [93]. Besides, Avinadav et al. (2015) analyzed the effect of application developers' risk-sensitive behavior on supply-chain performance [94]. We refer the readers to references [95–98] for related research.

Besides, in reality, digital platforms and service developers have different access to information [89]. Therefore, many researchers studied the distribution platforms and application developers' private information disclosure strategy regarding whether to share information and how to share. Some coordinate mechanisms like different contracts were proposed. For example, Avinadav et al. (2021) found that the developer was not willing to voluntarily disclose his private information, and they designed mechanisms for platforms to motivate the developer to share information [88]. Avinadav et al. (2022) studied the value of information-sharing when the developer is risk-neutral or risk-averse [89]. Qu et al. (2022) pointed out that market structure will influence the information sharing strategy, and the distributor sharing information can weak the double marginalization [96]. Avinadav et al. (2022) investigated the information decisions under the conditions that the platform's owing demand information is hidden superiority or known superiority [99].

Our analysis results show that the coordination of digital PSSC also receives some attention. Researchers compared different contracts' roles in coordinating and increasing the total digital PSSC profits. For example, Li et al. (2017) compared the wholesale price contract and the two-part tariff contract, and they found digital platform's risk-averse degree will influence the optimal choice of contracts [100]. Similar research can refer to [88,94,95].

3.4.2. Research Methods

Among the literature that we review, game theory and optimal control theory are used in mathematical models as the common research method.

For example, Qu et al. (2022) used a Stackelberg and Nash games model to identify the digital platform's equilibrium conditions [96]. Both Wang et al. (2018) and Ji et al. (2019) conducted differential game models to analyze optimal advertising strategy [92,98]. Hao et al. (2017) conducted an N-shaped dynamic model by considering consumers' different perceived valuations for applications to research the game between the platform and the app developer [97]. Other research on using game theory to conduct models can be seen in [89,91,94,99].

Besides, some scholars adopted optimal control to analyze the digital platforms' operation strategies. For example, Avinadav et al. (2021) developed a menu of contracts based on optimal control theory [89]. Avinadav et al. (2020) applied the principal-agent

framework to analyze the interaction between the platform and service provider and used optimal control to design the contract during their research [95]. Liu and Liu (2019) and Liu and Liu (2020) researched digital platforms and application distributors' quality and advertising strategies, respectively, by utilizing optimal control theory [90,93]. Apart from these, Li et al. (2017) used principal-agent models and used the mean-variance method when researching contract design [100].

3.5. Cluster 5: Recycling and Remanufacturing Platform

Research Topic

Apart from selling new products on platforms, out of consideration for environmental impact and profits, many manufacturers and retailers recycle and resell products to customers, especially electronics, on platforms [101]. Some research pointed out that coordination with third-party Internet service platforms like JD.com and Aihuishou makes the whole recycling and reselling progress more efficient [102]. Our review finds that research on remanufacturing has been widely investigated. However, research on recycling and remanufacturing platforms is not ample. The current research concerns pricing, marketing investment, and different members' coordination.

The literature on the recycling and remanufacturing platform researched the closed-loop supply chain (CLSC) that put new products and used or remanufactured products for sale on online platforms simultaneously. Research questions include the decision of channel choice and other operational decisions, like pricing, quality, and service.

Research on manufacturers' channel decisions concerned manufacturers' decisions on whether to recycle and sell remanufactured products on the platform as a trade-off of the profits from selling old and new products. Furthermore, whether recyclers will sell remanufactured products on self-built platforms or third-party agency platforms after they have decided to recycle and sell used has also attracted many researchers' attention [101,103]. For example, Jia et al. (2020) investigated the manufacturer and the e-retailer channel modes choices and found that determined by the order fulfillment cost and platform fee [101]. Zhong et al. (2021) considered the recycler's choice of selling remanufactured products through the e-retailer's platform or their own online platform while considering consumers' green education. They found that the e-retailer can benefit from the remanufactured goods' cannibalization in the agency channel when the consumer green education is under-developed, which is contrary to traditional opinions [103].

Besides, some research is concerned with operational decisions. For example, Xiang et al. (2019) analyzed supply-chain members' research and development investment, advertising investment, and Big Data marketing investment strategy [102]. Wang et al. (2021) analyzed the reward–penalty mechanism and the platform's altruistic preference's effect on the recycling service and the quality improvement decisions [104]. What is more, due to the uncertain qualities of secondhand or remanufactured products, some research analyzed the product information disclosure strategy. Shen et al. (2020) examined the value of blockchain for disclosing secondhand product quality, and they found that horizontal integration can improve the supply chain's total profit with blockchain [105]. Ma and Hu (2022) analyzed recycling platforms' blockchain adoption strategy and blockchain implementation effects on CLSC [106].

3.6. Cluster 6: Financial Service Platform

3.6.1. Research Topic

Nowadays, in the context of the demand for finance, many platforms provide rich financial services, such as mobile payment, online credit services, and funding [107–109]. Alipay and Wechat are two popular platforms in China that provide mobile payment services. The platforms that provide online credit finance for consumers include Jingdong pay and Huabei of Alipay, which make people able to consume in advance and pay later. The last mainly provides funding services, like JD Finance and some peer-to-peer (P2P) lending platforms, like PPmoney, PPDai, Hongling Capital, and Renrendai, etc. [110,111].

In terms of third-party payment platforms (3PP), Fan et al. (2020) researched the optimal decisions of the manufacturer, the retailer, and the 3PP under the non-information-sharing and information-sharing cases and analyzed the 3PP's effects on supply-chain performances [107].

In terms of online credit finance, researchers are concerned about whether platforms should provide credit services and how to make service-related decisions. Li et al. (2020) researched the platform's credit entry strategy when facing credit card competition. They found that the penetration rate of credit cards is vital for the platform's decision [108]. Wu et al. (2022) analyzed manufacturers' and platform retailers' credit payment service decisions and different scenarios' equilibrium results. Their results showed that the discount factor for credit payment service and the discount of cash opportunity cost will influence their decisions [112].

What is more, Luo et al. (2015) considered a firm with a financial services platform that pools the divisions' cash into a master account managed by the headquarters. They researched how to determine the optimal joint inventory replenishment and cash retention policy for the entire supply chain [109]. Wang et al. (2022) researched a P2P lending platform that connects individual investors and borrowers directly. They analyzed the P2P lending platform's information service fee rate, the credit guarantee company's guarantee service fee rate, etc., and compared the P2P lending platform's different credit guarantee types [111].

3.6.2. Research Methods

Almost all of the literature about the recycling and remanufacturing platform and the financial service platform that we reviewed used game models for analysis. Therefore, we will analyze the methods that the literature used in this section. The game models mainly include the Stackelberg game and the differential game.

In terms of the recycling and remanufacturing platform, Jia et al. (2020) conducted a single-period decision problem model to investigate CLSC members' optimal decisions [101]. Zhong et al. (2021) conducted a two-period game model to analyze [103]. Wang et al. (2021) developed three models to study and extended the models to multiple recycling periods [104]. Xiang et al. (2019) conducted a goodwill dynamic model based on the differential game theory [102]. Ma and Hu (2022) conducted a differential game model to analyze the market conditions that can incentivize the platform to adopt blockchain for waste-product recycling [106].

In terms of the financial service platform, Fan et al. (2020) built game-theoretic models when they researched 3PP's decision problems [107]. Luo et al. (2015) formulated a dynamic program for the cash pooling model that includes two inventory states and one cash state [109]. Wang et al. (2022) conducted a Stackelberg game model to analyze the P2P lending platform's optimal decision variables [111]. Mitra et al. (2022) used collaborative filtering technology and machine learning to identify defaulter borrowers in P2P platforms [110]. Wu et al. (2022) conducted analytical models based on game theory to analyze the problem of the manufacturer and retailer simultaneously deciding whether to implement credit payment service in their respective selling channels [112].

4. Conclusions

Platforms are playing an important role in enterprises' operations and people's daily lives. It is a broad research theme and involves many different subjects and activities. Extant research on this theme only concerns one specific area, and the research results are dispersed. Our review analyzed the research paper that was searched on the Scopus database and Web of Science comprehensively. The main findings of our review are concluded as follows.

Through our review, we find that research on the PSSC mainly concerns the e-commerce platform, especially online retailing platforms. Meanwhile, the development of O2O instant delivery services and online tourism services draws many researchers' attention now, and research trends are on the rise. What is more, with people's empha-

sis on environmental protection and sustainable development, manufacturers are paying more and more attention to recycling and remanufacturing platforms out of consideration for corporate social responsibility and economic profit. Therefore, a large amount of the literature showed interest in this theme, too.

In terms of the research context, our review shows that PSSC members' operational decisions, especially economically related, were researched comprehensively. Among them, pricing is a concern for almost all types of platforms. Information sharing strategy has attracted more researchers' attention recently, especially with the development of blockchain and other novel technologies. Different platforms make different decisions about what type of information to disclose. Research on typical online retailing platforms, sharing platforms, and recycling platforms is concerned with the merchants' and platforms' product quality information disclosure decisions. Research on online tourism platforms and digital platforms is concerned with the platforms' demand information disclosure decisions. Advertising strategies are mostly studied on typical online retailing platforms and digital platforms. Apart from these, many researchers are concerned about the merchants' channel and mode choices, especially in online retailing platforms, on-demand service platforms, and sharing platforms. What is more, the coordination of the PSSC is also a hot topic that the literature discussed. Many different coordination mechanisms were designed, like some contracts. Our review results demonstrate that there are still some challenges that one ought to pay more attention to. The first one is that research on food safety in on-demand food delivery platforms is not ample. The second one is that supply-chain finance is drawing more and more attention, but related research was also inadequate. In addition, supply-chain members' risk attitudes also need to be focused on during the research, which is seldom researched in the literature.

In terms of research methods, game theory is the most common and popular, and most of the literature used game theory models to analyze supply-chain members' behavior under different circumstances (e.g., collaborative and competition). Game models include the Stackelberg game, the differential game, and the evolutionary game. However, during mathematical modeling, the majority of the literature was concerned with certain demands. However, market demands are random in reality. Therefore, scholars can focus more on the uncertainness and the dynamics of demand in their future research. Besides, some research used optimal control theory in models for analysis. Apart from this, mixed-integer linear programming was used to analyze on-demand service platforms' instant delivery problems.

Our reviewed results describe the current research field of PSSC clearly and provide references for enterprises and platforms to optimize their operation progress and obtain more profits. Furthermore, our results provide future research direction and research innovation by recognizing gaps in the literature. For example, our review finds that, with consumers concerned with food safety, the research on takeout platforms' quality information disclosure is insufficient. Researchers can be more concerned about this problem in the future. What is more, the application of novel technology like blockchain and the Internet of Things in the PSSC can be researched deeper.

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